

1966 TECHNICAL PROBLEM & SOLUTION SUMMARY

PROBLEM	SOLUTION
ZERO-G WATER GLYCOL EVAPORATOR OPERATIONS	REDESIGN OF WICKS, WETNESS SENSOR & CONTROLS (BLOCK II)
CONTAMINATION OF ECU DISTRIBUTION PLATE	REDESIGN OF DISTRIBUTION PLATE & FILTER (BLOCK IIA)
TITANIUM-N ₂ O ₄ INCOMPATIBILITY	GREEN N ₂ O ₄ (ADDITION OF 0.4 TO 0.8% NITRIC OXIDE)
SERVICE PROPULSION SUBSYSTEM HELIUM INGESTION (SP-009 MISSION)	REDESIGN OF STANDPIPE
ASTRO-SEXTANT DOOR MECHANISM	PASSIVE ASTRO-SEXTANT THERMAL PROTECTION
POTENTIAL RECONTACT OF APEX COVER AFTER JETTISONING	ADDITION OF SEPARATION CHUTE IN APEX (BL I) DUAL POSITIVE EXPULSION (BL II)
SERVICE MODULE REACTION CONTROL SYSTEM PROPELLANT CAPACITY & GAGING ACCURACY	FOUR-ON-DOOR QUAD CONCEPT PVT GAGING CONCEPT

SLIDE 39. 1966 TECHNICAL PROBLEM AND SOLUTION SUMMARY

some of these are not major in themselves, but caused some real scrambling on our part to catch back and not have an impact on the schedule. For example, we concluded with the NASA, after a lot of soul searching, that the water glycol evaporator in our environmental control system couldn't be proven to work at zero G. It would work at one G in a laboratory, and it would work upside down, but you couldn't prove it would work at zero G. So after a lot of analytical work and some studies of the possibilities of it failing in zero G, we changed to a design which would work under any conditions of operation.

We had a contamination problem in the ECU distribution plate and had to redesign the distribution plate with larger holes; this is within the ECU.

Mr. CABELL. ECU?

Mr. MYERS. Actually, it is the environmental control unit of the overall cabin conditioning system of the spacecraft.

We had a problem with titanium and nitrous oxide, an incompatibility that caused a stress corrosion, and by adding four-tenths to eight-tenths of 1 percent of nitric oxide to the oxidizer, we got away from that problem and conclusively proved that it was a stress corrosion problem due to the interaction of very pure oxidizers.

Mr. WINN. Dale, what shows up? You're talking about stress corrosion?

Mr. MYERS. This particular one was a very interesting story. We were running a life test back at the Bell Aircraft Co., who supplied these tanks, and we popped 20 tanks in a period of 2 days—a sudden rash of failures of tanks. We couldn't understand it because we had

tanks under pressure out here, and we weren't having any trouble. We started metallurgical studies, and all the guys started to look through the data, going back through what we call traceability of our equipment. To make a long story short, there had been a change in specification of the oxidizer by the Air Force for the Titan II program, and they were the suppliers of this oxidizer. They didn't have any trouble with this change, but it turned out that the alloy that we used was incompatible with this much purer oxidizer. And by changing back to the old spec, we were back in business again. So what happened was they had sent the first of this new oxidizer to the Bell Co., while we still had a storage tank of the old oxidizer here. We couldn't break our tanks, but they were breaking every time they put in a tank there, so we got the spec changed.

I have already talked of the helium ingestion problem. In the astro-sextant door mechanism, we were having trouble with the mechanism itself. We went to a passive thermal protection of that door, which we tested on Spacecraft 011; it was very successful.

Another problem was potential recontact of the apex cover. The top of the command module pops off when you are getting the parachutes out, and the aerodynamic wake of the command module tends to bring that apex cover back down and recontact. We changed to a separation chute in the apex to pull that cover off, and it was tested on Spacecraft 011. On block II, because the docking mechanism is up there, we can't use the parachute, so we have gone to a dual-positive expulsion system that pops the top apex cover off at greater velocity than the single expulsion system.

Service module reaction control system propellant capacity and gaging accuracy were problems in the program. There was a radiation source in the gaging system which looked like it might get us into a problem later in the scientific experiments, so we changed to a system that actually had come out of the Gemini program. That was a much simpler system.

In the earth landing subsystem (slide 40), we had a test out at El Centro on what we call a boilerplate vehicle. We had a tear in the

1966 TECHNICAL PROBLEM & SOLUTION SUMMARY

PROBLEM	SOLUTION
EARTH LANDING SUBSYSTEM MAIN CHUTE FAILURE	REINFORCING TAPES AROUND CANOPY
TITANIUM-ALCOHOL INCOMPATIBILITY	REASSIGNMENTS OF SERVICE PROPULSION SYSTEM TANKS NOT EXPOSED TO ALCOHOL, DELETE USE OF METHYL ALCOHOL IN PROCESSES
BLOCK II SERVICE PROPULSION SUBSYSTEM ENGINE POPPING & STABILITY	MOD INJECTOR TO INCLUDE ADDITIONAL PORTS & COUNTERBORING

SLIDE 40. 1966 TECHNICAL PROBLEM AND SOLUTION SUMMARY

chutes, and, in about a 2-week period, Northrop put some additional reinforcing tapes around the canopy; we have since qualified that parachute.

The titanium alcohol incompatibility required realignment of service propulsion system tanks, so as not to expose them to alcohol, and deletion of the use of methyl alcohol in all processes.

In the Block II service propulsion subsystem, we had an engine popping problem and a dynamic instability problem earlier in the program. Through some reshaping and actually some very good analytical work by Aerojet, we were able to completely eliminate that. I think we have the most stable engine in the business right now.

New things we are getting into (slide 41): There is much greater emphasis in extravehicular activities now. As a result of the late flight of Gemini, there was a lot learned about the problems of man in space. We're in the process of some design changes with the NASA, soaking up these things that have been learned so recently in the Gemini program. We have been through one preliminary design review with NASA, and we are moving into some detailed design changes of the vehicle for handholds and foot constraints for the astronaut on the outside of the command module.

Mr. WINN. Say that again.

Mr. MYERS. These guys have trouble when they're outside the command module trying to get a purchase on something to accomplish whatever they are going to try to do.

RECENT PROBLEM & SOLUTION SUMMARY

PROBLEM	SOLUTION
DESIGN PROVISIONS FOR EXTRA VEHICULAR ACTIVITY	IN PROCESS - PRELIMINARY DESIGN REVIEW JAN 31, 1967
SUSTAINING ENGINEERING	CENTRAL RESEARCH, ENGINEERING, AND TEST SUPPORTS IN HOUSE NEEDS, SUB- CONTRACTOR ENGINEERING SUPPORT LEVELS TO APOLLO EXTREMELY REDUCED
DALMO VICTOR DEEP SPACE ANTENNA	CLOSE SURVEILLANCE BY NAA AND DALMO VICTOR MANAGEMENT ON QUALIFICATION TEST COMPLETION
AIRESEARCH COMPONENTS	COMPONENTS WHICH FAILED QUALIFI- CATION TEST HAVE BEEN MODIFIED OR REDESIGNED
BEECH TANK QUAL	MINIMIZE HEAT LEAKAGE BY USING VAC- UUM PUMP FOR MAINTAINING VACUUM BETWEEN TANK SHELLS

SLIDE 41. RECENT PROBLEM AND SOLUTION SUMMARY

Mr. WINN. To do the tests and the work?

Mr. MYERS. Yes. If they are going to do any work outside of the command module, they tend to twist a wrench and they torque off the other way. So the kind of thing we are getting into is getting good handholds so a man can grip something. The most recent one—they actually tested it on Gemini 12—is a couple of foot stirrups that you put your feet into, and, by twisting this way, they lock in position. So a guy is out there with good purchase with his feet so that he can do something like get the hatch out of the way or whatever. That's a very recent innovation, I guess that's the way to put it, to aid the guy when he is outside the command module. So these ideas from late flights of Gemini are now coming into the Apollo program.

Mr. WINN. Prior to this, they had to hold on with one hand and work with one hand?

Mr. MYERS. Or they tried gripping their legs over the front of the Gemini, and they had some real problems trying to work in space. This recent work that NASA has done in a water tank, where they tested these things before they went out with Gemini 11, proved a lots of things that helped the guys in the definition of work in space.

Mr. PETTIS. About this new material we saw down in Huntsville last weekend, it's sticky—does that work well outside?

Mr. MYERS. Velcro.

Mr. PETTIS. Velcro?

Mr. MYERS. Yes. They have used it on the outside. They actually used some steel Velcro on the outside of the command module. This is because of the heat problem during the boost. Inside we have had Velcro, which is sticky nylon material, for attaching things to the side of the spacecraft when they are not using them. But there is some yet to be learned about this problem of extravehicular activity and we need it in an emergency situation. If there is trouble with the LM as far as docking is concerned, the men come outside the LM and across to the command module for return to earth. So we do need extravehicular activity even on the main line of the job of getting to the Moon. Some of these changes will come in here as we learn more about extravehicular activity.

I'm going to show you a chart on our manpower shortly here, and we talk of an area called sustaining engineering. In the absence of continuing development activity for Apollo, you would normally say fine, get rid of the engineers, and we'll just run a production program. But it isn't that simple. We are going to be in the position when we go on lunar flights that we need top technical people here and at MSC who really understand these systems so they can communicate, while the guys are on the lunar flight, concerning any anomalies that show up during the flight. So we have looked into a thing we call sustaining engineering. It may be a poor choice of words. What we are looking for here are substantial and challenging programs that can hold top technical people, as required, in certain companies to support, from a subcontractor's standpoint, their equipment. We have concluded here at North American that our central research and engineering activity under John McCarthy, and the various test activities we have in-house, indicate that we don't need a basic sustaining engineering program. I guess we are betting on the thought that

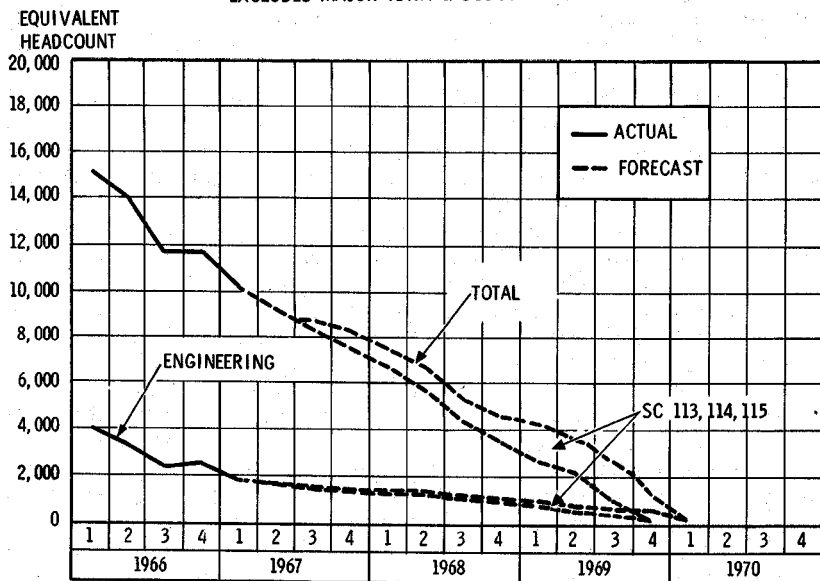
there will be other programs and other contracts that will come so that we can pull specialists back to support our activities, if required. Some of the smaller subcontractors, however, don't have future business coming their way, so we have talked to the NASA and, in fact, made proposals now for very small special tasks that will maintain high-level skills at places like Beech and the cryogenics business, and in a couple of the other outfits, for small groups of engineering people to be available in the 1967 to 1968 time period when we go toward the lunar flights. It's not a lot of money that is involved, and it will pay off as far as keeping skills available for this activity.

We're recently having a problem with our Dalmo Victor deep space antenna. We have what we call a tiger team up there in a special continuing management review with them to get their qualification tests complete in time to support the program. We have had some problems with AiResearch components, most recently in the area of a control box for the water boiler and an oxygen regulator, and we have had continuous surveillance with them. Most recently, we had a Beech tank qualification failure. Through long-term tests, we showed that we had a migration of molecules through the outside of the titanium shell into the vacuum space. This actually decreased the vacuum within the sort of thermos bottle we have for carrying our hydrogen, and would in fact eventually lead to loss of heat protection in the cryogenic tank. So we have had to add what we call a vac-ion pump. It's a vacuum-ion getter that is outside the vacuum space and pulls all the little molecules out of this vacuum area. That decision has just recently been made, because we had not recognized that as the molecules begin to fill this vacuum space there is a sudden sharp break in the increase in heat leak versus time. While it was down in the thing they call the mechanical shorting portion of the heat leak, we weren't having a problem; but it turns out these tanks, after storage for a period of about 6 months, begin to suddenly lose, very sharply, their vacuum capability. So putting this vac-ion pump on the thing, which is not a pump in itself, it's really a little electronic gadget that picks up the molecules that are in that vacuum space, we are able to sustain vacuum for a long period of time. That has caused us some rejuvelling as far as getting tanks to support our program. But that work is one of the standard businesses that we have, and that's to work around these problems to support our schedules.

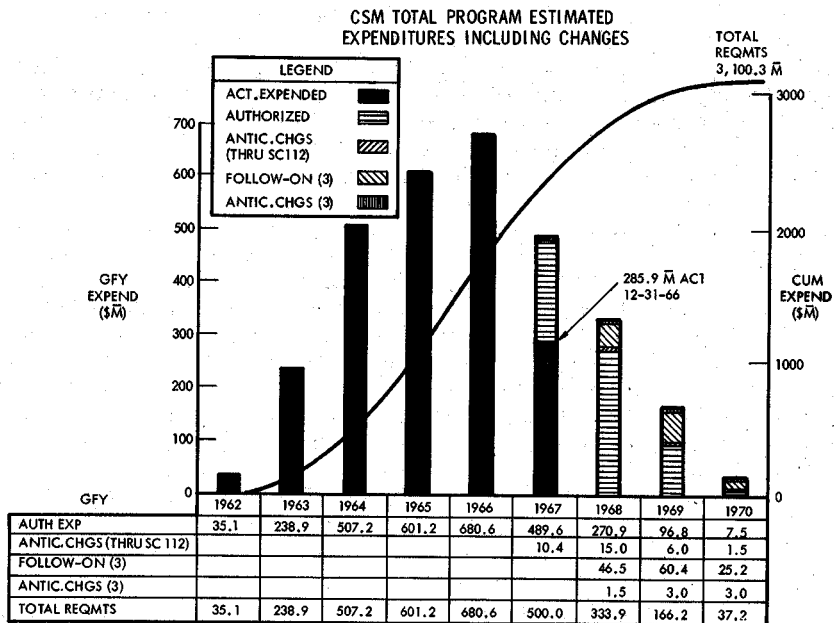
Here is our manpower in the program (slide 42). As you can see, it's going downhill very sharply. Our engineering level is down below 2,000 now and is heading down into sort of a straight-line reduction; our total activity, including our manufacturing and support, is also in a very hard down drive right now.

This has been the funding for the program up to the present time (slide 43). In fiscal year 1967, we have spent, up through December, \$285 million. We have a half year to go with a lot less than half of the funding for the year because we do plan, as you saw, a very sharp reduction in manpower here as we go on through 1967. It looks like we're staying within those funds right now. There may be changes in funds required as a result of the conclusions that are reached by the board on Spacecraft 012.

APOLLO DIRECT MANPOWER LOAD
INCLUDES TULSA & OFF-SITE NAA
EXCLUDES MAJOR IDWA & SUBCONTRACT



SLIDE 42. APOLLO DIRECT MANPOWER LOAD—INCLUDES TULSA AND OFF-SITE NAA, EXCLUDES MAJOR IDWA AND SUBCONTRACT



SLIDE 43. COMMAND AND SERVICE MODULES TOTAL PROGRAM ESTIMATED EXPENDITURES, INCLUDING CHANGES

Just to give you a hint on what some of the subcontractors are doing, they're going downhill very dramatically, too (slide 44). Honeywell, on the stabilization control system, will complete their activity by early 1968. Collins' activities include some system tests and refurbishment out in this time period; and they spill out a little further, but they're really down in the very low level of activity, too.

Mr. WINN. What is Collins—radio?

Mr. MYERS. Collins is radio, Cedar Rapids, Iowa. They're an old company. They used to be in the amateur radio business back in the early 1920's.

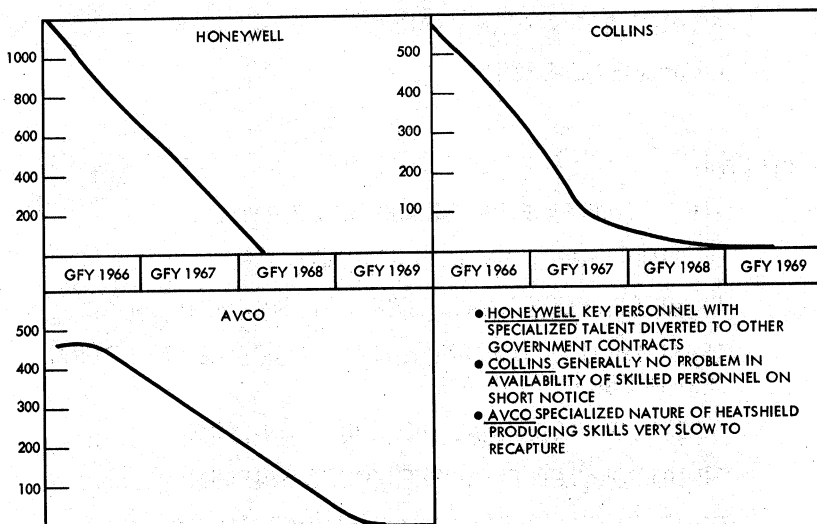
Mr. WINN. That's what I thought it was.

Mr. MYERS. They now supply very high-quality communications equipment for the Air Force and have done all the radios and communication equipment for Mercury and Gemini. They are our subcontractor on the communications and data system for Apollo.

Mr. TEAGUE. If you get another contract for four or five of these a year, what will it do to those charts?

Mr. MYERS. Well, Collins and Honeywell are both in the electronics-type business, and, to minimize costs in the program, we actually have them building ahead of our requirements. Electronics equipment can be done that way; it can be built and stored to a certain extent before it begins to age. And, in the case of Collins, for example, we had worked out a lot of detail. What happens to them, they just pick up a little bulge here which in terms of their overall business is a very small impact. For some of the little outfits, it makes a big difference.

TYPICAL SUBCONTRACTOR EFFORT REDUCTIONS
EQUIVALENT MANPOWER



SLIDE 44. TYPICAL SUBCONTRACTOR EFFORT REDUCTIONS—EQUIVALENT
MANPOWER

Mr. TEAGUE. What kind of charts do you have on your own company?

Mr. CARROLL. I will be covering that, Mr. Chairman.

Mr. MYERS. Bob will be covering that. We have worked out with each one of the major subcontractors what does happen as a function of when we really go, what happens to their manpower and their schedules on this.

Some of the big things coming up in the next 6 months (Slide 45) : Spacecraft 020 will be shipped to KSC; for 017, we expect the first Saturn V launch with 36,000-foot-per-second reentry velocity. We expect to meet our qual-test schedules. As I said, we only have two items to go in the Block I program. In Block II, our thermal vacuum vehicle will be shipped to Houston; the water egress ship will be shipped to Houston; Spacecraft 101, the first possible manned flight vehicle, will be shipped to KSC; our static test program will be completed; Spacecraft 102, the second of our manned capability vehicles, will complete its checkout and be shipped; 103 should be through its shipment; and our qualifications test for the basic lunar mission should be complete.

Any questions?

PROGRAM PROJECTIONS

NEXT SIX MONTHS

BLOCK I

SC 020 COMPLETE SHIPMENT TO KSC

SC 017 FIRST SATURN V LAUNCH

COMPLETE QUAL TEST

BLOCK II

2TV-1 COMPLETE FINAL CHECKOUT & SHIPMENT

SC 007A REFURBISHMENT & SHIPMENT

SC 101 COMPLETE FINAL CHECKOUT & SHIPMENT

2S-2 COMPLETE COMMAND & SERVICE MODULE STRUCTURAL TEST PROGRAM AT DOWNEY

SC 102 COMPLETE FINAL CHECKOUT & SHIPMENT

SC 103 COMPLETE FINAL CHECKOUT & SHIPMENT

COMPLETE QUAL TEST FOR BASIC LUNAR MISSION

2-15-67

Mr. TEAGUE. Thank you, sir.

Mr. CARROLL. Mr. Len Tinnan, from our advanced systems operations, will now cover some of the things we have looked at downstream for Apollo Applications.

Mr. PETTIS. May I ask one question? Have you changed in any major way the aerodynamics of this total craft in the last little while? Has it proved to be pretty much what you wanted to begin with?

Mr. MYERS. Yes. The only thing we have to worry about in the aerodynamics of the vehicle is really the location of the center of gravity. All the wind tunnel tests we have made have proven the shape was right. By having the right location in the center of gravity, this ship gets its lift-to-drag ratio by having the center of gravity offset. It tilts in the wind and gets lift from the aerodynamic forces on the heat shield and the rest of the ship. By having that tilt, and by rolling the ship with the reaction control system, we can maneuver it to come in. So there has always been a very sharp control of the center of gravity by the proper location of equipment in the ship, and it has worked out very nicely as far as the flights go.

Mr. PETTIS. Just to look at this thing at launch, you would think the thing is really going to go out of control right off the bat.

Mr. MYERS. At launch, there is a buffeting right at the edge of the command module down against the service module because of that sharp break there. That buffeting is an acoustic-forcing function normally on the service module, but we originally designed it to have a thick sandwich honeycomb structure there, and we have had no problems with it. We have tested it to the acoustic conditions that we learned from these early flights that we had on Saturn I. It's in good shape, we haven't had any problem.

Mr. TEAGUE. Before you start, Len, what you are going to present, are they strictly North American ideas? Has it gotten down into NASA?

L. M. TINNAN. I'm going to touch on various aspects of what we call Apollo Applications programs, as we define them at North American. Some of these have been done in conjunction with and under contract to NASA; others have been done under our own funding and pertain to ideas that have been suggested to the Government. I will cover both types of activities.

I am actually pleased to state at the very outset, that since my last opportunity to meet with Mr. Wilson and other members of your staff during their visit here last summer, that the Apollo Applications program has improved from what we then considered to be a bleak and uncertain picture to an outlook now which is reasonably clear and meaningful. This improvement has resulted primarily from two factors: First, from among the many space missions and vehicle design options that were then under consideration, the NASA and the industrial contractors, like ourselves, have been able to chart a course of action that we believe to be of significant national value. Secondly, and of equal or perhaps even greater importance, is the fact that, whereas in fiscal year 1967 the funds available to support the Apollo Applications program were virtually nil, there now appears to be a high probability that within fiscal year 1968 a reasonable level of

funding will exist with which to initiate the program. The prime problem now, I believe, remains simply to mount and move out.

As he pointed out in his budget message of just about a month ago, President Johnson indicated, and I quote here an excerpt from the message (slide 46):

We have progressed far enough that we must look beyond our original objective and set our course for the more distant future. Indeed, we have no alternative unless we wish to abandon the manned spacecraft capability that we have created.

On the heels of this message came the news release and the press briefings that NASA had relative to the budget, which included an approximate \$450 million request for the Apollo Applications program. And as Dr. Seamans from the NASA indicated:

There are a number of unique contributions with practical application, operational capability, science and technology that we can make with this program. And, in addition, we can place the Nation in a position to assess on the basis of valid experimentation and experience the value and feasibility of future space flight.

That sets some of the background for what I am going to cover. We are often asked the question, "What is the Apollo Applications program?" (Slide 47). The inquiry is unlike that when someone asks the question "what is the Apollo program?" where we could bring forth the mental image of a particular spacecraft configuration and we think of that vehicle going to the Moon. By contrast, however, the Apollo Applications program is not a vehicle concept. It is, in fact, a low-cost program concept that is aimed at determining in a firm sense the character of the U.S. next-generation space activities—whether they be manned or unmanned, whether they be planetary, lunar, or earth orbital in nature—and at the same time, maintaining

"IN 1961, THIS NATION RESOLVED TO SEND A MANNED EXPEDITION TO THE MOON IN THIS DECADE. MUCH HARD WORK REMAINS AND MANY OBSTACLES MUST STILL BE OVERCOME BEFORE THAT GOAL IS MET. YET IN THE LAST FEW YEARS, WE HAVE PROGRESSED FAR ENOUGH THAT WE MUST NOW LOOK BEYOND OUR ORIGINAL OBJECTIVE AND SET OUR COURSE FOR THE MORE DISTANT FUTURE. INDEED, WE HAVE NO ALTERNATIVE UNLESS WE WISH TO ABANDON THE MANNED SPACE CAPABILITY THAT WE HAVE CREATED."

JANUARY 1967 BUDGET MESSAGE
PRESIDENT L.B. JOHNSON

"...THERE ARE UNIQUE CONTRIBUTIONS TO PRACTICAL APPLICATION, OPERATIONAL CAPABILITY, SCIENCE AND TECHNOLOGY, THAT WE CAN MAKE WITH THIS PROGRAM AND, IN ADDITION, THAT WE CAN PLACE THE NATION IN A POSITION TO ASSESS ON THE BASIS OF VALID EXPERIMENTATION AND EXPERIENCE THE VALUE AND FEASIBILITY OF FUTURE SPACE FLIGHT AND THE INTERRELATED ROLES OF MANNED AND UNMANNED SYSTEMS IN ORDER TO GET THE BEST COST TRADE-OFF IN THE FUTURE FOR ULTIMATE OPERATIONAL SYSTEMS."

DR. ROBERT C. SEAMANS, JR.
DEPUTY ADMINISTRATOR, NASA
JANUARY 24, 1967
PRESS BRIEFING ON NASA FY 68 BUDGET

SLIDE 46. BUDGET MESSAGE AND PRESS BRIEFING QUOTATIONS

WHAT IS AAP?

**APOLLO APPLICATIONS PROGRAM IS LOW COST
PROGRAM CONCEPT FOR MAINTAINING PRODUCTIVE
& VIABLE POSTURE OF PERTINENT EXISTING INDUSTRIAL
& GOVERNMENTAL RESOURCES --WHILE FIRMLY
DETERMINING CHARACTER OF U.S. NEXT-GENERATION
SPACE PROGRAMS**

SLIDE 47. WHAT IS AAP?

the viable posture of pertinent national resources that has been created.

Mr. TEAGUE. I certainly hope that both Houses of Congress agree with you that it's a low-cost program this year.

Mr. TINNAN. We think the Apollo Applications program that has been defined to date and the plans that are being made by ourselves and other contractors in conjunction with the NASA represent a reasonable cost, a relatively low-cost program. However, I think, and the NASA has said, it does not necessarily represent the most ambitious program that could be laid out.

Within the Apollo Applications program, as it is currently defined by North American Aviation, there are five major objectives (Slide 48). The first of these, related to usefulness of man in space, appears on this slide. This and all of the other objectives are aimed toward a fundamental scientific and economic payoff. As contrasted to the past, where planned activities were very heavily oriented toward the scientific contributions, we think the program as presently defined is equally or even more heavily oriented toward a national economic payoff.

In the category of usefulness of man in space, the approach is not simply to prove that man is necessary in space, but, rather, involves a series of activities in which we will try to determine in which of the subsequent space operations man is best suited. In some cases, continuous manned operations may be indicated. In other cases, he may be best suited for intermittent operation, for example, like visiting an unmanned spacecraft, repairing or maintaining it as necessary, or, perhaps, gathering up film records and other data, and then bringing them home. Finally, it is evident that there may be other cases where the unmanned satellite fits best.

Now, these can be broken down into several categories: meteorology, Earth resources, satellite communications, navigation, as indicated here. The primary interest and heavy emphasis are oriented toward

PROGRAM OBJECTIVES

✓ SCIENTIFIC & ECONOMIC "PAYOFF"

• USEFULNESS OF MAN IN SPACE

METEOROLOGY

- EXPLORE/UNDERSTAND MOTION & BEHAVIOR OF ATMOSPHERE
- REDUCE IMPACT OF WEATHER ON OPERATIONS & ECONOMY

EARTH RESOURCES

- AGRICULTURE & FORESTRY
- GEOLOGY & MINERAL
- GEOG, CARTOG & CULTURAL
- HYDROLOGY & WATER
- OCEANOGRAPHY



- CROP STATUS & PRODUCTION
- WEED CONTROL
- CATTLE
- FLOOD CONTROL
- FOREST INVENTORY

SATELLITE COMMUNICATIONS

- VOICE (TELEPHONE)
- TELEVISION

NAVIGATION

SLIDE 48. PROGRAM OBJECTIVES

the Earth resources operational application: agricultural and forestry in nature, geological and mineral explorations, and the other items indicated here.

In exploring these resources, both from national and international aspects, we feel that orbital vehicles—some manned, some unmanned—will eventually lead to supporting the Nation in determining factors such as crop status and production. For example, this would represent an extension of some of the work that has been done in aircraft flying over small citrus areas with infrared sensors—we have been able to detect diseased orange trees. Such information would enable us, therefore, to distinguish which trees should be pulled out and replaced by new saplings, so as to maintain the production levels. The same could be done relative to many types of crops.

Further, by repetitive orbital surveys, we would be able to distinguish good grazing areas for large cattle herds that are not otherwise visible to us on the earth's surface. And, within the broad view of repetitive orbital vehicles, we can monitor changing weather conditions; and we can detect, perhaps in the same vehicles, data pertinent to flood control and forest inventory assessment.

With the meteorological explorations being considered, we can try to understand the motion and behavior of the atmosphere. We may not be able to change the weather, but we can certainly try, at least within the present technology, to reduce impact of the weather on our daily operations and economy.

Mr. GURNEY. When you are talking about usefulness of man in space, do you mean total space activities or manned space flights?

Mr. TINNAN. I'm sorry, I don't quite understand the question.

Mr. GURNEY. The term usefulness of man in space, do you mean our total space activities like spacecraft unmanned, or are you talking about manned space flight?

Mr. TINNAN. I'm talking about all of them. We are trying to determine in which of these possible operational applications we would be better off having a manned spacecraft as opposed to having an unmanned satellite; or the case where a manned spacecraft would simply be shuttle vehicle back and forth between various unmanned spacecraft.

If I understand your question, sir, a combination of the two.

Mr. WINN. Would you tell me what the last two things under "Satellite communications" are? Thank you.

Mr. TINNAN. To continue with our five primary program objective categories, the first I touched on. The second relates to scientific advancement (slide 49). I believe you have and will be hearing much from the NASA along these lines, therefore, we will not try to amplify further here.

PROGRAM OBJECTIVES (CONT)

• SCIENTIFIC ADVANCEMENT

SOLAR ASTRONOMY (1968-70 PEAK ACTIVITY)
SPACE PHYSICS

- X-RAY ASTRONOMY
- U-V SPECTROSCOPY
- ION WAKE
- PARTICLES & FIELDS

• R&D SUPPORT OF D.O.D. PROGRAMS

• CAPABILITY FOR ECONOMICAL SPACE FLIGHT

HARDWARE REUSE
LONG-DURATION OBJECTIVES

- MEASURE EFFECTS ON MEN & SYSTEMS
- ACQUIRE OPERATIONAL EXPERIENCE

• LUNAR EXPLORATION

UNDERSTANDING OF LUNAR SURFACE & INTERIOR
PERSPECTIVE IN UNDERSTANDING SOLAR SYSTEM
ESTAB ROLE OF MOON IN FUTURE SPACE OPERATIONS

The objective is to acquire information of a purely scientific nature.

The third objective relates to in-orbit research and development support of Department of Defense programs—for example, trying out operational techniques and possible hardware equipment.

The fourth major objective identified is to explore what our capability is for economical space flight. This relates back very heavily to the initial objective I discussed on the preceding slide. And as you will see in a few moments, our current investigations lean heavily toward the consideration of reuse of hardware from previous flight; whether we leave it in space and go back and reuse it, or whether we bring it home from space and then launch it again. We'll touch on some of the results of our work there later.

In terms of long-duration objectives, as Mr. Myers pointed out earlier, we have much to learn about men in space. Men have been there 14 days, but we have yet to know the full extent of extended-duration zero-G exposure. Here I am referring to time spans out to the order of 600 to 900 days, the types of duration that would be involved with manned planetary flights.

The fifth objective, and incidentally these are not in any order of priority, the fifth category listed relates to lunar exploration. This involves getting a better understanding of the lunar surface and what is beneath the lunar surface, and trying to better understand, from our lunar explorations, the total solar system and how it evolved. And perhaps most important is to establish the role of the moon in future space operations—for example, as an astronomical observatory.

Some of the primary parameters that govern the program within which we operate are based upon the common use of modules (slide 50). By this, we mean that the steps that we presently consider taking evolve from or revolve about the consideration of hardware that would be used, for example, in early earth orbital space station operations, being potentially useful in subsequent space activities, even leading to planetary activities. With this approach, we can make use of every step along the way. The use of the long-range planetary "goal" is intended simply to set some of the standards for the earlier near-earth type of operations. The use of that "goal" does not require an early decision for the long-term commitment to place a man on or near the planets in the 1980 period or later. But, in fact, each step of the program, as it is currently defined and as we are pursuing it with NASA, is a complete step by itself, and is one that is of major national significance.

Mr. PETTIS. Mr. Chairman, may I ask a question? You aren't going on to this, so I'd like to go back to a previous slide. You don't have to go back to it, just the question. Relating this to manned flight on this earth, or airplanes, let's say, the chain is no stronger than its weakest link. Now, something in this space capsule is weaker than the craft itself. Is there research and development going on toward the development of a way to maintain these weak links in the spacecraft?

Take, for example, the radio, I don't know how advanced the art is in this particular field, but ultimately some parts of this are going to go before the total hardware has gone; and in servicing this, is there thought for taking care of it so that you don't have to throw the whole thing away because some part of it wore out before the rest of it?

PROGRAM PARAMETERS

✓ HARDWARE

COMMONALITY
OF
MODULES



- EARTH ORBIT SPACE STATION
- LUNAR SHELTER
- LUNAR ORBITING STATION
- PLANETARY MISSION MODULE

✓ STEP-BY-STEP PROGRAM DECISIONS

- ESTABLISHMENT OF PLANETS AS "GOAL" DOES NOT REQUIRE EARLY DECISIONS FOR LONG-TERM COMMITMENTS
- EACH STEP COMPLETE--AND OF SIGNIFICANT NATIONAL VALUE--BY ITSELF

SLIDE 50. PROGRAM PARAMETERS

Mr. TINNAN. There are two aspects to your question, I believe, and we have examined both of these extensively. One is what happens when failure occurs in orbit; that is, can we remove a failed component and replace it with a spare that we have carried along? Yes. Our studies have indicated that such can be done, and usually some technical debate occurs on whether the "spare" should be built in so that the man simply throws a switch from the bad unit to the good one, or whether he should physically remove the failed unit and put the new one that's carried as a spare in its place. Our analyses have shown that both approaches are possible. In fact, some previous studies which we reported on to your committee previously have indicated that the Apollo spacecraft is nominally defined as a 14-day mission vehicle. In fact, we don't know how to design the equipment for just 14 days. We qualify it for 14-day missions, we believe it is good for many more days. Our early estimates were that the spacecraft could operate for well over a month without failure of many of the systems. In summary, the answer to your question is that the best solution is a function of the mission duration that you expect.

Mr. CARROLL. And you carry the expendables on board?

Mr. TINNAN. Yes. The mission duration may tend to be more limited by the oxygen, the food, the chemicals which remove the carbon dioxide that the astronauts expel, and the other on-board expendables, rather than the equipment life.

Mr. PETTIS. You are talking about the manned. I'm talking about the unmanned, the satellite which you are talking about keeping something up there for meteorological studies and surveys.

Mr. TINNAN. I believe you're referring to the category which I defined earlier as intermittent manned operations. If we had a fairly sophisticated unmanned communications satellite that operated well for a year and all of a sudden it failed, it would be possible for a manned vehicle to visit it and make certain repairs on it, thus putting it back in operation.

Mr. WINN. You are talking about a maintenance system?

Mr. TINNAN. In-flight maintenance, yes.

Mr. PETTIS. All right. After all, they say it costs, in terms of weight, the equivalent of an Oldsmobile to get a pound of weight up there. I'd like to see it stay up there a while and stay in service with maintenance behind it.

Mr. TINNAN. It's quite feasible and is under study now.

Mr. TEAGUE. Mr. Tinnan, are you going to comment at all on the recommendations of the President's Scientific Advisory Board in conjunction with this?

Mr. TINNAN. Sorry, Mr. Teague, I'm not personally familiar with those recommendations, so it's not possible for me to comment on them.

Within the scope of the Apollo Applications program as we define it, and I believe this gets back to one of your earlier questions, Mr. Teague, there are two areas that are covered by current or recent NASA contracts with us (slide 51). The first of these relates to the

PRESENT AAP SCOPE

(AS DEFINED BY NAA)



APPLICATION OF SATURN & APOLLO VEHICLES TO ALTERNATE EXTENDED-DURATION MISSIONS

- EARTH ORBITAL OPERATIONAL INVESTIGATIONS
- LUNAR EXPLORATION



REUSE OF SPACECRAFT

- RE-VISITATION & RE-EMPLOYMENT OF ORBITAL VEHICLES
- RENOVATION OF RECOVERED APOLLO COMMAND MODULES (CM)
- ALTERNATE USE OF APOLLO-QUALIFIED HARDWARE
 - SUBASSEMBLIES FOR NEW ORBITAL MODULES
 - SUBSYSTEMS & GROUND SUPPORT EQUIPMENT (GSE) FOR DOD PROGRAMS
- DEFINITION & DEVELOPMENT OF "BLOCK III" COMMAND & SERVICE MODULES (CSM) 6-MAN LOGISTICS (SPACE STA RESUPPLY) VEHICLE WITH ADV LANDING SYSTEM

SLIDE 51. PRESENT AAP SCOPE—As DEFINED BY NAA

application of Apollo and Saturn vehicles to alternate missions. They would employ launch vehicles and spacecraft, which, if they are not required for the lunar landing program, could be applied to the types of earth-orbital operations which I touched on earlier, and to some of the lunar-exploration type of activities.

The second activity relates to reuse of spacecraft. The reuse of spacecraft falls into two subdivisions: One, can we take a vehicle into space, return the crew to earth, return only part of that vehicle, and leave part behind which can be subsequently revisited? That aspect is the heart of what is now known as the Saturn-IVB orbital workshop, I'll touch on this in more detail.

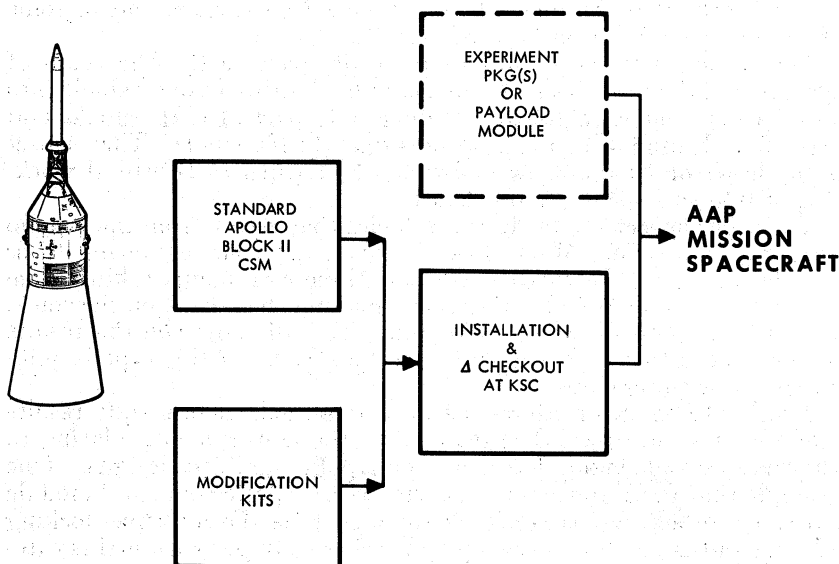
The other aspect relates to the vehicles that result from the Apollo program, which Mr. Myers has described for you, recovering these vehicles again on the earth with their three astronauts, taking them back into the shop, refurbishing them, putting them back on the stack, and launching them into orbit again. We will show you the results of the studies that have shown that vehicle reuse of this type is quite a reasonable thing to do.

Another category of interest pertains to some in-house study results that we have only recently presented to the Government, relating to alternate uses of Apollo hardware, or Apollo-qualified designs. One example that I will touch on relates to use of Apollo command module hardware in a new spacecraft module, such as the multiple-docking adapter in the orbital workshop. Another example within this category, but outside of the NASA world, pertains to some recent investigations of ours that show that significant cost savings might be accrued by the Department of Defense in their Air Force MOL program, by the use of ground support equipment that had been developed under the NASA Apollo program.

The fourth category I will touch on that falls within our own definition of AAP scope, relates to the development of Block III command and service modules. Mr. Myers touched on the Block I early development vehicles, the Block II lunar mission vehicle, which added such items as the docking capability, and other minor revisions. This change is analogous to the change from the F-86A to an F-86D airplane, and now we're talking about going to the next version of the same basic vehicle, but in this case carrying possibly six men in the command module instead of three men, and using it as a logistics resupply vehicle in support of space station operations.

I am going to run through these four categories of effort, touching only on examples of the work in each category that we have underway (slide 52). In the first category, the ultimate use of Saturn-Apollo vehicles for these missions is primarily focused on a "modification concept." Under this approach, we take standard Apollo Block II command and service modules (CSM), and, concurrent with shipment in a standard lunar mission configuration to the Kennedy Space Center, we will ship minor modification kits which can be installed in that vehicle at KSC, and the incremental checkout will then be performed there. After that is accomplished, this vehicle, with the appropriate modifications, can then be coupled with experimental packages or with payload modules to give us what we call an AAP mission spacecraft.

ALTERNATE MISSION CONCEPT



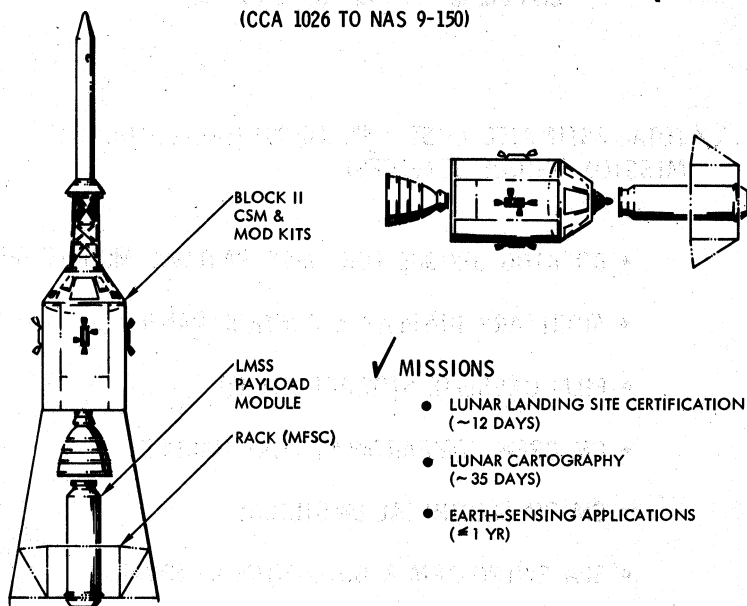
SLIDE 52. ALTERNATE MISSION CONCEPT

I'd like to show you an illustration of one such example, and Mr. Myers touched on this briefly when he pointed out that we had just, this past December, completed the preliminary design review on the lunar mapping and survey system (slide 53).

In this program we take the standard Apollo command and service modules, and in the LM adapter section, instead of carrying a lunar module, we carry the lunar mapping and survey system. The LMSS, the lunar mapping and survey system, is housed in a payload module that is carried on a support rack which is built in-house by the Marshall Space Flight Center. The vehicle is launched into orbit, and depending upon whether it's going toward the Moon or into Earth's orbit, on a Saturn V or an uprated Saturn launch vehicle. After reaching orbit, the command and service modules lift off slightly and turn around. We call this a transposition maneuver; it then docks to the vehicle as shown in the upper right-hand corner of the slide, and then operates in that mode. The potential mission applications being considered include those listed in the lower right-hand corner. These include certification of possible lunar landing sites either for initial or later Apollo lunar landings, and here we're talking about mission durations on the order of 2 weeks. Next, for lunar cartography, and now instead of placing the vehicle into an orbit around the Moon's equator, as we do in a normal Apollo mission, we would place it in a polar orbit, orbiting the poles of the Moon so that it will be able to cover the entire lunar sphere and give us

LUNAR MAPPING & SURVEY SYSTEM (LMSS)

(CCA 1026 TO NAS 9-150)



✓ MISSIONS

- LUNAR LANDING SITE CERTIFICATION (~12 DAYS)
- LUNAR CARTOGRAPHY (~35 DAYS)
- EARTH-SENSING APPLICATIONS (≠ 1 YR)

SLIDE 53. LUNAR MAPPING AND SURVEY SYSTEM—LMSS

cartographic coverage, a map, of the entire Moon. That mission, including the transit time out and back, would be on the order of 35 days. If we use the mapping and survey system for some of the sensing functions, for example, related to the Earth resources applications we were talking about before, like crop control, location of cattle grazing areas, and the like, it could be used in a more continuous mode of operation.

In order to adapt the CSM to these missions, we find that minor hardware modification kits are required (slide 54). I won't try to describe them in detail, but they include, for example, placing within the command module film cassette stowage kits. This entails simply adding relatively small hardware items so that the film cassettes, the containers, can be carried home with the men. There are also some modification kits that are associated with ground support equipment. The important point is that to convert from the basic lunar mission to the mapping and survey system capability costs nominally \$2 million, a rather small incremental cost.

Mr. GURNEY. Is that manned or unmanned flight?

Mr. TINNAN. This is manned flight.

Mr. GURNEY. Duration?

Mr. TINNAN. In its primary mode, as presently defined, it is nominally a 2-week mission.

Mr. GURNEY. The lunar mapping and survey system which you mentioned, was going to be built in-house. Whose idea was that?

Mr. TINNAN. Only the rack which supports the payload module in the adapter section is built by the Marshall Space Flight Center. I

LMSS MOD KITS

✓ TOTAL ESTIMATED COST = \$2,100,000 (INCLUDING ALL MISSION-UNIQUE SERVICES)

- DOCKING DROGUE FOR LMSS PAYLOAD MODULE (PM)
- AUXILIARY DISPLAY & CONTROL PANEL
- FILM CASSETTE STOWAGE KIT (2)
- CM CREW COMPARTMENT WIRE HARNESS
- CM-PM ELECTRICAL UMBILICAL
- SLA SWING ARM & GUILLOTINE REMOVAL
- RF CHECKOUT KIT
- DOCKING ALIGNMENT GROUND SUPPORT EQUIPMENT
- SLA/PM TRANSPORTER MOD KIT

SLIDE 54. LMSS Mod Kits

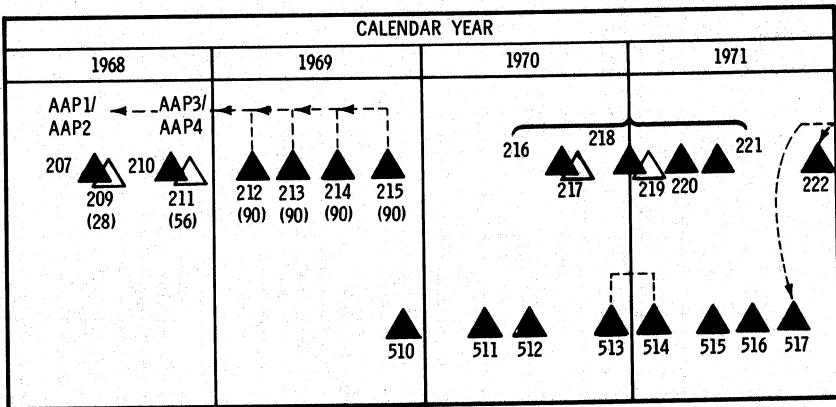
have no idea as to how that decision was reached. The payload module itself is built by an associate contractor.

This is the flight schedule which is used for our current AAP study (slide 55). It does not represent a firm proposal on the part of either North American Aviation or NASA; it is intended only as a study guideline. Flights that we are considering could begin as early as mid-1968. In 1968, there are actually two series of two flights each being considered—one manned and one unmanned in each series. The first pair of flights could produce a manned mission duration of 28 days; and approximately 6 months later the second pair of flights could produce a manned mission duration of 56 days. I am going to get into some of the characteristics of these specific missions which comprise the so-called orbital workshop missions.

In looking ahead, however, just very briefly to 1969 and later possibilities, we are examining a series of four flights at 3-month periods of 3 months' duration each. With this series, before one set of astronauts would come home, the second set of men would arrive, and by selective crew rotation, the program could provide for one man remaining in orbit for a full year under the flight sequence being considered. That

AAP FLIGHT SCHEDULE

(NAS 9-6593 STUDY GUIDELINES)



- NOTES: (1) INDICATES UNMANNED LAUNCH;
 ALL OTHERS MANNED
 (2) 200 SERIES = UPATED SATURN I
 500 SERIES = SATURN V
 (3) MANNED MISSION DURATION
 SHOWN IN PARENTHESES

SLIDE 55. APP FLIGHT SCHEDULES—NAS9-6593 STUDY GUIDELINES

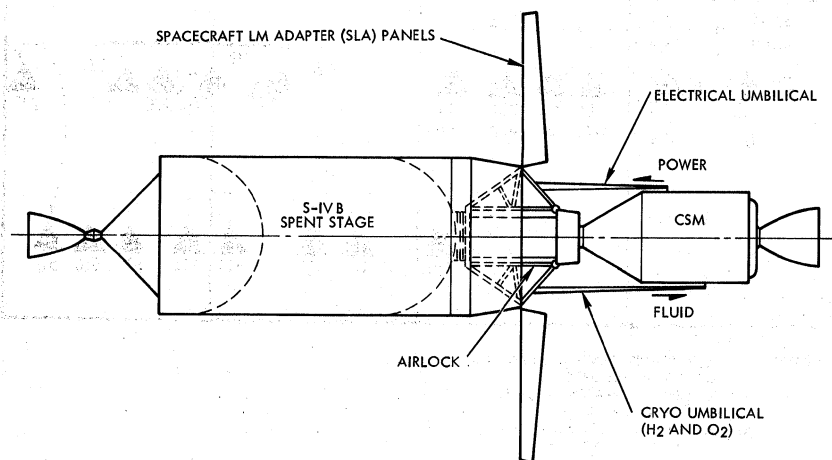
could be done in conjunction with the orbital workshop which is initiated in 1968.

When Mr. Wilson visited with us last summer, I covered some of the details of the orbital workshop configuration that was then under study (slide 56). At that time, only a single manned launch on an uprated Saturn I into Earth orbit was being evaluated. The spent S-IVB stage, the Douglas-built stage, would be evacuated in space to get rid of residual propellant and then pressurized with oxygen to permit habitation by astronauts performing experiments. Attached to the end dome of the S-IVB would be an air lock which is being built by the McDonnell Co. The command and service modules would turn around and dock to the air lock and then this would sort of give a form of an embryonic space station. At this point in time, however, it has been shown to be more effective if we assemble in orbit a clustered configuration which is represented by this slide (slide 57). However, rather than describe the drawing on this slide, we have a model of this configuration and I think I can perhaps describe it better by showing how it works (slide 58).

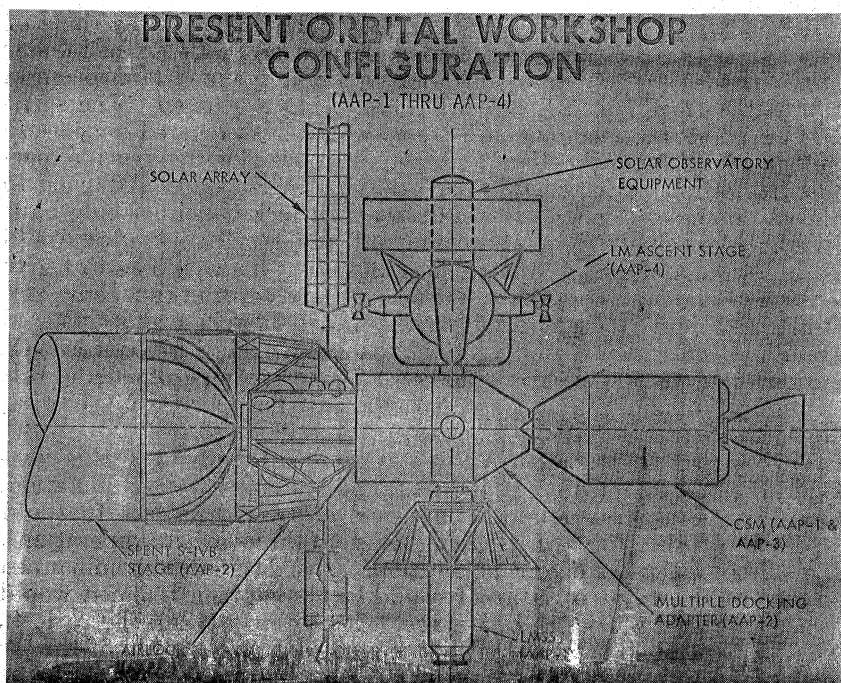
On the first flight, called AAP-1 in present terminology, this combination, the standard lunar and mapping system survey combination, previously described, would be launched into Earth orbit. It would operate in orbit for 5 days doing photographic sensing operations. This first launch is a manned operation. Five days later an unmanned launch of the uprated Saturn I would be accomplished, and it would place in orbit the spent S-IVB stage. At the top of this is the air lock, similar to the one I mentioned just a moment ago. On top of the air lock is a module called a multiple-docking adapter. These are the

PREVIOUS ORBITAL WORKSHOP CONFIGURATION

(SINGLE, MANNED LAUNCH)



SLIDE 56. PREVIOUS ORBITAL WORKSHOP CONFIGURATION—SINGLE, MANNED LAUNCH



SLIDE 57. PRESENT ORBITAL WORKSHOP CONFIGURATION—AAP-1 THROUGH AAP-4

panels on the LM adapter vehicle that Mr. Myers referred to as the SLA. They would fold back, and then solar-cell panels would fold out to provide electrical power. The AAP-1 vehicle, which is in a different orbit, would transfer and rendezvous with the second AAP flight. It will dock the lunar mapping and survey system payload module to one of the side ports of the multiple-docking adapter. The command and service modules will back off and then dock to the top port of the multiple-docking adapter. That then becomes our 28-day mission configuration. The three astronauts will operate for 28 days, performing various experiments that were carried up on the unmanned launch. At the end of that period of time this vehicle (the CSM) would depart and carry the astronauts back to Earth. Approximately 6 months later, when AAP-3 is launched to start the second mission sequence, manned command and service modules would be launched into orbit. Approximately 1 day later, an unmanned lunar module, the LM built by Grumman, would be launched into Earth orbit carrying on the bottom, instead of the lunar descent stage, a rack with special solar observation equipment. These vehicles would rendezvous in Earth orbit and would then transfer to and rendezvous with this station. The lunar module would dock to one side port and the command and service modules to the end port. That would give us our 56-day manned mission configuration.

Now, that's where most of our present AAP contract study effort is focused.

Mr. TEAGUE. Bob, let me understand something: North American has this proposal, I assume other companies have proposals. What are the steps we go through to get this thing going?

Mr. FREITAG. This is not a North American proposal, per se; this is a plan worked out jointly by Marshall, by Houston, by all of the contractors who contribute parts. North American works on their parts, Grumman on their parts, and each of the other contractors, as well as a few potential new contractors, who are involved in some of the new equipment that's coming along, works on its parts.

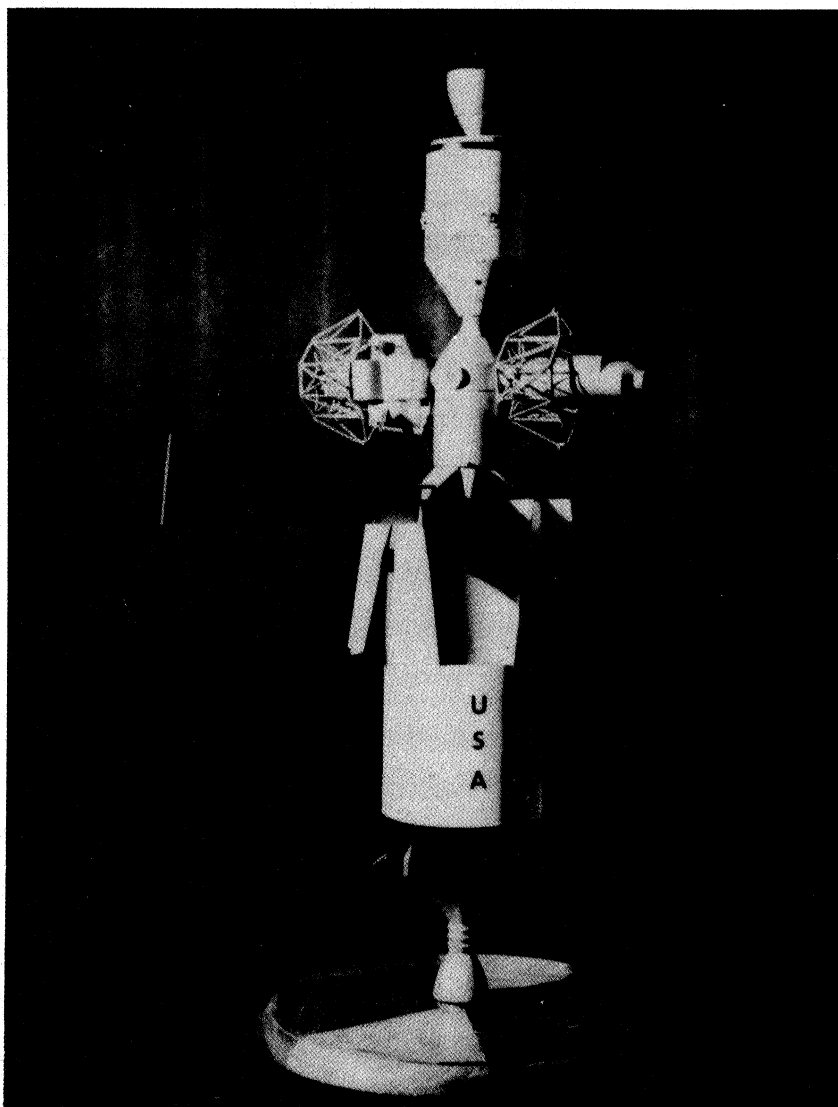
Mr. TEAGUE. Is this within the \$400 million?

Mr. FREITAG. This is within the \$400 million.

Mr. TEAGUE. And if you get the \$400 million, then you would assume you would go ahead with this kind of a program?

Mr. FREITAG. That's right. With last year's \$41 million we got started on the definition. That's what we're doing, we're defining the program. And we also got started on some of the design work, not fabrication and building, but design work on some of the key parts. For example, that air lock you see on the end of it, we have given a contract to McDonnell to start designing it because that's one of the real long leadtime items we talked about, and that's out of the \$41 million you authorized last year.

With the money we are asking for on the \$450 million, we do three major things: One is to provide additional launch vehicles and spacecraft modified to do this work; two, we buy lots of experiments that go inside of this spacecraft and on the spacecraft; and three, we start continuing to define the following year's work so we are always 1 year ahead on the definition part. There is always a possibility that, if the Apollo program goes very well beyond this point now, some of



SLIDE 58. ORBITAL WORKSHOP MODEL

the Saturn IB's that are remaining in the program could be used for this at an early date. So we are extremely anxious to get started with the design of the spacecraft now or during the current period so we can have the stuff ready to transfer to the available Saturn I-B's should they ever become available. Otherwise, the program is faced with the vehicles that are being bought with the \$450 million. This is a plan that's worked out by the entire manned space flight team with North American contributing its share of it. Tomorrow,

at Douglas, you will probably see a model just like that where Douglas is doing their share, and so on down the line.

Mr. GURNEY. Did that come out of this year's Apollo Application money?

Mr. FREITAG. Yes. The \$41 million of Apollo Application money that you authorized in the current year did several things. It bought long leadtime items for some of the vehicles and spacecraft; it defined this project which is what you are seeing now; it also paid for some long leadtime experiment definition and design and some of the design of the hardware.

Mr. GURNEY. Was this idea here the product of this year, last year, or the year before?

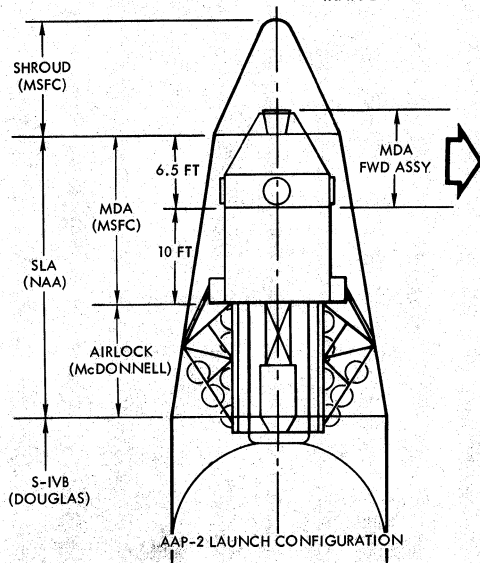
Mr. FREITAG. This idea is the product of the \$41 million that you authorized a year ago last July. We had ideas as far back as May. You may look in your testimony last year where you had a spent-stage experiment which was proposed originally by Douglas. For example, a modification of the MORL house study that was proposed a year ago at this time was picked up and the money put into it out of the \$41 million to really see what could be engineered. And you can see it is being engineered and now we are moving up, designwise, but not hardwarewise.

Mr. TEAGUE. Thank you, Bob.

Mr. TINNAN. Within this embryonic space station, the item called the multiple docking adapter is sort of the hub of the operation since it is the element to which all vehicles dock (slide 59). Fabrication and development of this new element has not yet been fully initiated.

MULTIPLE DOCKING ADAPTER

(NAA/S&ID APPROACH)

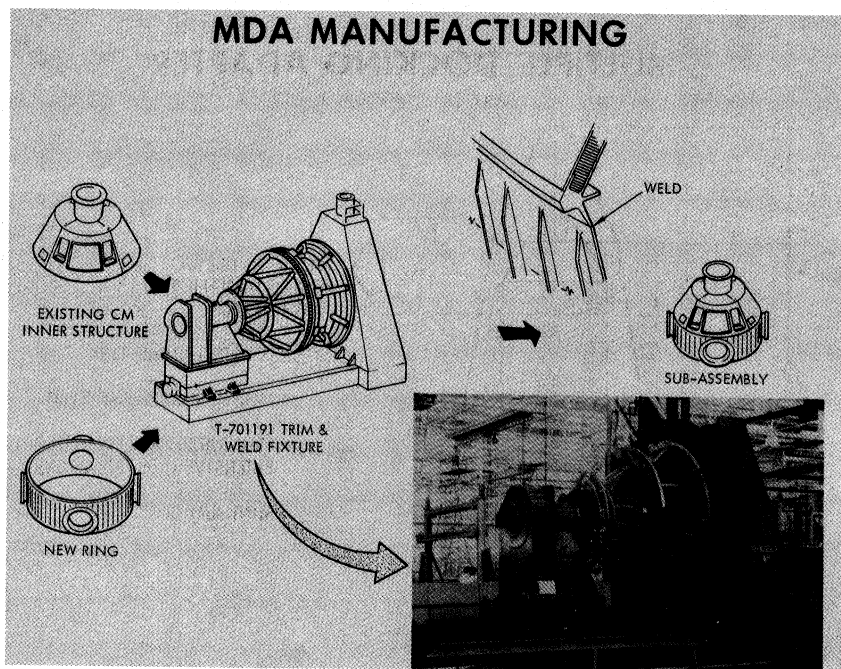


BASED ON USE OF
APOLLO QUALIFIED
HDWR DESIGN

- LOW TECHNICAL RISK
- MINIMUM SCHEDULE RISK
- MAN-RATED QUALITY WITHOUT
EXTENSIVE QUALIFICATIONS
- MINIMUM COST

SLIDE 59. MULTIPLE DOCKING ADAPTER—NAA/S. & I.D. APPROACH

We have recently delivered to the Marshall Space Flight Center a proposal (this is a part which is a North American proposal) for the front end of the multiple-docking adapter to be built by us using all Apollo-qualified hardware to preclude the necessity for expensive and time-consuming development. This proposal is based on taking the same hardware that we designed and have built many times for the Apollo spacecraft and shipping that to the Marshall Space Flight Center for subsequent assembly into the total module (slide 60). This activity would employ some of the existing facilities and the experience of our Apollo personnel. This proposal takes the existing command module inner pressure structure, combines it with a 37-inch-long cylindrical section, and places at four positions around its periphery the standard Apollo docking mechanism—adapter rings, probes, and drogues. The assembly operation would be performed on this existing weld device, which under the Apollo program took us one year to qualify, so it would make full use of a very expensive and very effective piece of machinery. Now, switching to another area I mentioned earlier, we have begun some investigations on our own related to applicability of Apollo ground support equipment, to possible other program needs like those of the Air Force MOL program (slide 61). The kinds of applications that have been examined fall into two basic categories: the use of existing surplus, and I'll qualify the surplus terminology in just a moment, surplus ground support equipment; and the category of using qualified ground support equipment designs and simply building identical copies of these. In the former category,



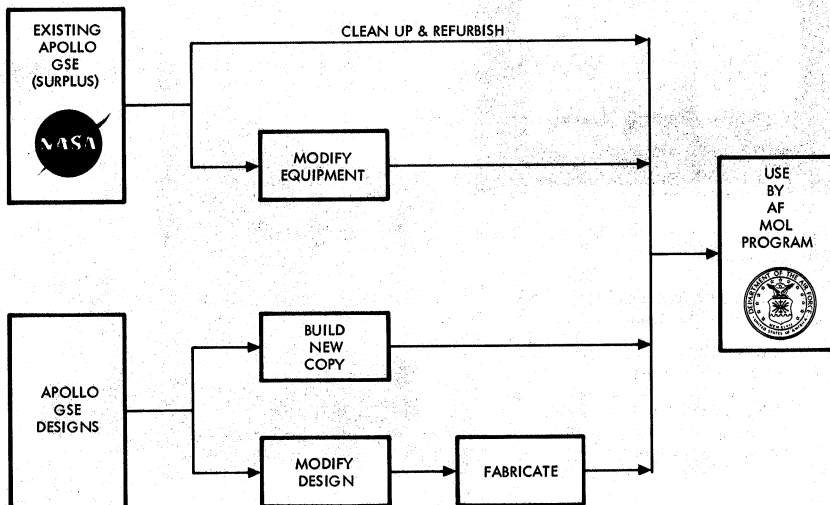
SLIDE 60. MDA MANUFACTURING

surplus does not mean it was an excess procurement. There were many pieces of ground support equipment that were built to support the early developmental phases of Apollo; for example, the propulsion system development that we accomplished at the White Sands Test Facility is now complete and we no longer have any need in the Apollo program for much of this equipment. That kind of equipment could be picked up, and with minor refurbishment, used elsewhere. In other cases where existing surplus items are not carbon copies of existing Apollo support equipment, designs could be fabricated, also saving considerable funds and time.

Touching very briefly on examples, there are items like these (slide 62). In the upper left-hand corner is shown an electrical power system test unit which is completely surplus and could be made available to any other U.S. program. In conjunction with NASA, we have begun discussions with the Air Force to determine their possible use of such equipment. Many hundreds of thousands and possibly millions of dollars are tied up in equipment that could be used elsewhere.

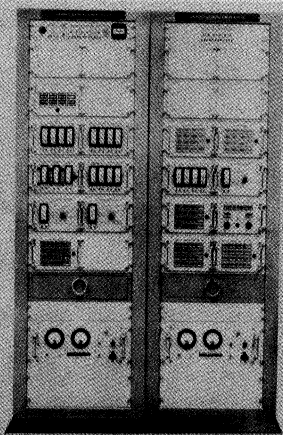
In the other category, the lower right-hand corner of this slide shows a picture of an Apollo reaction control system servicing unit (slide 63). This is the system which actually loads the oxidizer into the reaction controls of the Apollo spacecraft prior to launch. This hardware is not excess equipment; it is now down at the Cape required for servicing of all spacecraft. But our analysis indicates that a duplicate copy of that ground vehicle which has undergone extensive engineering and development could be built and used for the MOL program, since their needs for that kind of subsystem servicing are

APPLICABILITY OF APOLLO GROUND SUPPORT EQUIPMENT (GSE)



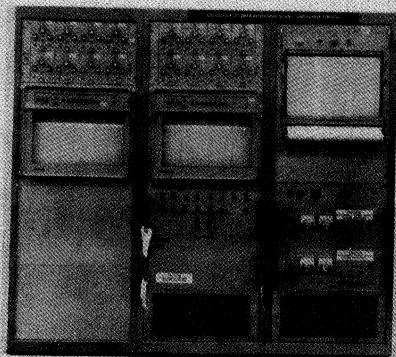
SLIDE 61. APPLICABILITY OF APOLLO GROUND SUPPORT EQUIPMENT

TYPICAL SURPLUS GSE



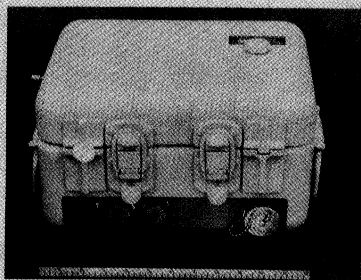
- MODEL C14-600
- ELECTRICAL POWER SYSTEM (EPS) TEST UNIT
- FUNCTION
PROVIDE ELECTRICAL STIMULUS & MONITORING
TO TEST EPS

- MODEL C14-020
- DATA RECORDING GROUP
- FUNCTION
SIGNAL CONDITIONING & DATA
RECORDING FOR SPACECRAFT TESTING



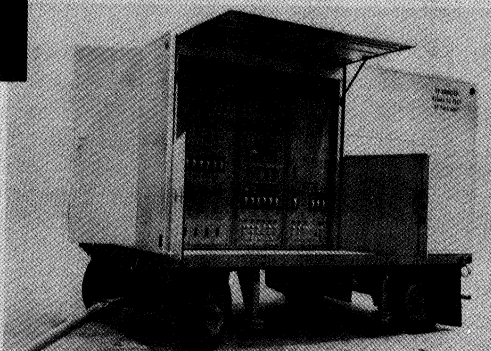
SLIDE 62. TYPICAL SURPLUS GSE

TYPICAL GSE DESIGN



- MODEL A14-139
- PYROTECHNIC INITIATOR SUBSTITUTE UNIT
- FUNCTION
PROVIDE IMPEDANCE & TIMING
SIMULATION FOR PYROTECHNIC DEVICES
DURING SPACECRAFT TESTS

- MODEL S14-057
- REACTION CONTROL SYSTEM (RCS)
OXIDIZER SERVICING UNIT
- FUNCTION
PROVIDES CONDITIONING OF
OXIDIZER FLUID & TRANSFERS
FLUID TO SPACECRAFT
PROVIDES PURGE & DRAIN
FUNCTIONS FOR RCS



SLIDE 63. TYPICAL GSE DESIGN

probably very similar, if not identical. So again, we suggest this as one way of saving money in the MOL program within the Air Force jurisdiction.

When I discussed the reuse of spacecraft in the orbital workshop, I mentioned that we could revisit and reuse the orbital element, the piece that was left in orbit. Another reuse possibility, that we have recently examined under contract to the NASA Manned Spacecraft Center, deals with the RCM, renovated command module, program (slide 64). Our studies have shown that renovation and reuse of the Apollo command module is very practical: it is technically feasible, and the accomplishment of such a program would not interfere with on-going lunar program commitments. I will show you in just a moment that the technique of flying a vehicle over again provides major economic advantages over buying another vehicle for a flight of an identical type. We have for the moment been somewhat conservative and have restricted ourselves to examining the accomplishment of a second flight in earth orbit only, as opposed to using a vehicle that's gone to the moon for a second lunar mission. The crew safety factors are much less difficult to satisfy if we restrict the second flight to earth orbital missions. Under this RCM program, the existing facilities and GSE would be fully applicable with only very insignificant modifications. Under this concept, we recover a command module in the normal fashion, bring it on board one of the recovery ships and, as I will describe a little later, perform some

RENOVATED COMMAND MODULE (RCM)

(NAS 9-6445 STUDY)

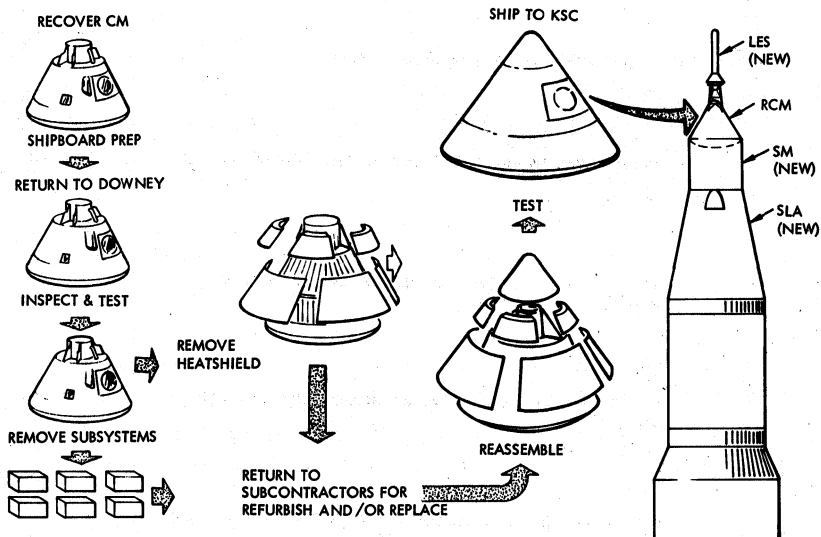
- RENOVATION & REUSE TECHNICALLY FEASIBLE
- RCM PROGRAM WOULD NOT INTERFERE WITH NORMAL APOLLO ACTIVITIES
- RCM PROVIDES MAJOR ECONOMIC ADVANTAGE OVER NEW VEHICLE
- ADAPTABLE TO AAP EARTH-ORBITAL MISSIONS (RCM OR RCM LAB)
- EXISTING FACILITIES & GSE SUITABLE WITH ONLY MINIMAL MOD

SLIDE 64. RENOVATED COMMAND MODULE—NAS9-5446 STUDY

preliminary postflight operations (slide 65). The vehicle would be returned to our facility here in Downey, where inspection and tests would begin with the recovered vehicle. Certain subsystems would be removed, the heat shield could 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 reshipped. The renovated command module 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.

There is one other version we have studied at NASA's direction in which we go through a similar process, but after we inspect the recovered vehicle, we remove the heat shield and subsystems. We would purge and store these subsystems and the heat shields for possible use as spares for later flights. The stripped-down inner vehicle minus the subsystems would be assembled with a new support rack and with an air lock that attaches to the side. This would provide what we call an RCML, renovated command module lab (slide 66), that could be carried in the adapter section on the same support mounts which carry the lunar module on a normal lunar mission. Once in orbit, the CSM, transposes and docks to the RCML. We would thus have another type of small space station that fits certain applications well, for example, operations at synchronous orbit altitude where payload becomes fairly critical.

RCM CONCEPT



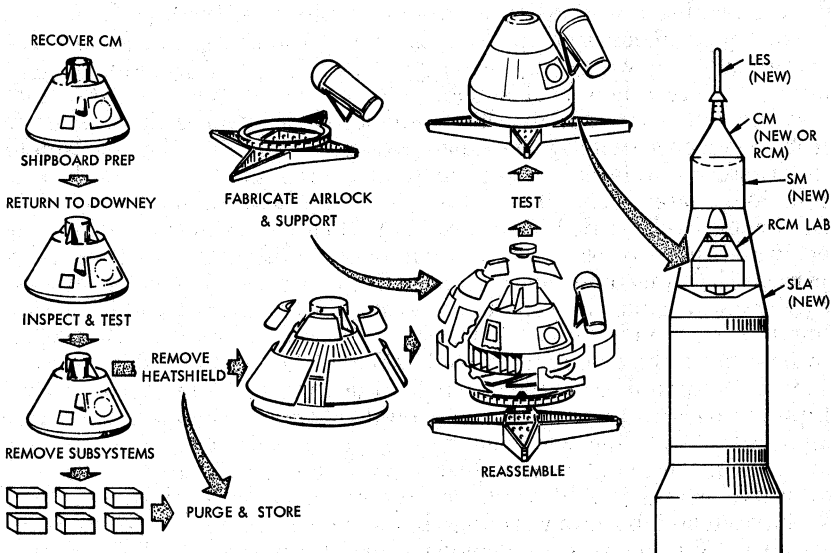
SLIDE 65. RCM CONCEPT

In the cost studies that we did under NASA ground rules, we have indicated that the cost of a new command module based on the cost model of Spacecraft 103, this is our third block II vehicle, is approximately \$25 million (slide 67). And then, in a very conservative vein, we have shown that over \$9 million could be saved by refurbishing it and flying it again instead of a brand new vehicle. I say very conservative because our flight experience so far has been limited to two unmanned spacecraft flights. So, much like a used car dealer, we have to be somewhat wary and plan or lay out the program costs for the worst case rather than the best case. We believe, however, that significantly greater savings than that which is reflected here would be possible.

In the case of the lab, the renovated command module lab approach, our analyses have indicated that for less than \$2 million per copy we could provide a laboratory which is based upon the use of a renovated command module.

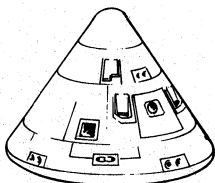
Our analyses have not been limited to paper studies. We have actually flown Spacecraft 009 and 011, as Mr. Myers has indicated to you. They have been returned to the factory and undergone extensive inspection and disassembly operations; so we have a reasonably good feel for what's involved. We found, for example, that the ablator that is used on the heat shield may be reused in some cases. You have a small specimen from Spacecraft 009; this is the specimen from Spacecraft 011. Both of these have been earth orbital flights, have reentered at velocities between 25,000 and 30,000 feet per second and at varying angles so that the heating rates would vary. But you

RCM LAB CONCEPT

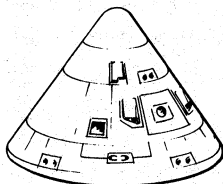


SLIDE 66. RCM LAB CONCEPT

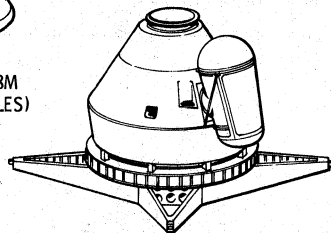
PRELIMINARY COST RELATIONSHIPS



- NEW CM = \$24.8M
(COST MODEL SC 103)



- REFURBISHED CM = \$15.8M
(AVG COST FOR 5 VEHICLES)

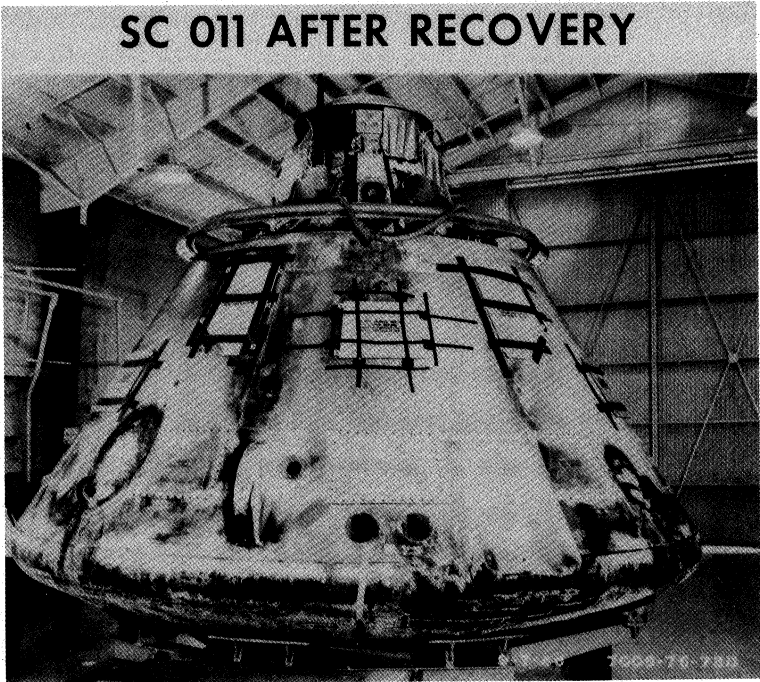


- DEPENDENT LAB = \$1.9M
(AVG COST FOR 6 VEHICLES)

NOTE: COSTS SHOWN DO NOT INCLUDE FDP
& DO NOT REFLECT SAVINGS FOR
RCM/RCML COMBINED PROGRAM

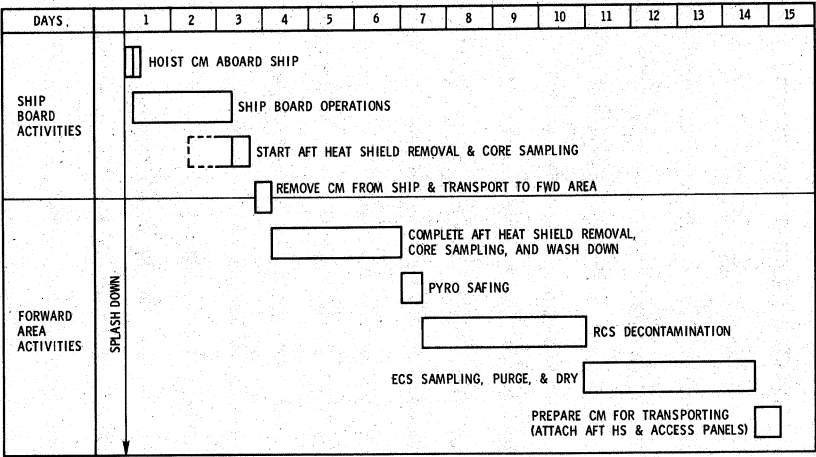
SLIDE 67. PRELIMINARY COST RELATIONSHIPS

will note, both on the one you have and the one I have in my hand, which shows even more severe charring, that we have used actually less than 30 percent of the total ablator. This charred area could simply be machined off and we could use the remainder. The total ablator has been designed for a lunar mission reentry at velocities in the order of 36,000 feet per second. So, if the first flight is an earth orbital mission, we simply machine this off, and fly again without having to buy a new heat shield. One of the problems we did find, however, when we brought these vehicles back into the plant was the problem of corrosion of the inner pressure vessel and the heat shield substructure (slide 68). The inner pressure vessel is obviously airtight and watertight. The outer shell, the heat shield, however, is not a completely sealed structure, and when the vehicle dips into the sea, water penetrates through various openings and into the cavity between the inner and outer vessels, and it begins a corrosion process which would make the vehicle unusable unless we take special action shortly after we pick it out of the sea. Our studies indicate that when we first hoist the command module aboard the recovery ship, certain operations should take place within the first few days prior to its shipment back to Downey, which would prevent corrosion from starting (slide 69). One would be to open up some ports to let the sea water drain out, and then to flush it with deionized water so that the sea water would not have any corrosive effect on exposed surfaces. We have done laboratory studies that show this action would be fully effective. We do have to provide some shipboard postflight equipment in order to provide this capability, or else the vehicle corrosion will begin.



SLIDE 68. SPACECRAFT 011 AFTER RECOVERY

**RECOVERY OPERATIONS
SCHEDULE**



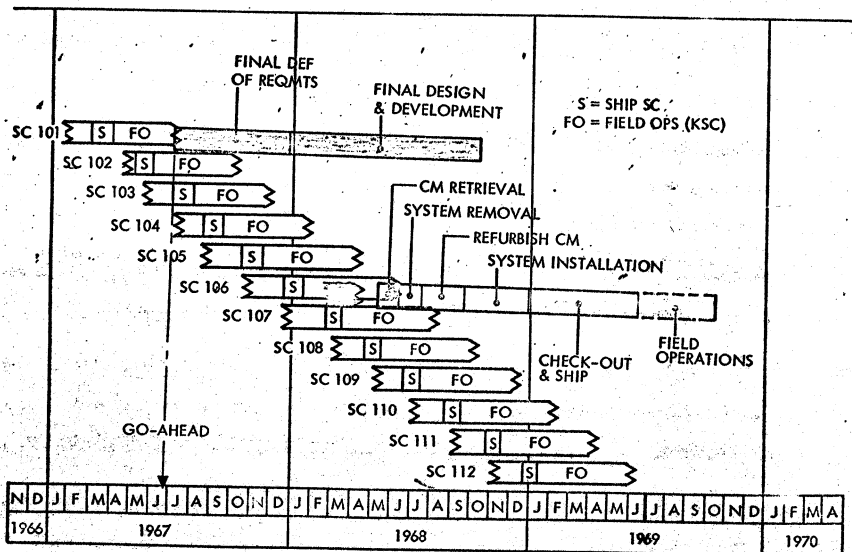
SLIDE 69. RECOVERY OPERATIONS SCHEDULE

What are the schedule aspects of this? The schedule indicated here is what we call Master Development Schedule 9, revision 3 (slide 70), which is currently being followed by Mr. Myers' Apollo program activity. The schedule shows the delivery—the "S" means ship—to the Cape of the 12 Block II spacecraft for which we have a firm

We have separately, under the renovated command module study, laid out some of the steps that are involved in order to provide for the renovation capability (slide 70). Some engineering and development work must be accomplished to provide the shipboard ground support equipment prior to flight. And we have indicated here the flight of a vehicle that we will try to renovate by this mark, and then, of course, after recovery of the flight we retrieve the command module, remove the systems, refurbish, and check them out, and ship the vehicle back to the Cape for subsequent operations. A conclusion that has come out of our analyses is shown by an overlay of slide 70. If a contract for a renovated command module program were awarded on July 1, 1967, as indicated here, which is the beginning of fiscal year 1968, then the first spacecraft we could renovate satisfactorily is Spacecraft 105. The first four block II spacecraft will not have had sufficient provisions made in advance of their flights. If we could advance the contract start date to April 1, we could move this effectively back to cover one additional spacecraft. The point is that the program must be initiated early or the spacecraft will simply have been dumped into the ocean, in the nominal recovery mode, and will not be satisfactory for reuse due to the sea water corrosion problem.

APOLLO SCHEDULE

(MDS 9, REV 3)



SLIDE 70. APOLLO SCHEDULE—MDS 9, REVISION 3

Though the nominal recovery mode for Apollo is water recovery as indicated here (slide 71), safe landing can be accomplished either on water or on land. I will show you the effects of what happens, what the extreme variations would be. But normal recovery is, as in the case of the Mercury and Gemini programs, in the water, with recovery by Navy forces. At the direction of the NASA we have carried out analyses and design studies pertaining to advanced landing systems (slide 72). We prefer this terminology, though it is often referred to as the land-landing system, since the latter is somewhat confusing because Apollo does possess a land-landing capability. With an advanced landing system—which would include steerable gliding chutes instead of the conventional parachutes, coupled with an attenuation device like landing retrorockets—we could have greater mission flexibility and choice of landing areas. We would not have to land in the ocean. Instead, we could recover, for example, at Edwards Air Force Base or other recovery areas on land within the continental United States. In so doing, we could minimize the cost of the recovery force and retain only that which is necessary for emergencies—for example, when a quick abort from orbit would require us to come down into the sea. With the land landings, we could significantly enhance the reusability of the Apollo command module.

The last, but most significant point, is that the incorporation of the advanced landing system will permit us to carry three more men in the Apollo command module. That's where the economy of operation would come in. If we can carry six men to a space station, instead of three, then the cost of transporting each man is cut in half.

APOLLO RECOVERY MODE

HEAT SHIELD
JETTISONED
AT 24,000 FEET

DROGUE CHUTES RELEASED & PILOT
CHUTES DEPLOYED AT 10,000 FEET

AFTER 1.6-SEC
TIME DELAY
DROGUE CHUTES
DEPLOYED REEFED 8 SEC

MAIN CHUTES EXTRACTED
& DEPLOYED TO A REEFED
CONDITION AT APPROX
10,000 FT

MAIN CHUTES FULLY
OPENED AFTER BEING
REEFED FOR 8 SEC

MAIN CHUTES RELEASED AT IMPACT

SLIDE 71. APOLLO RECOVERY MODE

ADVANCED LANDING SYSTEM

(GLIDING STEERABLE CHUTES + LANDING RETRO-ROCKETS)

- PROVIDES GREATER FLEXIBILITY IN CHOICE OF LANDING AREA
- MINIMIZES SIZE & COST OF RECOVERY FORCE-- ONLY EMERGENCY CAPABILITY REQD
- ENHANCES REUSABILITY OF APOLLO COMMAND MODULE
- PERMITS INCREASE OF CREW COMPLEMENT (TO 6) IN APOLLO CM

SLIDE 72. ADVANCED LANDING SYSTEM—GUIDING STEERABLE CHUTES PLUS LANDING RETRO-ROCKETS

Reuse and the ability to carry twice as many men will result in major economies.

A number of different glide chutes are being evaluated at present (slide 73).

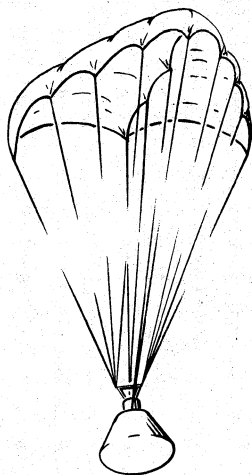
This parawing is one that's under study by the Langley Research Center of NASA. It is a triangular form device that resulted from the earlier Rogallo paraglider concept; it is a limp, noninflatable paraglider.

Another concept called the Barish sailing is under development and flight test by the Manned Spacecraft Center. I have here a model of another chute with a scaled version of the Apollo (slide 74). This is the slotted circular wing devised by North American engineers. It can operate in a pure parachute mode or operate in a lifting mode. I won't try to glide the model here, but it does work quite well. A reasonable choice of landing area is possible with any of these types of gliding chutes. More important, they allow you to avoid obstacles in the landing area which can upset and therefore possibly damage the vehicle or injure the crew.

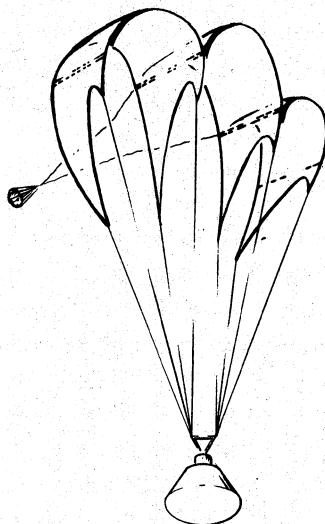
In the standard Block II Apollo command module, three astronauts are lying abreast as indicated there (slide 75). In orbit and pre-impact, this triple couch is at this upper position. In the worst water-landing case—now, this would mean one of the three chutes

GLIDE SYSTEM CANDIDATES

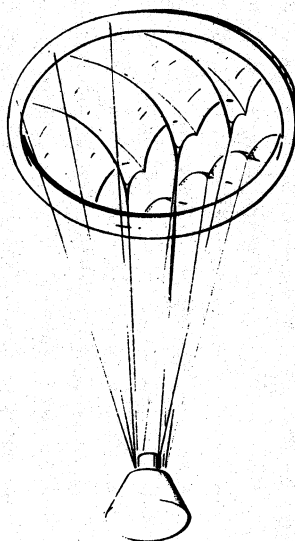
PARAWING (LRC)



SAILWING (MSC)



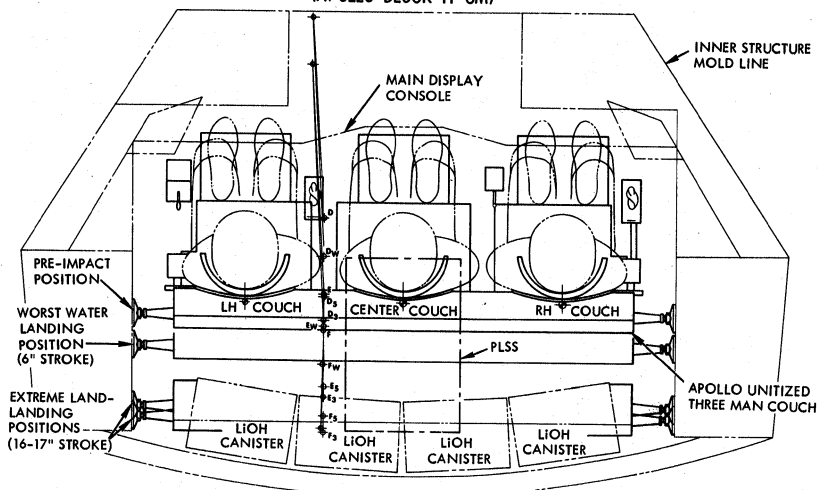
SLIDE 73. GLIDE SYSTEM CANDIDATES



SLIDE 74. SLOTTED CIRCULAR PARAWING—S & ID DEVELOPMENT

CREW COUCH ATTENUATION

(APOLLO BLOCK II CM)



SLIDE 75. CREW COUCH ATTENUATION—APOLLO BLOCK II COMMAND MODULE

had failed—this couch (which is supported on shock struts, which are much like the shock absorbers in your automobile only they have a longer stroke) moves down to this position, a distance of about 6 inches, it's just like a shock absorber. In the case of an extreme land-landing case, which would represent an emergency of off-nominal mode for the Apollo, the hydraulic shock struts would allow the couch to come down to the position indicated, a travel of about 16 inches instead of 6 inches, and again act like a shock absorber in an automobile. However, in order to provide the land-landing capability with this type of attenuation system, we have to reserve the space underneath the couches; we cannot put anything there because the seat has to have the ability to go down and not be blocked by equipment.

A side view of this indicates the various seat positions (slide 76). However, with a gliding chute and with small landing retrorockets that will fire about 20 feet above the ground to cushion the vehicle, instead of hitting the ground at 20 to 30 miles per hour, it will touch down at a very few feet per second. Therefore, the seats would not need the stroke and we would not have to reserve the space under the present triple-couch system. With the advanced landing system, then, we could install another triple couch and carry six people (slide 77). All that has to be done is to change the couch mounting system, and add the new landing system with glide chutes and retrorockets.

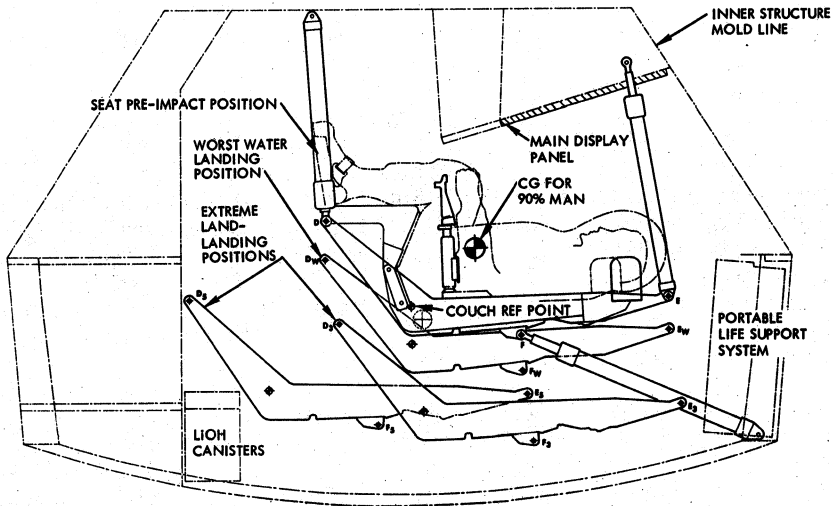
Mr. CABELL. Can you stand that extra weight?

Mr. TINNAN. Yes, sir.

I mentioned earlier that one of the unique features of the early AAP flights entails the use of Apollo-Saturn vehicles, not required for the lunar program, for alternate applications by simply adding low-cost modification kits. When we begin, however, to consider the logistics vehicle, we believe that the mod kit approach, the idea of modifying many systems at the Cape rather than in the factory prior

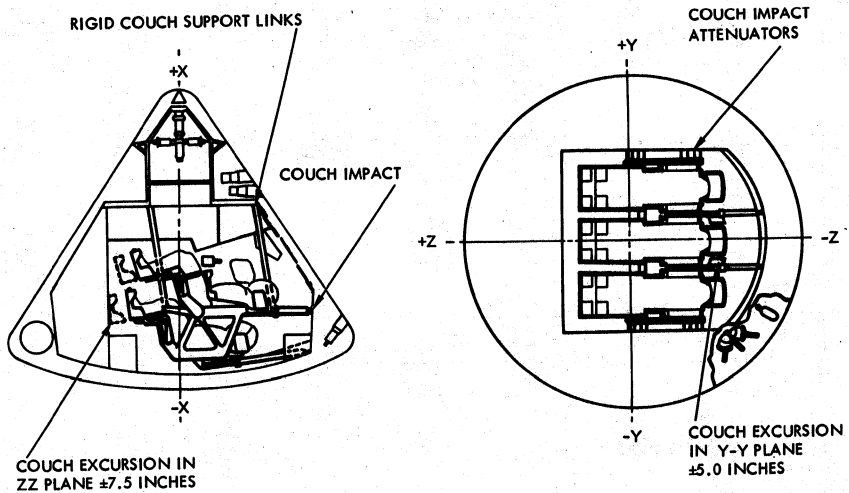
CREW COUCH ATTENUATION

(APOLLO BLOCK II CM)



SLIDE 76. CREW COUCH ATTENUATION—APOLLO BLOCK II COMMAND MODULE

6-MAN CREW MODULE



SLIDE 77. SIX-MAN CREW MODULE

to checkout and shipment, seems to become impractical and excessively costly. In spite of the fact that our so-called Block III logistics vehicle has not yet been fully defined, some of the possible subsystems additions and deletions being considered now are itemized here (slide 78). We would, for example, have to take out the three-man couch and replace it with a six-man couch. Certainly, that modification could be done at the Cape. We could add the advanced landing system and take out the regular Block II recovery system; we could take out the fuel cells and put in a simpler battery system, for electrical power, that is suitable for the logistics function; we could take out some of the propellant tanks and make any of the other modifications that I have indicated here. The point is, however, that there appears to be, within the logistics vehicle version of the command and service modules, a large number of complex subsystem changes. Any one of these could be done off site, but it seems to us to be more costly and more complex to do it in that way. Rather, we would recommend instead a Block II lunar mission vehicle shipment, the AAP Block III logistics vehicle shipped from Downey. In this way, all the changes and all the associated facilities, equipment, and supply problems at the Cape can be avoided. We think significant dollar savings can be realized and the impact on normal operations can be avoided.

Let us go back again to schedule considerations, and assume we were to start in the middle of the calendar year 1967—which is the start of the Government fiscal year 1968—with a final definition study

POTENTIAL SUBSYSTEM CHANGES

(FROM BLOCK II TO "BLOCK III" LOGISTICS VEHICLE)

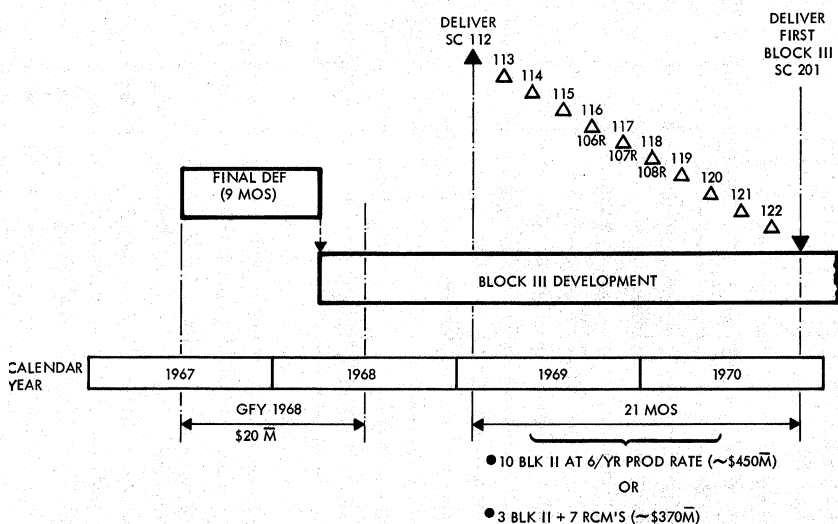
SUBSYSTEM	ADD	DELETE
CREW SYSTEMS	6-MAN COUCHES (OPTIONAL)	CM FOOD STORAGE
EARTH RECOVERY	LAND LANDING (GLIDE CHUTE & LDG RETRO-ROCKETS) • OPTIONAL-3 MEN • REQD-6 MEN	3 RINGSAIL PARACHUTES (IF LAND LDG ADDED)
GUIDANCE & CONTROL		✓ (OPTIONAL)
ELECTRICAL POWER (EPS)	BATTERIES	• FUEL CELLS • EPS RADIATORS
CRYO STORAGE		✓
ENVIRON CONTROL	• WATER SUPPLY • GO ₂ STORAGE	PARTIAL LIQH STORAGE
PROPULSION (SPS)	• SOLID MOTOR DE-ORBIT SYSTEM • SPS TANK GAGING • SPS HEATERS	• 2 SPS PROPELLANT TANKS OR • 4 TANKS (ADD 2 SMALL TANKS)
REACTION CONTROLS (RCS)	• BIGGER RCS PROPELLANT TANKS • RCS TANK GAGING • METAL BELLOWS TANK	ALL TANKS ON SM RCS QUADS
COMM/DATA SYSTEM		• TV • S-BAND (DEEP SPACE) ITEMS
STRUCTURE	• CARGO SUPPORTS IN SM • REMOVABLE SM SECTOR COVERS	

SLIDE 78. POTENTIAL SUBSYSTEM CHANGES—FROM BLOCK II TO
"BLOCK III" LOGISTICS VEHICLE

of the Block III logistics vehicle. In the 9-month final-definition phase, all the necessary engineering would be accomplished, allowing us to produce and test the vehicle and ready it for shipment. Based on the time phasing which would be indicated by our Apollo experience, and assuming go-ahead on July 1, 1967, we could not deliver our first Block III vehicle, arbitrarily titled here as Spacecraft 201, until the end of 1970 (slide 79). For reference, Spacecraft 112, the last spacecraft that Mr. Myers' present CSM contract will deliver, will be shipped to KSC at the beginning of 1969. This would result in a lapse of 21 months without production activity in the Apollo industrial facilities here at Downey and elsewhere throughout the country. In order to maintain the present production capability at six spacecraft per year or one every 2 months, production of 10 additional spacecraft would fill the gap. Incidentally, Spacecraft 113, 114, and 115 are now the subject of discussions and negotiations with NASA. Behind those, seven additional Block II spacecraft could be procured to fill the gap. An alternate approach would entail procurement of only three new vehicles—113, 114 and 115—and the simultaneous implementation of the renovated command module program. Then, we could recover the Block II spacecraft, refurbish them, and put them back in flight service. In this way, we could fly 106-R instead of 116—"R" meaning Spacecraft 106 renovated—107-R, then 108-R, et cetera. With this approach—using three new Block II's plus seven renovated command modules—an estimated cost saving in excess of \$80 million during that period of time could be realized.

I'd like to show next one part of North American's fiscal 1968 cost requirements to implement our portion of the NASA AAP program

BLOCK II/III SCHEDULE INTERACTION



SLIDE 79. BLOCK II/III SCHEDULE INTEGRATION

(slide 80). The three categories shown here relate to activities that I have previously touched on. Only NASA-approved or NASA-planned activities are included. The cost of Block II mod kits is approximated at \$8 million for fiscal year 1968. For the renovated command module program, including 5 months of definition and 7 months of actual hardware activities related to one spacecraft, a total of \$19 million is estimated. To begin the Block III program, which would produce our first operational flight article in late 1970, \$20 million, including \$13 million for the 9 months of final definition, would be required. This would yield a composite of \$47 million as fiscal year 1968 requirements for NASA's AAP development efforts. This does not include production vehicle costs that would occur in this year. Mr. Carroll will touch on those in a few moments.

In summary then (slide 81), I have touched on the four basic categories within the scope of the AAP program as we have defined it. In the first of these, we believe that significant space accomplishments can be realized at relatively low cost, providing 1968-69 flights of the lunar mapping survey system, the orbital workshop, and so forth, using Apollo vehicles which are not required for the lunar-landing program with appropriate mod kits. The 1968-69 date is only for planning purposes; it cannot be stated as a firm situation since we don't actually know when vehicles will be available from the lunar program.

The application of Apollo hardware designs to other uses, both within NASA and Department of Defense programs, offers minimum risk, cost, and schedule solutions to a number of current needs. This

S&ID AAP GFY 68 COSTS *

	BUDGETARY & PLANNING COST ESTIMATES
BLOCK II MOD KITS	\$8M
REN OV COMMAND MODULE • 5 MO FINAL DEF • 7 MO DEV (SC 105)	(4) 19 (15)
BLOCK III PROGRAM • 9 MO FINAL DEFINITION • 3 MO DEVELOPMENT	(13) 20 (7)
TOTAL	\$47M

*NOTE:

- (1) BASED ON 1 JUL 67 CONTRACT AWARD
- (2) DOES NOT INCL SUPPLEMENTAL BLOCK II PRODUCTION
- (3) DOES NOT INCL S-II COSTS

SLIDE 80. S. & I.D. AAP GFY 1968 Costs

SUMMARY

- SIGNIFICANT SPACE ACCOMPLISHMENTS POSSIBLE AT RELATIVELY LOW COST VIA 1968-69 AAP FLIGHTS--USING APOLLO VEHICLES NOT REQD FOR LUNAR LANDING PROGRAM WITH MOD KITS
- APPLICATION OF APOLLO-QUALIFIED HDWE DESIGNS TO OTHER USES OFFERS MINIMUM RISK/COST/SCHED SOLUTIONS
 - MULTIPLE DOCKING ADAPTER FOR ORBITAL WORKSHOP
 - GROUND SUPPORT EQUIPMENT FOR AF MOL PROGRAM
- USE OF RENOVATED COMMAND MODULES PERMITS SAVINGS OF APPROX \$10 MILLION PER FLIGHT--BUT PROGRAM NEEDS TO BE STARTED NOW
- MOD KIT APPROACH FOR LOGISTICS VEHICLE APPLICATION OF CSM CONSIDERED MORE COMPLEX & COSTLY THAN USE OF "BLOCK III" APPROACH
 - SYSTEM DEFINITION STILL REQD
 - SYSTEM AVAILABLE LATE 1970 WITH 1 JUL 67 PROGRAM START

SLIDE 81. AAP SUMMARY

pertains to the multiple-docking adapter for the orbital workshop, for example.

The use of the renovated command modules, as opposed to the use of totally new vehicles, the third aspect, we think will result in eventual savings in excess of \$10 million per flight. We have to be conservative at this point, but we think this cost saving can be even greater. But, in order to accomplish this, we need to start the program now or many of the spacecraft will just normally land in the ocean and the corrosion process will begin, which then preempts this reuse possibility.

The last point that I have covered relates to the CSM mod kit concept approach. This makes a lot of sense in early flights, but is a very costly and complex way to go for the logistics vehicle. We strongly urge that the system definition of a Block III vehicle be initiated now if we are to provide flight vehicles at a reasonably early date.

Mr. TEAGUE. Thank you, sir.

Mr. FREITAG. Mr. Chairman, Len's comments about the refurbished command modules are very valid. I think, for the new members of the committee, it's significant to note that in Gemini we have done this already. One of the major contributions of the NASA program to the Air Force MOL program was that we took the Gemini II space-

craft, turned it over to the Air Force, allowed them to modify it and refurbish and modify it, just as Len described, and it was done and flown—has been flown twice. And it took less than 50 percent of the original cost of the Gemini to refurbish it and modify it with a new heat shield; it was a very successful program. So the feasibility of what he described has been demonstrated by actual flight.

Mr. TEAGUE. Bob, his proposal on schedule, how realistic is that?

Mr. FREITAG. We consider it quite realistic, and it's within the framework of the overall AAP plan.

Mr. TEAGUE. If you get your money by July, you'll be lucky. Do you have to have money?

Mr. FREITAG. Well, that's going to be a tough proposition because this is a new program and requires new authority. Continuing authority from our previous program doesn't apply.

Mr. TEAGUE. You can't possibly know how much money you are going to get.

Mr. FREITAG. That's right. This is a difficult problem. It's unlike an annually funded program that's previously authorized. This means new authority as well as new money.

Mr. TEAGUE. I think it will be real tough to expect it by July.

Mr. FREITAG. He is pointing out our savings by July can't accomplish it. The same thing Boeing pointed out on the long-leadtime items that follow on the Saturn V vehicle. Figuring it to that date is the best planning date we can operate under. We can't figure earlier. Anything we take after that date is lost.

Mr. WINN. I'd like to ask a question of Len: On the reuse idea, it seems, and I don't know the cost, of course, but it would be pretty expensive to take the craft and dismantle it, and send it clear back to its original subcontractor. Would not a smaller version on an overall base at Kennedy or Houston save a lot of transportation?

Mr. TINNAN. Yes. Actually, the transportation cost has turned out to be a relatively small percentage of the total program cost. The refurbishment center could be set up in Florida just as well as here or elsewhere. The new pieces would still come out of Downey, like the new service module that has to fly with it. Keeping it in Florida, however, would mean that the checkout which is normally done with a mated command module and a service module would then be done there rather than in our building 290 checkout facility here.

Mr. WINN. Yes, but you are talking about your part of it only. I'm talking about the overall deal.

Mr. TINNAN. Yes.

Mr. GURNEY. Your discussion of Apollo Applications seems to me to be a NASA-generated idea; is that correct?

Mr. TINNAN. NASA is the customer, but I think the ideas reflect interests of a lot of organizations like our own.

Mr. GURNEY. Does North American have any ideas of its own of what Apollo Applications ought to be?

Mr. TINNAN. NASA's Apollo Applications program?

Mr. GURNEY. Well, the space program of this Nation, not confining it to NASA. I mean just the Nation's space program. Do you have any ideas of your own?

Mr. TINNAN. I tried to touch on a few examples of these. One is the Block III approach, which I don't think is a real NASA position at the moment. We are in discussions with them on this. We have had several studies underway, both under contract as well as our own, which lead to later lunar exploration activities that are based upon Apollo-derived hardware; I did not try to delve into this in this briefing.

Mr. GURNEY. I wonder, Mr. Chairman, if we could have those for the record?

Mr. TEAGUE. Ed, our oversight committee wrote North American and asked them to tell us every item they had on post-Apollo, and we do have a very complete document spelling out not only North American, but all of them on this thing. I think it goes much further than what you have gone into.

Mr. TINNAN. Yes, sir. When Mr. Wilson was here this past summer, I think we ran clear through the manned planetary activities that we would suggest.

Mr. TEAGUE. Yes, it's very complete.

Mr. CABELL. Mr. Tinnan, this post-Apollo appears to be a composite of collaborative efforts. Are any of your original ideas incorporated in this comprehensive program? I think what Mr. Gurney was getting at is: How much originality?

Mr. TINNAN. I think we could, in many of the design features incorporated here, stand up and take credit for North American innovation as opposed to being simply responsive to the NASA. I think it's been a complete cooperative collaborative effort.

Mr. STORMS. Len, you might point out on that model over there the portion that you are proposing that NASA has not agreed with you on or picked up.

Mr. TINNAN. Yes.

Mr. STORMS. That portion in here.

Mr. TINNAN. This center portion, which is called the multiple docking adapter, is a North American innovation. Not the idea of a multiple docking adapter, but the specific design that we think could provide a minimum cost and schedule solution. We are talking specifically about providing the top or forward part of that based on the use of Apollo hardware. So we are trying to take the benefit of the experience and the dollars that have been invested in the Apollo program. The proposal now rests with the Marshall Space Flight Center.

Mr. FREITAG. May I comment very briefly, Mr. Chairman, on this point: NASA does the synthesis of ideas, but we are using ideas that are not only from the Apollo family, but from all other contractors. For example, the Apollo telescope mount—there were at least six separate proposals for how to do this—one using the lens as we have it. Homer Newell, in the Office of Space Sciences, their astronomer, had two or three other proposals; other contractors had other proposals. And in that particular case, we brought together everyone who wanted to contribute, who had an idea, and ended up using this as the most effective means. We actually ended with a synthesis of some OART on controlled-movement gyro work they had, plus the LM, plus some of OSSA's astronomy and telescopes, and it was a combination. There

are contractors who are new to the operation. For example, we have two contracts, one with the Martin Co., and one with the Lockheed Co., which studied the very questions Mr. Winn brought up. For example: Is it better to do it with one contractor who has an extension of a program, like North American, or to do it in a modification center where several contractors can work into the program. This is a part of the definition program supported with the \$41 million to define the best way of doing it. And during the hearings of the Manned Space Flight Subcommittee, we will report on all of these, how they work in detail.

Mr. GURNEY. My question was not to indicate that NASA's ideas were not good. I mean I was just curious, since we're here at North American, what ideas are we talking about? There's not much use in the subcommittee coming out if we don't ask questions.

Mr. TEAGUE. Ed, we had a bunch of proposals. At Douglas, we had a bunch of proposals last time. It's obvious from seeing this that all of you have been working together.

Mr. TINNAN. I think we're all working together on the same basic project applications.

Mr. TEAGUE. Even in the Senate's Budget Committee, they definitely came out with generally the same thing.

Mr. TINNAN. The point we make here, just as we suggest that the multiple docking adapter be built out of parts of the Apollo command module, this item (on the model) uses the LM ascent stage and the same rack which is used to support the lunar mapping and survey system payload module. There is commonality of modules, so we don't have to redesign and qualify a new piece for every use. The Marshall Space Flight Center builds this; another associate builds this; Grumman builds this. So we're all involved in the process.

Mr. CARROLL. Mr. Chairman, recognizing the time situation, let's quickly go through the material we have in summary. There are several charts I'd like the opportunity to include in the record rather than take the time during the session here.

Quickly, in summary, I'd like to review for you a little of the manpower status, the facility status, the Government fiscal year 1968 funding requirements, and a list of time-phased critical events, in order to refresh your minds (slide 82).

You may recall during this past year, we were asked, when Mr. Wilson was out here, to present not merely an S. & I.D. level of participation in the Apollo program, but that of the corporation. This gives you some idea of the total North American personnel participating in the program (slide 83).

The two lines on the chart represent the fact that, at the time we made our forecast a year ago, we were forecasting manpower drop as shown by the dotted line. Based on a concerted effort by the corporation, we have actually been able to achieve a manpower savings, and we are now at the beginning of the solid line, and here is the current forecast for the total North American work force on the Apollo program.

In this next chart we have S. & I.D.-only manpower status and forecast (slide 84). It shows that approximately 33,000 personnel are now in the division, and the vast majority of those are working on

SUMMARY

RESOURCES

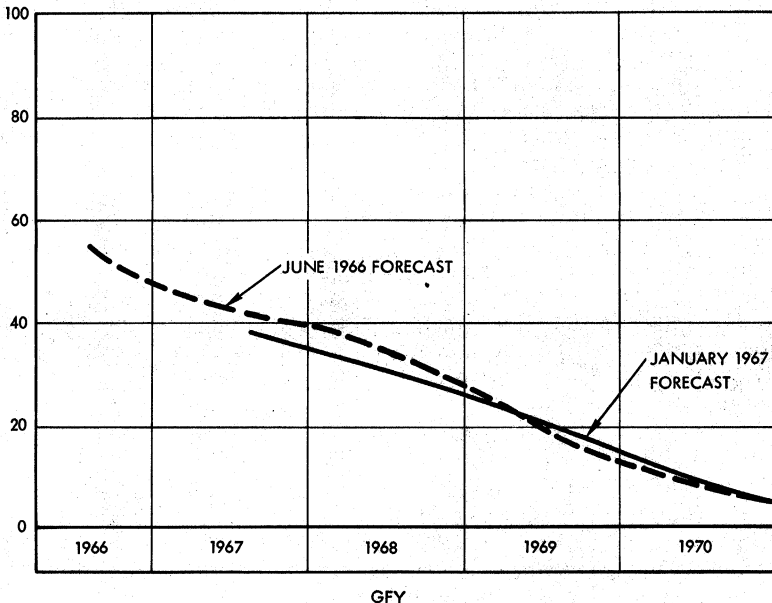
- MANPOWER - PRESENT AND PLANNED UTILIZATION
- FACILITIES - PRESENT AND FORECAST UTILIZATION
- FUNDING - S&ID FOLLOW-ON GFY 1968 REQUIREMENTS

S&ID FOLLOW-ON CRITICAL EVENTS

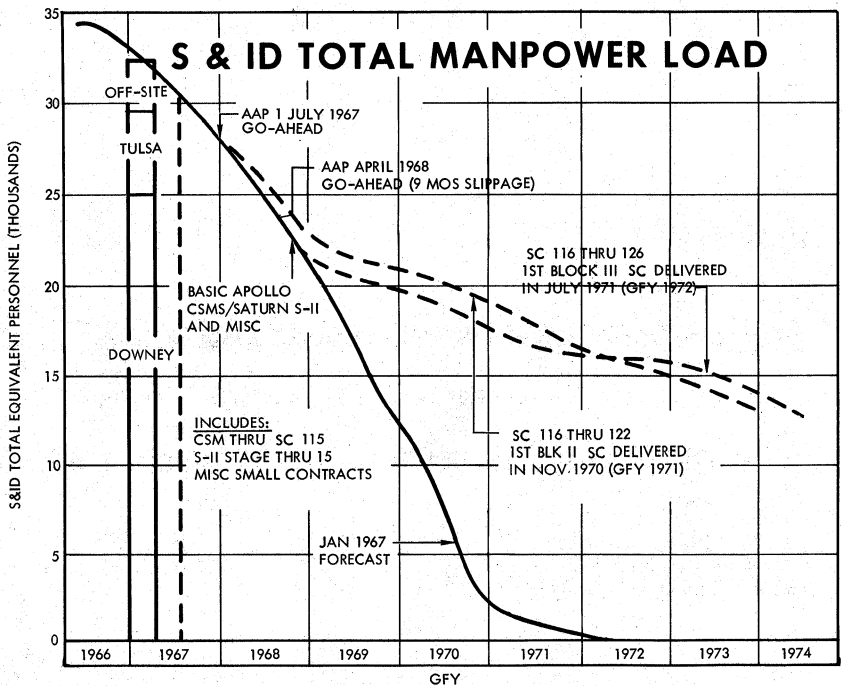
SLIDE 82. SUMMARY

NAA APOLLO PROGRAM TOTAL MANPOWER LOAD

MANPOWER (THOUSANDS)



SLIDE 83. NAA APOLLO PROGRAM TOTAL MANPOWER LOAD



SLIDE 84. S. & I.D. TOTAL MANPOWER LOAD

the Apollo program. In the event that NASA were to be able to obtain Government fiscal year 1968 funding to permit an AAP go-ahead by July 1, as Mr. Tinnan talked about, the S. & I.D. manpower forecast would then follow the dotted line across the chart. It should be noted that July 1 go-ahead also involves funding for additional Block II spacecraft to fill the gap that he showed between the current deliveries of Spacecraft 112, 113, 114, and 115, which would go out into the middle of calendar year 1969 and the beginning of Block III production and deliveries. To prevent this gap in the CSM production line, seven additional basic spacecraft would be required.

In the event that we were to slip from a July 1 go-ahead to an April 1 go-ahead, the lower dotted line represents the manpower forecast at S. & I.D. The time phasing would result in a 9-month slip in availability of Block III spacecraft, and it would require going through Spacecraft 126 in the Block II, rather than Spacecraft 122, again to fill in the line to keep it in being and to permit economical production of the Block III's without a down time and a restart time. In the event that we went to the renovated command module program, we would still need Spacecraft 116 through 118, plus seven renovated command modules.

This chart depicts the manpower load you would have on that program (slide 85). Here, again, this chart is based on a July 1, 1967, go-ahead and an April 1, 1968, go-ahead. In the event that April 1 of next year turns out to be the case, you can see that the manpower difference is less than on the programs involving all new spacecraft.

However, at the same time, you do have a little sharper buildup in the Government fiscal year 1972-73 time period.

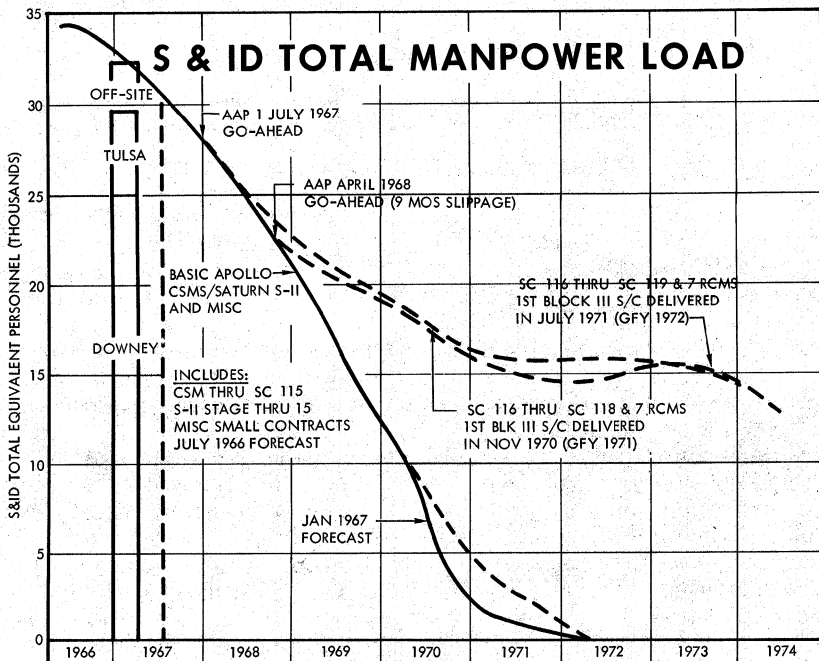
Mr. TINNAN. That's if the renovated command module program started on 1 July.

Mr. CARROLL. That's correct. The facilities material, I think, we will cover in the record.

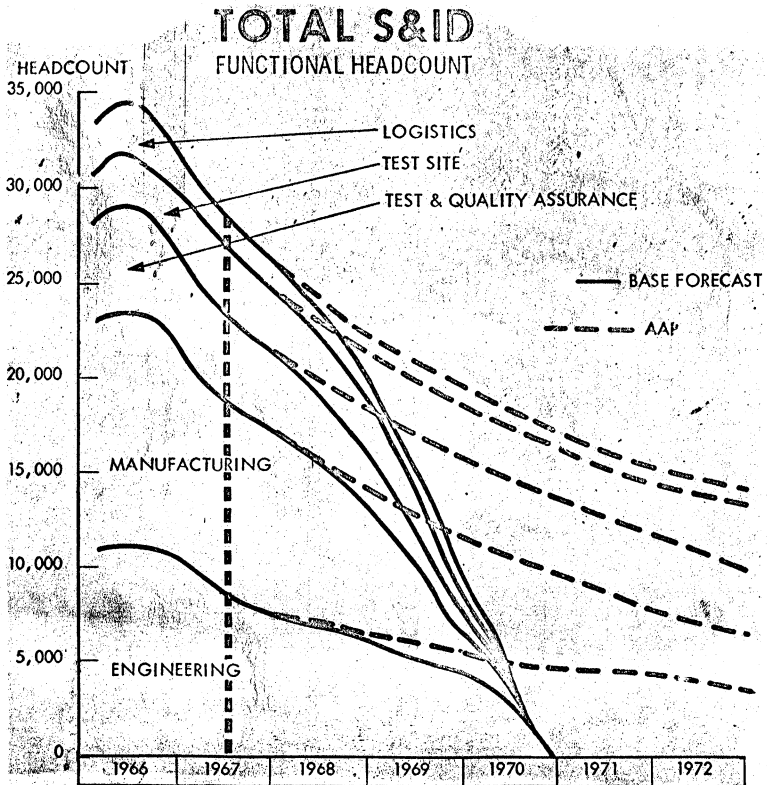
We are now depicting headcount by major function as opposed to equivalent personnel shown on the previous charts (slide 86). As you can see, the trend follows closely that established on the prior charts, and, even with a July 1 go-ahead on AP, overall headcount at S. & I.D. will continue to decrease, but at a lower rate.

Shifting then to our next major resource, that of facilities, slide 87 indicates the major space manufacturing and research facilities in use by North American Aviation. These total about \$514 million, representing a very sizable capability, and include both Government-furnished and NAA funded facilities. This chart is basically the same as that shown to Mr. Wilson during the oversight briefing in July 1966.

The next several charts show the phasing from our present contracts for CSM and the S-II into the AAP program. In slide 88, we take the primary CSM unique facilities, show how they will phase out of the present program in percentage of utilization, and show the effect of Spacecraft 113 through 115 to utilize these facilities based



SLIDE 85. S. & I.D. TOTAL MANPOWER LOAD



SLIDE 86. TOTAL S. & I.D. FUNCTIONAL HEADCOUNT

on a February 15, 1967, go-ahead. The next space beyond the dotted area for Spacecraft 113 through 115 shows how Spacecraft 116 through 122 would phase in and out to keep the production line going on manufacture of basic spacecraft prior to the Block III production operation. As you can readily see, without these filler basic spacecraft, there will be a sizable gap in facilities use, which would require us to drastically reduce the highly trained manufacturing work force that we have on hand, with the obvious result of added restart costs and possible time delays.

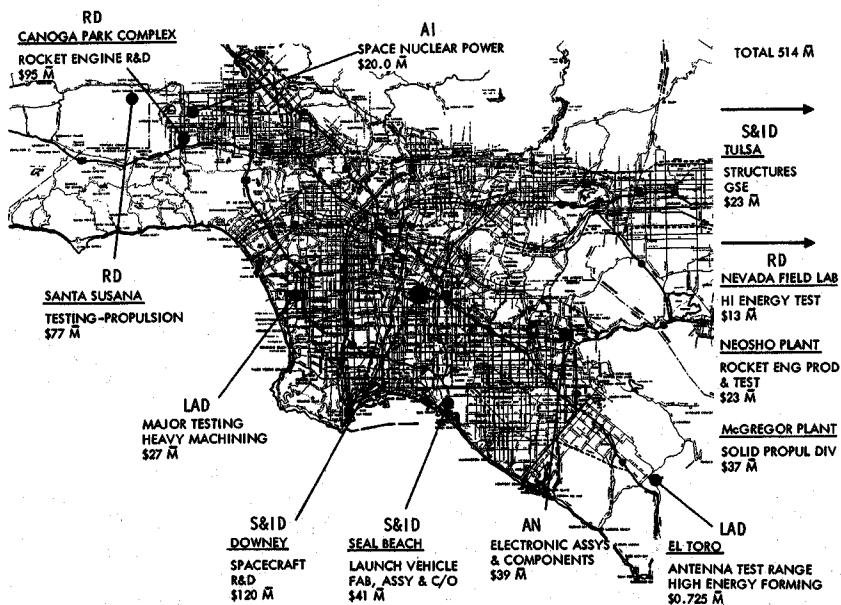
Slide 89 shows the same type of presentation based on an April 1, 1968, go-ahead for AAP Block III. The date of April 1 has been chosen based upon the possibility that the Government fiscal year 1968 budget might not be approved until December 1967, which, in turn, could result in not having the contractor under contract for 3 more months. The critical time period is again filled with Spacecraft 116 through 126, prior to the formal Block III production, and is almost 2 years in duration. Please note that in either case, Spacecraft 116 and subsequent will require a go-ahead for long leadtime items on April 1 of this year and a full go-ahead of July 1. If this does not come to pass, then we will again be faced with a gap

in the production line. Slides 90 and 91 show the major Saturn S-II unique facilities available. In this case, the situation does not appear as severe as that of the CSM, in that we have projected NASA Headquarters planning which indicates follow-on production at a rate of four per year after the present additional five vehicles, which are now in negotiation and which have been authorized by the Marshall Space Flight Center.

Summarizing the capability and planned utilization of S. & I. D. facilities in support of the overall Apollo program, we are already down somewhat from 100-percent usage (slide 92). As we come down the line, we will eventually be reaching less than 50-percent utilization, even with the kinds of programs which have been discussed today. So, the point we would like to make is that we are not capacity-limited as far as the ability to meet the AAP program. In fact, there will be plenty of facilities space available at S. & I. D., which could be used for other Government contracts.

Looking at GFY 1968 Space Division funding requirements, slide 93 shows the requirements for follow-on effort over and above that presently on contract. These are S. & I. D. requirements only, not other North American division funding requirements, such as for rocket engines, which will be needed for the various boosters and things of that nature. There are funding requirements for Spacecraft 113, 114, and 115, which are not yet on contract, and for Spacecraft 116 through 122, which could be alternates for spacecraft using the reno-

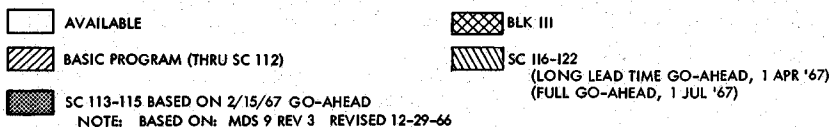
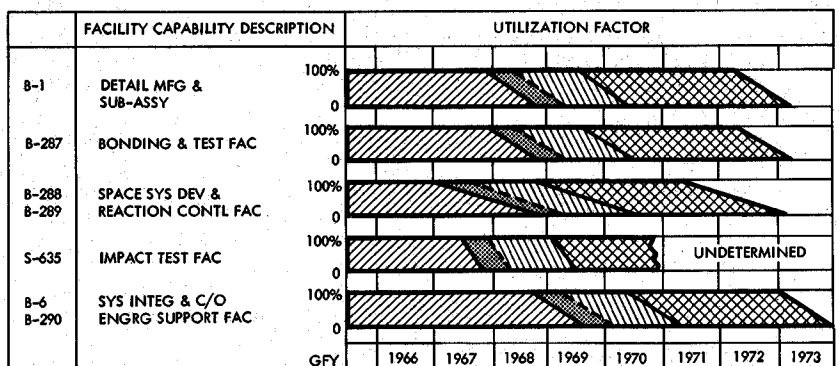
MAJOR SPACE MFG & RESEARCH FACILITIES IN USE BY NAA



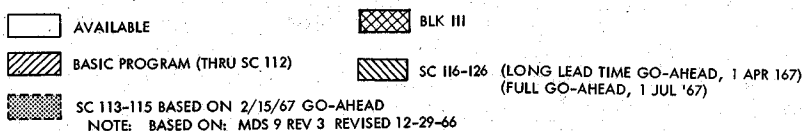
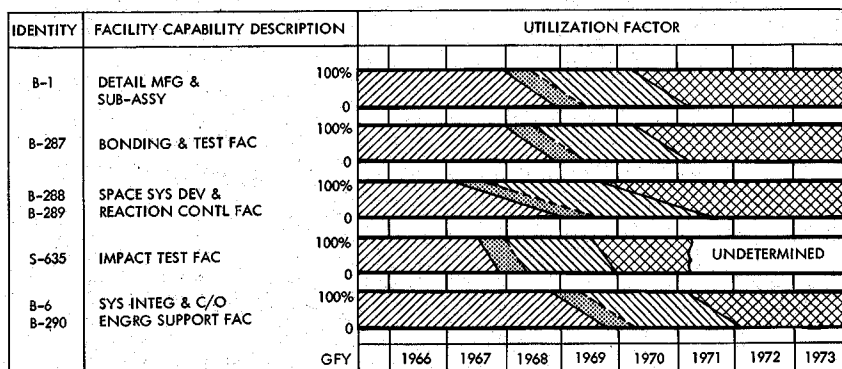
SLIDE 87. MAJOR SPACE MANUFACTURING AND RESEARCH FACILITIES IN USE BY NAA

MAJOR APOLLO UNIQUE FACILITIES AVAILABILITY

AAP 1 JULY 1967 GO-AHEAD

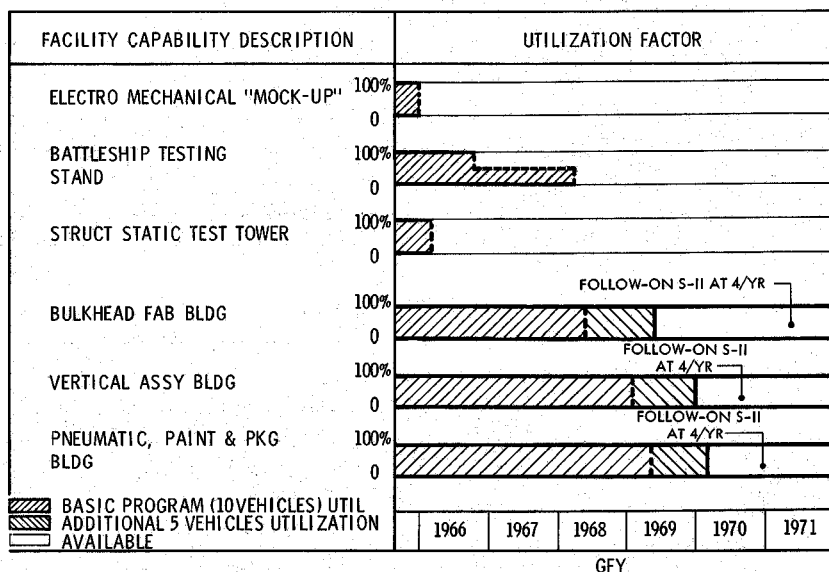
**SLIDE 88. MAJOR APOLLO UNIQUE FACILITIES AVAILABILITY—**
AAP JULY 1, 1967 GO-AHEAD**MAJOR APOLLO UNIQUE FACILITIES AVAILABILITY**

AAP 1 APR 1968 GO-AHEAD

**SLIDE 89. MAJOR APOLLO UNIQUE FACILITIES AVAILABILITY—**
AAP APRIL 1, 1968 GO-AHEAD

MAJOR SATURN S-II UNIQUE FACILITIES AVAILABILITY

PER MASTER PROGRAM SCHEDULE 67A REVISED 30 JAN 67



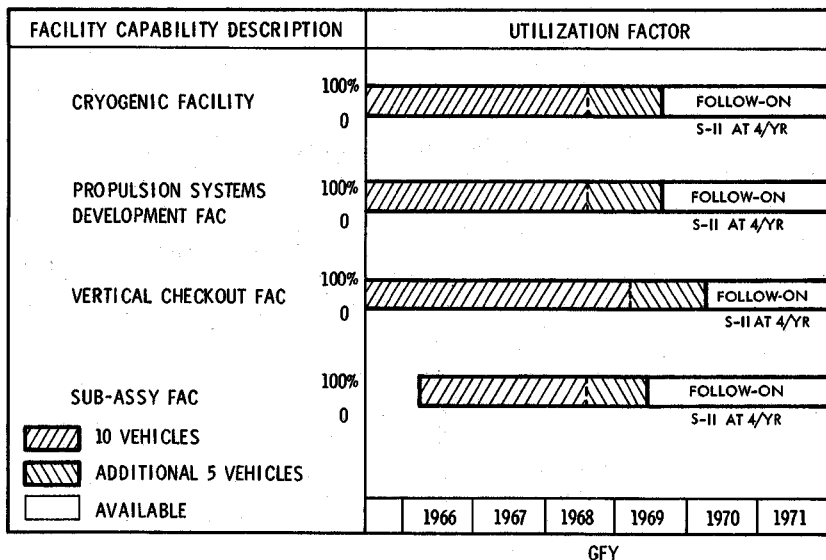
SLIDE 90. MAJOR SATURN S-II UNIQUE FACILITIES AVAILABILITY—
PER MASTER PROGRAM SCHEDULE 67A, REVISED JANUARY 30, 1967

vated command modules. You then have, as Mr. Tinnan showed, \$47 million for the development operations in the Block III, as well as renovated command module alternates. In the Saturn S-II program stages 11 through 15, for which, as Mr. Greer mentioned this morning, we have coverage on just a short-time basis—through March—we need additional funding of \$58.5 million for these. The additional stages 16 through 19, which would be used for the launch vehicles for additional AAP missions, will require initial funding of \$12.2 million.

In summary, with reference to critical events coming up in the command and service modules area (slide 94), we need full go-ahead on Spacecraft 113, 114, and 115 by February 15. We have actually had long leadtime procurement authorization on those items, on the basis of using the spare parts contract, but not full coverage. We are currently in negotiation with NASA, and we need to consummate that and get full go-ahead. We need the procurement of long leadtime items for the followon vehicles, which we discussed earlier, to fill the gap. This is necessary if we are to have no break in the production line and particularly this is true at the major subcontractors, especially at Beech and several others where they have a short-time cycle. Alternatively, we need the full go-ahead on the renovated command module program by July 1, and we need contract authorization by July, if we are to live with only 10 additional Block II spacecraft (Spacecraft 113-122). The longer we delay this contract authorization, if we are going to maintain the line in order to keep the cost down and utilize

MAJOR SATURN S-II UNIQUE FACILITIES AVAILABILITY (CONT)

MASTER PROGRAM SCHED 67A REVISED 30 JAN 67

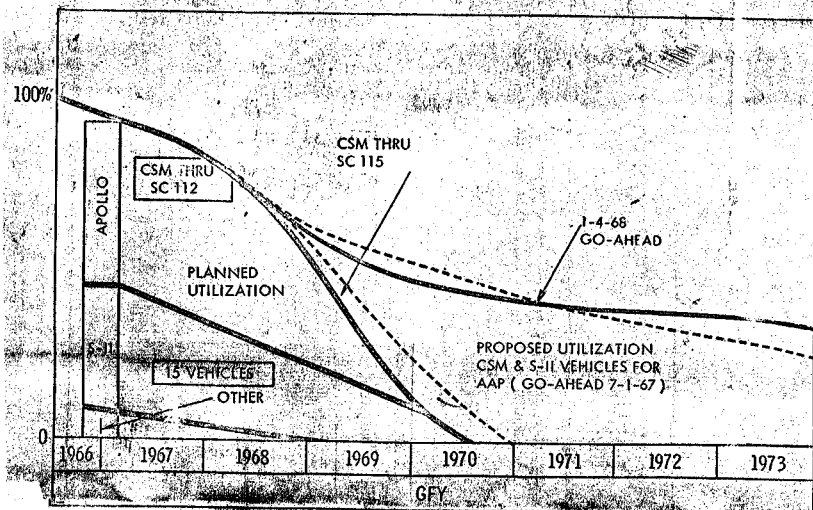


SLIDE 91. MAJOR SATURN S-II UNIQUE FACILITIES AVAILABILITY—
MASTER PROGRAM SCHEDULE 67A, REVISED JANUARY 30, 1967

CAPABILITY & PLANNED UTILIZATION

APOLLO/SATURN S-II
S&ID FACILITIES

CAPABILITY



SLIDE 92. CAPABILITY AND PLANNED UTILIZATION—APOLLO/SATURN S-II

S&ID FOLLOW-ON GFY 1968 FUNDING REQUIREMENTS

CSM

PRODUCTION

SC #113 - 115	\$52.0 M
SC #116 - 122*	<u>\$17.5 M</u>
	\$69.5 M

DEVELOPMENT

EXTENDED MISSIONS

RCM, FDP + DEV*	\$19.0 M
BLK III FDP + DEV	\$20.0 M
BLK II MOD KITS	<u>\$ 8.0 M</u>
	\$47.0 M

SATURN S-II STAGE

STAGES #11 - 15	\$58.5 M
STAGES #16 - 19	<u>\$12.2 M</u>
	\$70.7 M

*ALTERNATES

February 15, 1967

SLIDE 93. S. & I.D. FOLLOW-ON GFY 1968 FUNDING REQUIREMENTS

S&ID FOLLOW-ON CRITICAL EVENTS SUMMARY

COMMAND & SERVICE MODULES

- FULL GO-AHEAD FOR CSM 113, 114, 115 BY 15 FEBRUARY 1967
- PROCUREMENT OF LONG LEAD TIME ITEMS FOR CSM 116 - 122
BY 1 APRIL 1967
- OR
- FULL GO-AHEAD ON RCM PROGRAM BY 1 JULY 1967
(EFFECTIVITY S C #106 & SUBSEQUENT)
- CONTRACT AUTHORIZATION FOR FINAL DEFINITION OF BLOCK III
BY 1 JULY 1967

LAUNCH VEHICLES

- FULL GO-AHEAD FOR S-II STAGES 11 - 15 BY 15 MARCH 1967
- GO-AHEAD FOR LONG LEAD TIME ITEMS FOR S-II STAGES 16 - 19
BY 1 OCTOBER 1967

February 15, 1967

SLIDE 94. S. & I.D. FOLLOW-ON CRITICAL EVENTS SUMMARY

the proper facilities and experienced personnel in the fabrication of Block III vehicles, the more Block II vehicles we have to build.

In the launch vehicle area, as mentioned this morning by Mr. Greer, we need full go-ahead by March 15 for stages 11 through 15, and for long leadtime for stages 16 through 19, by October 1 of this year.

That concludes our material, Mr. Chairman.

Mr. TEAGUE. Thank you, Bob.

Mr. WINN. I hate to slow it down a minute; I know what you're talking about, I get the picture real fast, but are you talking about the production of the same type of capsule or space unit clear to 26?

Mr. CARROLL. Len, if I may go back into your charts here—

Mr. WINN. In other words, 126, is that the same as 101, 103, and 104?

Mr. CARROLL. Let me use Mr. Tinnan's chart (slide 79). As you can see, this would be using the same basic Block II vehicle, using it with modification kits, and using it with experimental packages, such as we are doing right now. We have currently defined additional AAP-type missions which utilize these vehicles—the identical configuration as far as the total vehicle is concerned—but with certain changes made inside the service module and certain changes made inside the command module to do different kinds of things and to carry different types of experiments.

Mr. TEAGUE. That answers your question, Larry?

Mr. WINN. Yes. What if we wanted to make a drastic change in this? You keep talking about minimum changes. What if at 114 or 112, that you want to be funded for shortly, we wanted to make a drastic change in this thing?

Mr. CARROLL. Len, do you want to step in and answer that?

Mr. TINNAN. Yes.

Mr. TEAGUE. You pay for it in money and time.

Mr. TINNAN. Spacecraft 112 is under firm contract; 113, 114, and 115 are under current negotiation and we have had long-lead authorization there.

Last year at this time we presented to the committee the points that if we were to in fiscal 1967 get authorization, we could come right behind it with our first Block III drastically changed vehicle. We have lost 1 year, which says the first one here. Now, we can compress this schedule in response to your question, but it will cost if we try to go into a high-priority accelerated run.

The point is that we have laid out this schedule based upon our Apollo experience on a nonemergency, nonovertime basis.

Mr. WINN. OK.

Mr. TEAGUE. Mr. Storms, may I thank all of you.

Mr. STORMS. It's been a pleasure to have you here.

Mr. TEAGUE. It's always a pleasure to come out here.

APPENDIX E

HEARINGS OF THE SUBCOMMITTEE ON MANNED SPACE FLIGHT, DOUGLAS AIRCRAFT CORPORATION, HUNTINGTON BEACH, CALIFORNIA, MARCH 28, 1967.

DOUGLAS AIRCRAFT CO., INC.,
OFFICE OF THE PRESIDENT,
Santa Monica, Calif., March 28, 1967.

HON. OLIN E. TEAGUE,
*Chairman, Manned Space Flight Subcommittee,
U.S. House of Representatives, Washington, D.C.*

MY DEAR MR. TEAGUE: Your visit to our Space Systems Center on February 18 with members of your subcommittee and staff gave us a welcome opportunity to report on the present status of our efforts as prime contractor to the National Aeronautics and Space Administration on the Saturn S-IVB stage, and on our view of the essential elements of the national space program beyond Saturn/Apollo.

The record of the day's discussion has been compiled in the enclosed document for your future reference, as you requested. It includes a transcript of the presentations by T. D. Smith, senior director, Saturn/Apollo programs; and C. J. Dorrenbacher, vice president, Advance Systems and Technology, with all of the graphic materials they used.

As you know, progress in the Saturn/Apollo program has reached the point where future applications beyond the lunar landing are demonstrable. The essence of this report is that the experience we have gained will allow us to go forward with existing systems and hardware, while continuing to develop the essential technology for even greater advances in the long-term future.

Once again, I would like to express my thanks to you, your subcommittee, and staff for inviting us to make this presentation as a part of your deliberations. Your continued awareness and personal interest in the progress and needs of the space program are most gratifying to those of us in the aerospace industry.

Sincerely,

DONALD W. DOUGLAS, JR.

**PRESENTATION TO THE HONORABLE OLIN TEAGUE, CHAIRMAN, MANNED
SPACE FLIGHT SUBCOMMITTEE, U.S. HOUSE OF REPRESENTATIVES,
WASHINGTON, D.C.**

**Presented at Douglas Missile and Space Systems Division, Space
Systems Center, Huntington Beach, Calif., February 18, 1967**

Congressman Teague and his party consisted of:

Congressman Edward J. Gurney

Congressman Earle Cabell

Congressman Jerry L. Pettis

Congressman Larry Winn, Jr.

Mr. James E. Wilson, committee staff, technical consultant

Mr. Peter A. Gerardi, committee staff, technical consultant

Representative for the U.S. Air Force was:

Col. E. A. Kiessling

**Representatives for the National Aeronautics and Space Administra-
tion were:**

Col. Leonard Hall

Capt. Robert P. Freitag (USN)

Mr. John S. Brown

Mr. Robert Pease, J-2 representative, Rocketdyne

Douglas representatives and attendees were:

Donald W. Douglas, Jr., president

Charles R. Able, group vice president

J. P. Rogan, vice president-general manager, MSSD

**C. Jim Dorrenbacher, vice president, Advance Systems and
Technology, MSSD**

Ted Smith, senior director, Saturn/Apollo programs, MSSD

**Osmond J. Ritland, vice president, reliability and launch
operations**

Walter C. Cleveland, director, public relations, MSSD

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Saturn/Apollo stage status-----	860
Advanced technology-----	895
Advanced systems technology review-----	897

INTRODUCTION

(By D. W. Douglas, Jr., President, Douglas Aircraft Co., Inc.)

Gentlemen, I hope the tour we have just completed will be helpful to you in the course of the report we will present to you this morning. We are making good progress in the production of Saturn S-IVB stages, and we are helping to explore the possible advanced applications of Saturn and Apollo hardware to refine and extend the country's aerospace technology. I feel very strongly that we must keep moving ahead in this field.

There's a proper pace and effort in the program, that I've discussed before on your previous visits here. If you go too fast, you may be wasting money, and taking too high a technical risk.

On the other hand, if you go too slow, you do not have the spirit—the enthusiasm for space exploration—which is very strong in most of the people in the space program, and which I believe is a very important factor in our success. It's very difficult to keep that spirit.

We do have to consider all the economic factors, so there is a proper kind of schedule, a proper approach that we should follow. We feel that with all the tremendous work that's been done in the Apollo/Saturn program, that we should definitely move on into the Apollo Applications program.

As you know, we are working on the "hotel in the sky," so to speak, as part of that program; we feel that it is a very important step ahead, and so will be some of the other things being planned—the solar observatories, observing the stars, and all the various possibilities of the Apollo Applications program are further steps ahead.

I personally feel that just visiting the Moon once doesn't do the whole job; that we must be able to move ahead with further exploration. What we are going to find, none of us is absolutely sure, but we are sure we're going to find tremendously interesting and exciting things. I sincerely hope that the Congress this year can see fit to carry on what I think is a pretty moderate, forward-looking program.

That's about all I have to say, except you are most welcome to interrupt at any time and ask us any questions.

With that I'll turn the program over to Ted Smith. Most of you gentlemen know, but I'll repeat it—our Missile and Space Systems Division is prime contractor on the Saturn S-IVB stage, which is used as the top stage on both the uprated Saturn I and the Saturn V launch vehicles. Ted is the program director on Saturn at Douglas; he's been on the program since its inception.

SATURN/APOLLO STAGE STATUS

(Presented by T. D. Smith, Senior Director, Saturn/Apollo Programs,
Missile and Space Systems Division)

I've talked to you gentlemen before—I think this is the third year. Today, I've got a rather unpleasant duty; I've got to tell you about one of the most serious incidents we've ever had in the program. And I think it bears taking a moment to reflect that the reason the Saturn/Apollo program has had such tremendous flight success is because we put the money we have into ground testing and redundant testing and this incident, as unpleasant and unfortunate as it is, it was better to have it happen at Sacramento than at the Cape.

So with that, I thought before I started the basic Saturn briefing, I would tell you a little bit about the loss of the S-IVB stage at our Sacramento Test Center. It was down-played with the other incident at the Cape the following week. But this one is our problem, we think we have it solved, and we think you are entitled to know about it.

On January 20, we were static firing the third Saturn V/S-IVB (fig. 1) at Sacramento. I was in the blockhouse. It was a very smooth countdown. It was about 4:30 in the afternoon, about 10 minutes from the time we planned to ignite the engine.

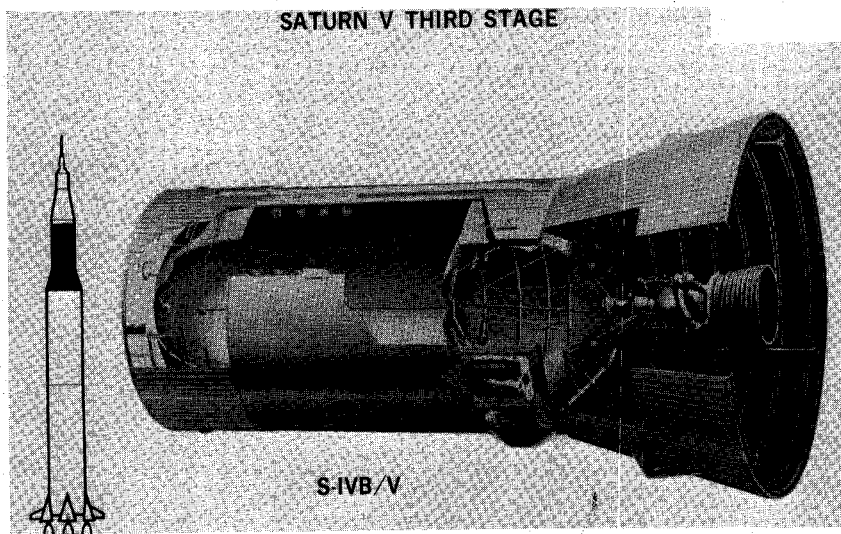


FIGURE 1

As you know, we simulate the entire Saturn flight during these static tests. At simulated S-IC liftoff, we do exactly the same things we would on the pad at the Cape. We pressurize our propellant tanks,

we bring our gas supply bottles up to pressure, and we check the list for liftoff: then the S-IVB sits quietly on the pad for the simulated boost time of the S-IC and the S-II stages, and then we ignite our stage, burn a third of the propellant, shut it down, and finally simulate the three-orbit coast and then relight the remaining propellants.

On this particular day, at about 20 seconds prior to T-zero or the simulated liftoff time, our stage exploded. I think I was talking to MSSD Vice President-General Manager Jack Rogan, within 2 minutes after it happened, and by 6 o'clock that evening, an hour and a half later, Mr. Rogan, Charley Able, Jack Bromberg, our chief engineer, and the members of our Douglas investigation committee were assembled and on the way to Sacramento.

Before we left the base that night, we had organized ourselves into teams to gather the data and to interview every man who was participating in the countdown. We organized committees to scrub our procedures to see if there was a procedural problem.

We organized eight committees and by the time the NASA official board was convened in Sacramento on Monday, we were completely prepared to support their investigation.

In the succeeding week, within about 4 days, we pinpointed the cause as one of the helium gas bottles mounted on the thrust structure of the stage; we had the data and physical evidence all correlated.

This bottle came apart; half of it drove down into the engine, tore up the engine, then it went down, hit the flame bucket, and washed out into the flume.

Either the other half of the bottle or the overpressure caused by the release of $4\frac{1}{2}$ cubic feet of gas stored at 3,000 p.s.i., tore up the S-IVB LOX tank and the hydrogen-LOX tank interface. The propellants mixed and within half a second from the bursting of the bottle the entire stage was destroyed, and all instrumentation was lost.

This (fig. 2) is a plan view of the engine gimbal point plane showing the relation of the bottle. In correlating the evidence we found that the overpressure against the engine bell, in such a burst, can be calculated to give exactly the pressure rise we observed in the hydraulic actuators as well as the engine link restrainers which have load cells in them.

The thing that triggered us into looking at the bottles very carefully was the fact that over here on the stairs (fig. 3), and one down-range, and one up-range, we found three helium bottle halves that were burst right on the weld seams. We went back and looked at our previous records of tests on those bottles. We had never seen a failure like that. Always before, they burst in many pieces with failures going right across the welds.

We immediately went to the vendor who built this bottle for us and collected and brought back to our plant his relevant records. Within a few days we discovered documentation that indicated he had accepted from his supplier an improper bundle of welding wire of pure titanium rather than alloy titanium. He welded 12 bottles with this wire, which reduces their strength some 40 percent. They still were strong enough to pass the proof test, but in addition to reducing strength, the

503 INCIDENT
THRUST STRUCTURE - VIEW LOOKING AFT

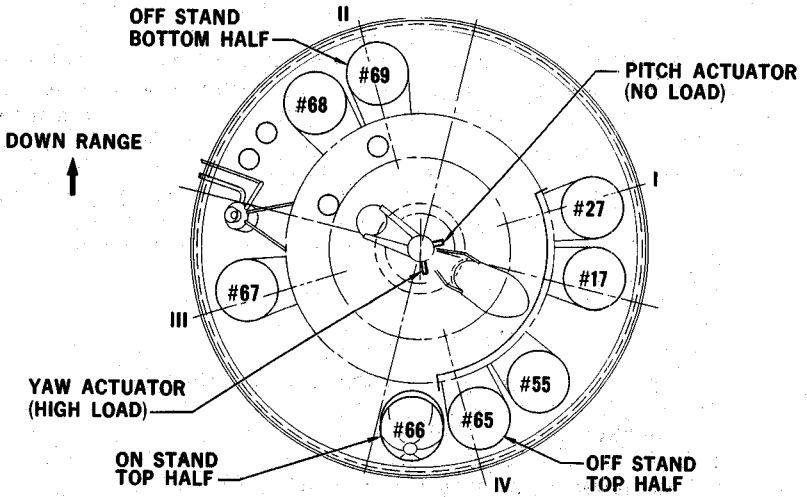


FIGURE 2

503 INCIDENT
PART MOVEMENT DIAGRAM

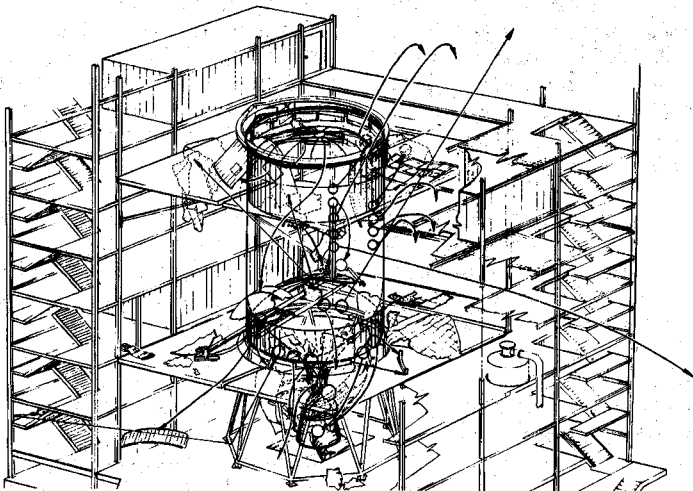


FIGURE 3

combination of pure titanium with the alloy that we use has a habit of forming titanium hydrides at the weld face, which can give you a creep-type failure under sustained load. This has been determined as the cause of the accident.

This is an artist's sketch (fig. 3) of where the various pieces of the debris landed. The explosion occurred down at the intersection between the LOX and hydrogen tanks. The engine and the thrust structure were pushed downward, everything else went up. Some of the upper skirt equipment is not even singed. The damage to the stand approximates 10 percent. This stand cost in the order of \$8 million 2 or 3 years ago. It's estimated it will require something close to a million to refurbish it. The ground support equipment replacement cost is of the same order of magnitude.

Mr. ABLE. You might mention the fact that we were not only looking at the data, but also the burst tests we conducted on a series of bottles in order to try to reproduce the conditions.

Mr. SMITH. We have probably spent 5,000 engineering manhours since the accident in correlating the data available, and we have mountains of data from a static test like this. As we zeroed in on various possibilities, we initiated test programs.

We have now located all the helium bottles that were bad. We have devised a test that will tell us whether or not the correct weld wire was used. We find the vendor's documentation was accurate. The 12 bottles that his records show he made the wrong bundle of wire are verified and have been impounded. All the other bottles have been checked and we are now sure they have been welded with the right wire.

We have absolute confidence that the cause has been determined. As a result of this, we feel there will be certain things we will do with all our vendors to prevent any such thing from ever happening again.

The basic fundamental error was the receiving inspector's accepting a bundle of wire into stock without checking the certificate that the supplier sends with this kind of material against the purchase order. The purchase order clearly called for the alloy wire, the certificate coming with the wire clearly stated he was filling that purchase order with another wire, in error. The vendor made an error in sending the wire; the person receiving the wire failed to check and cross-check his documentation. He accepted the wire, and put it into stock. A very unfortunate circumstance.

Mr. DOUGLAS. Well, I think we learned one very fundamental thing; that bottle was supposed to be good for burst of 8,000 pounds, but, this proof test unfortunately didn't tell the whole story, due to the "creep." That's why we developed a new testing technique.

Mr. SMITH. Unfortunately, the proof test took this particular metal combination right to ultimate. Once you've had a metal up to ultimate strength, you don't know how many cycles are left in it. The next time it can go at half strength.

Mr. PETTIS. Don, what do you mean when you use the word "creep"?

Mr. DOUGLAS. "Creep"? The creep failure is when you have a certain piece of material under force, under sustained load—and they had to have a hold in this case—and it just means it starts to give slowly, and stretches so to speak, and then—boom.

Mr. SMITH. It's a characteristic of brittle-type material, and this combination of metal is subject to precipitation of hydrides along the interface of the two. They don't want to mix.

Mr. ABLE. Ted, I think it is interesting to point out there remains quite a technical argument whether you could use, or should use, pure titanium—and there are definitely some differences of opinion. There is a group agreeing you can use pure titanium wire under certain circumstances if your processes are right, such as if it's thin walled and under different pressure conditions.

Mr. SMITH. There is still a technical argument going on, but this happens to be a very thick walled, high-pressure vessel. Many of the titanium containers in the Apollo program are welded with alloy sheet and pure titanium wire, but always in thin gages. They are welded from both sides, so that there is mixing in the weld nugget with the parent metal. The metal near the weld is purposely thickened so that the stress levels in the weld are way down compared to the parent metal. In our designs the weld thickness and the parent metal are equal.

Mr. TEAGUE. What was your wait, Ted, before you came out of the blockhouse?

Mr. SMITH. It was probably 45 minutes before the stand was secured. I might mention that the NASA investigating board was extremely complimentary, and I think it was very well justified. I think our crew performed in exemplary fashion. Our test conductor had the deluge system on within 30 seconds. In every part of the countdown, the institution of the emergency backout procedures was really something to behold.

Mr. DOUGLAS. Didn't you also do something else, Ted, that was to immediately tape-record all the people?

Mr. SMITH. Everyone who was connected with that countdown, Don, had a nondirected interview by Sunday morning. This was Friday, at 4:30 p.m. By Sunday morning, at 8 a.m., the 68 people who were involved in that countdown had had a nondirected interview, and had had their observations recorded on tape for Dr. Debus.

Mr. DOUGLAS. Well, in that one week, we were 99 percent sure we had the answer.

Mr. SMITH. Since that time, every scrap of data has been correlated and has fallen right into line.

Mr. WINN. What do you do to somebody like the inspector, or to the vendor that supplied the bad wire?

Mr. SMITH. We've had the vendor's records impounded ever since the day of the accident. We've just had our first meeting with him on Thursday. The Marshall legal people asked us to hold off until the official accident report was issued. We don't know what happens to him yet; we know of no situation where any punitive action was taken in a case like this. Whether or not there will be in this case, I do not know.

Mr. WINN. Do you plan to continue to use the same vendor, or will you look for someone else to do the job? That's what I'm trying to get at.

Mr. SMITH. I don't know yet. We will have to use him for a certain length of time. There is nothing wrong with his technical process,

other than this mistake. It is a certified company. Every product he's made with the right wire more than exceeds all the specifications.

Mr. TEAGUE. It was done by one person in his organization, and you'd probably destroy his company if you went too far.

Mr. SMITH. This is a decision that will have to be made between ourselves and Marshall. We have confronted the company. I met with their general manager, their inspection head, their chief design engineer, along with our procurement head and our legal counsel Thursday. We showed them the records, the findings we had made from examining their records, and presented them as fact. We did indicate that we had drawn these conclusions from the records. We asked them to study the records and to come back again next Thursday and see if they could contribute anything to the factual evidence. We have been in contact with Marshall's Chief Counsel Ed Guilan, and we'll make a decision on how to proceed.

Mr. WINN. Let me continue on the line we are in. If this man or woman that received the bad wire knew it was bad, then through the job of the various remaining people involved in the installation of this wire—did anybody—anyone speak up and say this doesn't seem like the right stuff we're putting in here?

Mr. SMITH. If you'd like to pursue that a minute—

Mr. WINN. Since you are the prime contractor, am I wrong in assuming that you are responsible for the results of their work?

Mr. SMITH. We are fully responsible to the Government, for our prime contract obligations, yes. You have to be aware that in all Government contracts, certain disciplines are laid down on the prime contractor. There is a point at which there isn't enough money in the world to have one prime contractor man for every one of the subtler vendors. That is why we strive to select subcontractors of proven competence. This particular bottle vendor has four additional subcontracts: forging supplier, weld wire supplier, heat treating subcontractor, and testing contractor; and the amount of money involved putting absolute surveillance in all these things is almost beyond comprehension. When you consider that this one is just one of perhaps two or three hundred that Douglas uses for the Saturn program, one of two or three thousand in the Apollo program.

Mr. FRIETAG. 20,000 is closer.

Mr. DOUGLAS. 20,000 is closer, Bob.

Mr. SMITH. On the other hand, we are certainly going to take a good look at our own procedures.

As a result of this, we are starting to look at hardware—we look at hardware in many ways. Are they critical to the flight? Are they critical to the safety of the astronaut? We are starting to look at them in terms of: Do they contain enough potential energy to destroy the stage? On these we will go back and review our requirements: Do our requirements, if followed, insure that every piece of hardware that comes out of the vendor is proper? Then we will look to see whether or not we have the disciplines that insure he is following those requirements. I'm sure that as a result of this incident, both ourselves and other NASA contractors, Government contractors, will change some of their methods of surveillance of these potentially dangerous components.

Mr. PETTIS. What is your approximate value of this third stage?

Mr. SMITH. About \$10 million. Replacement cost would be just under \$10 million.

Mr. TEAGUE. Ted, as a result of your investigation, would you comment on the way this is being handled at the Cape as far as how the board and the panels are going about trying to solve it.

Mr. SMITH. I'd rather not try to do that. I'm not involved; I don't know first hand.

Mr. TEAGUE. It disturbs me to have newspaper people say that it's going to be a whitewash.

Mr. DOUGLAS. I'd like to make a comment. I don't believe the people in this program, be they NASA or the contractors, have any approach to whitewash. My own personal opinion is that if you have an accident you should include the contractor and, obviously, the Government people in your investigation. But, I think of the quality of the people in this program, and I used to be in charge of accident investigation in airplanes for many years, and I've never seen the time when the technical person wasn't doing everything he could to find out the cause of an accident. He just has too much pride in his career to do anything else. And I don't appreciate the press or anybody else saying somebody is going to whitewash it.

Mr. ABLE. We certainly have never seen that, and I might comment on that myself. I flew up on Sunday with Jack Rogan, the general manager. We were a little hesitant to sit in on some of the hearings they were holding with our own people. We felt it might inhibit them. Jack Bromberg and Ted Smith said no, so we sat in the back of the room. All the items were brought out that we could consider as deviation from the ultimate of perfection. Even though they were irrelevant to the incident, they didn't hesitate to bring them out. As a matter of fact, in an incident like this, it really becomes a most thorough review then of all your procedures and you will cover lots of things that might eventually cause trouble in the future. Because it is a real tough job, with all these technical disciplines and procedures that have to be followed, to get everybody right exactly where they should be all the time.

Mr. TEAGUE. Well, Bob, if I understand what's happening, it would be a complete impossibility for it to be whitewashed, as broad as the scope of this investigation is.

Mr. DOUGLAS. I just don't believe it. Now I'm not trying to make a hero out of myself, but some of you may remember the very serious Bryce Canyon accident of the DC-6. A short time later there was an accident in Gallup, N. Mex. A DC-6 landed with part of it burned away. I grounded every DC-6 in the United States, much to the disgust of my airline customers, some of them, who weren't exactly sure that I was smart enough. But I could tell technically by looking at the thing there was something seriously wrong. Any engineer that has been in business all his life has only that attitude. I mean if there is something wrong, he is going to say, "no soap, it's not going."

We called all those airplanes back in and fixed them with Douglas money.

I think if you're in this business, you're in it all your life—there is just no idea of whitewash. I believe the Government people have this

same feeling of responsibility as the contractors. I don't believe any suggestion of a whitewash.

Colonel KIESSLING. It will establish a precedent, Mr. Congressman, if there is anything of that nature, and we've had a batch of accidents in this business, obviously this is what the testing procedure is for. The thoroughness of the procedures are pretty well known. The way you go about them, and the way you make sure there is no fooling with records, no possibility, even when it turns out to be personnel glitch. Boy, these guys get pretty traumatic results when they really realize they may have contributed to an accident. We even had some guys go nearly off their rocker. We have no evidence in the past of anything but just plain straight honesty.

It's embarrassing at times, but I don't think that there is any evidence to sustain the idea there has been a whitewash, or anything of this nature.

Mr. SMITH. In spite of the personal factors, our motivation is also that—you just would have no rock to hide behind if you ever let the same thing bite you twice. Then in my position, and Don's position, and Charlie's position, if we don't nail that to the mast and know what happened, if we ever have another one of these and didn't find it, we just couldn't live with ourselves.

Mr. GURNEY. Ted, is there any difference in welding techniques, using pure titanium wire and titanium alloy wire? Does the welder sense any difference in the work of the good wire?

Mr. SMITH. I'm not that much of a metallurgist to know, I don't believe so.

Mr. ROGAN. There is a divided opinion.

Mr. ABLE. Some of our welding people think the consistency of the weld is—some of our welding people claim a good welder can tell by the way it puddles. But there are some others that think you can't.

Mr. GURNEY. It's a gray area?

Mr. SMITH. It's a gray area, I'm sure.

Just to summarize (fig. 4). We feel that our documentation, our operational test and our emergency procedures and controls were good. I think the launch site crew is really to be commended on their performance. The automatic checkout equipment was not involved in any way and the cause has been determined and we are in the process of taking corrective measures on this and all other components that have a potential of destroying major hardware.

Now, to get into the Saturn program itself—we have looked at schedules, since the incidents at Sacramento and the cape, in relation to the need dates for our stages at the cape. These (fig. 5) are not even official yet, but only the initial planning since the two incidents. They are based on the idea that whatever comes out of the capsule accident investigation can be corrected within the current schedule.

The impact on our program is that we will have to fulfill the Apollo/Saturn 503 mission with our 504 stage, and likewise, the 504 mission with our 505 stage, and so on down the line.

We plan, if the decision is made to refurbish Beta 3, we will be operating with one stand down to this point (fig 6). This stage is on the stand now. We will run about 7 weeks behind in meeting this stage, so we have an opportunity to bring this up.

503 INCIDENT SUMMARY

- EXPLOSION EQUIVALENT TO 1% PROPELLANT MIXING
- SAFETY PROGRAM DOCUMENT & CONTROL WERE GOOD
- CREW PERFORMANCE EXCELLENT
- AUTOMATIC CHECKOUT EQUIPMENT NOT INVOLVED IN EXPLOSION
- IMPROPER WELD WIRE IN AMBIENT HELIUM SPHERE
CAUSED LOWER ULTIMATE STRENGTH DUE TO
HYDROGEN EMBRITTLEMENT

FIGURE 4

SATURN S-IVB PROGRAM MILESTONES

<u>STAGE NUMBER</u>	<u>K DATE</u>	<u>4G SCHEDULE</u>	<u>FORECAST WITH BETA 3</u>	<u>FORECAST WITHOUT BETA 3</u>
208	5/15/67	7/15/67	3/17/67	3/17/67
504	8/29/67	6/21/67 (503)	7/24/67	7/24/67
209	8/15/67	10/15/67	8/25/67	8/25/67
505	11/30/67	8/31/67 (504)	10/2/67	10/2/67
506	2/28/68	11/30/67 (505)	11/27/67	11/27/67
210	11/15/67	1/15/68	1/4/68	1/17/68
211	2/15/68	1/15/68	1/26/68	3/22/68
507	4/30/68	2/28/68 (506)	3/4/68	5/10/68
212	5/15/68	4/15/68	4/15/68	7/1/68

FIGURE 5

SATURN S-IVB PROGRAM MILESTONES

<u>STAGE NUMBER</u>	<u>K DATE</u>	<u>4G SCHEDULE</u>	<u>FORECAST WITH BETA 3</u>	<u>FORECAST WITHOUT BETA 3</u>
508	7/31/68	4/30/68 (507)	4/15/68	8/23/68
509	9/30/68	7/31/68 (508)	7/5/68	10/17/68
510	11/30/68	9/30/68 (509)	8/16/68	12/11/68
511	1/15/69	11/30/68 (510)	11/15/68	2/4/69
512	3/14/69	1/15/69 (511)	1/3/69	3/26/69
513	5/15/69	3/15/69 (512)	3/1/69	5/15/69
514	7/15/69	5/15/69 (513)	5/1/69	7/7/69
515	9/15/69	7/15/69 (514)	7/1/69	8/25/69
503R		9/15/69 (515)	9/1/69	10/17/69

FIGURE 6

This is a first cut of the schedule and does not involve extraordinary overtime. If it appears warranted, we can bring that date up a little. It looks as though we're in fine shape against that date, but there is some talk that they would like to have the stage a couple of weeks earlier than this, in order to go into the stack on the S-II spool again, and come up the way 501 was handled. We show the 209 stage as being a little late, but it appears that when they really get their planning done, the Saturn I stages will take care of that discrepancy.

On the 504 mission, they would like to see our stage down there in August and we're going to be about 3 months late if this schedule holds. On the 506, we're about 2½ months late. Then we'll come back into schedule position as soon as Beta 3 comes back on line. And from here on down we can meet all the Apollo schedules. Now, whether or not there is a further reshaping as the result of the Apollo accident we don't yet know. We are working with these to see if we can't pull up our skirts and keep the program going.

I beg your pardon, I was looking at the wrong dates. Here are the dates that we will be able to make. Now we will be about 4 weeks late here. We'll make that date, because this stage is already built. We'll be about one month late here, and almost back on schedule there, and from here on out our schedule is back in gear with Apollo.

Mr. DOUGLAS. I want to make a point right here. There have been many questions on these new incentive contracts and the incentive bonuses about schedules. The point I want to make is—the reason we're going to be so close on schedule is that we were fighting real hard to make our incentive bonus, and it proves to me the value of the incentive programs.

Mr. SMITH. As you can see here, Don, we have the entire program running approximately 2 months ahead of our contract requirement.

This is going to allow us to come very close to moving these stages up and meeting the required dates. With extraordinary effort, if it is indeed necessary, I think we'll probably meet them all as a result of the incentive schedule.

Mr. PETTIS. Is there a lot of thievery of technical people in this business here in southern California?

Mr. SMITH. Proselyting you mean?

Mr. PETTIS. Maybe there is a better word which might have some relativeness to phrasing or slowing one program down in one company. Highly qualified people say, "Well, there is no future here" and they go somewhere else to work.

Mr. SMITH. I don't really believe it happens too much. If anything, it affects people who are not so highly qualified as some others.

Mr. PETTIS. Oh, it does?

Mr. SMITH. If the newspapers start saying that a given program is having funds withdrawn, or slowing down, then the lower echelons of technical people who think their jobs might be in jeopardy sometimes start looking elsewhere. But, I don't think that it is a serious factor at all.

Mr. ABLE. I believe that we actually have one of the lowest turnover rates in the industry, it's so minor.

Mr. DOUGLAS. On the other hand, according to popular consensus, if there is a great big rhubarb and lots of discussion that there are going to be big cuts in a program, then you're going to lose some men.

Mr. SMITH. That's when we start losing them—these younger engineers who are not confident of their positions in the company, start to look around.

Mr. TEAGUE. They wouldn't be human if they weren't trying to improve the situation.

Mr. SMITH. These charts we have shown you before. As you notice, on one side (figure 7), we have graphically depicted the various major structures of the S-IVB: the lox tank; the forward dome; the tank cylinder, which is consolidated; the full tankage; the thrust structure; and so forth. The first third of our program is complete. These stages are built, checked out, test fired, awaiting launch. When some of you were here last August, we were at this point (fig. 8) in the middle third of the program. Since last August, we have completed that phase. In other words, the 6 months, we have made about four to five of every major structure. We are working on a rate of somewhere close to 8 to 9 per year. And this is what we offer on our program additions in the future (fig. 9). So, as you can see, the hardware is roughly 60 percent concluded.

The 212 stage, the final uprated Saturn I stage under the present contract—you saw the last of it in the shop this morning. Unless there is a follow-on order from here on out, we are talking only about Saturn V. These (figs. 10, 11, and 12) are the structural components, the black boxes, the wires, the tubes, the valves, the instrumentation and the purchased parts. This shows about the same picture—the first third of the program is complete; we are about through with the Saturn I. About 60 percent of the overall program is complete. The manufacturing performance (fig. 13)—I think the learning curve on

SATURN S-IVB PRODUCTION LINE STATUS

		201	202	203	204	206	207	501	502
LOX TANK		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
FWD DOME		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
TANK CYL.		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
TANK ASSY.		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
AFT SKIRT		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
FWD SKIRT		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
THRUST STRUCT.		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
STAGE (JOIN & FINAL INSTLN)		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
AFT INTER STAGE		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP

FIGURE 7

SATURN S-IVB PRODUCTION LINE STATUS

		208	504	209	210	505	211	506	212	507
LOX TANK		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP	73% COMP
FWD DOME		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP	STARTED
TANK CYL.		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP	75% COMP
TANK ASSY.		COMP	COMP	COMP	COMP	COMP	COMP	COMP	STARTED	START MAR 67
AFT SKIRT		COMP	COMP	COMP	COMP	COMP	75% COMP	36% COMP	START FEB 67	START APR 67
FWD SKIRT		COMP	COMP	COMP	COMP	COMP	54% COMP	START FEB 67	START MAR 67	START MAY 67
THRUST STRUCT.		COMP	COMP	COMP	COMP	COMP	56% COMP	START FEB 67	START APR 67	START MAY 67
STAGE (JOIN & FINAL INSTLN)		COMP	COMP	99% COMP	COMP	50% COMP	START MAR 67	START APR 67	START JUN 67	START AUG 67
AFT INTER STAGE		73% COMP	54% COMP	STARTED	START MAR 67	START APR 67	START JUN 67	START JUL 67	START SEP 67	START OCT 67

FIGURE 8

SATURN S-IVB PRODUCTION LINE STATUS

		508	509	510	511	512	513	514	515
LOX TANK		STARTED JAN	3-28-67	6-1-67	8-8-67	10-11-67	12-15-67	2-20-68	4-24-68
FWD DOME		3-23-67	5-29-67	8-3-67	10-6-67	12-12-67	2-15-68	4-19-68	6-24-68
TANK CYL.		3-9-67	5-15-67	7-20-67	9-22-67	11-27-67	2-1-68	4-4-68	6-10-68
TANK ASSY.		5-24-67	7-31-67	10-3-67	12-7-67	2-12-68	4-16-68	6-19-68	8-22-68
AFT SKIRT		6-16-67	8-22-67	10-24-67	12-29-67	3-4-68	5-7-68	7-17-68	9-13-68
FWD SKIRT		7-11-67	9-13-67	11-14-67	1-22-68	3-25-68	5-28-68	8-1-68	10-4-68
THRUST STRUCT.		7-26-67	9-28-67	12-1-67	2-6-68	4-9-68	6-13-68	8-16-68	10-21-68
STAGE (JOIN & FINAL INSTLN)		10-4-67	12-8-67	2-13-68	4-17-68	6-20-68	8-23-68	10-28-68	1-6-69
AFT INTER STAGE		1-24-68	3-28-68	6-3-68	8-6-68	10-9-68	12-13-68	2-19-69	4-24-69

FIGURE 9

SATURN S-IVB MANUFACTURING & PROCUREMENT STATUS

	201	202	203	204	205	206	207	501	502
55 BLACK BOXES		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
76 WIRE HARNESSES		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
310 TUBE ASSEMBLIES		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
35 VALVES		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
40 TRANSDUCERS		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
3,250 PURCH PARTS		COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP

FIGURE 10

SATURN S-IVB MANUFACTURING & PROCUREMENT STATUS

	208	504	209	210	505	211	506	212	507
55 BLACK BOXES 	COMP	COMP	COMP	COMP	90% COMP	85% COMP	28% COMP	22% COMP	18% COMP
76 WIRE HARNESSES 	COMP	COMP	COMP	COMP	COMP	COMP	95% COMP	52% COMP	48% COMP
310 TUBE ASSEMBLIES 	COMP	COMP	COMP	COMP	99% COMP	96% COMP	76% COMP	33% COMP	29% COMP
35 VALVES 	COMP	COMP	COMP	94% COMP	86% COMP	29% COMP	23% COMP	12% COMP	8% COMP
40 TRANSDUCERS 	COMP	COMP	COMP	COMP	COMP	65% COMP	42% COMP	22% COMP	18% COMP
3,250 PURCH PARTS 	COMP	COMP	99.99% AVAIL	99.98% AVAIL	99.97% AVAIL	99.97% AVAIL	99.94% AVAIL	99.96% AVAIL	95% AVAIL

FIGURE 11

SATURN S-IVB MANUFACTURING & PROCUREMENT STATUS

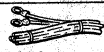
	508	509	510	511	512	513	514	515
55 BLACK BOXES 	13% COMP	10% COMP	—	—	—	—	—	—
76 WIRE HARNESSES 	43% COMP	35% COMP	—	—	—	—	—	—
310 TUBE ASSEMBLIES 	24% COMP	20% COMP	—	—	—	—	—	—
35 VALVES 	3% COMP	—	—	—	—	—	—	—
40 TRANSDUCERS 	14% COMP	10% COMP	—	—	—	—	—	—
3,250 PURCH PARTS 	90% AVAIL	80% AVAIL	50% AVAIL	25% AVAIL	10% AVAIL	—	—	—

FIGURE 12

SATURN S-IVB/IB & V MANUFACTURING PERFORMANCE

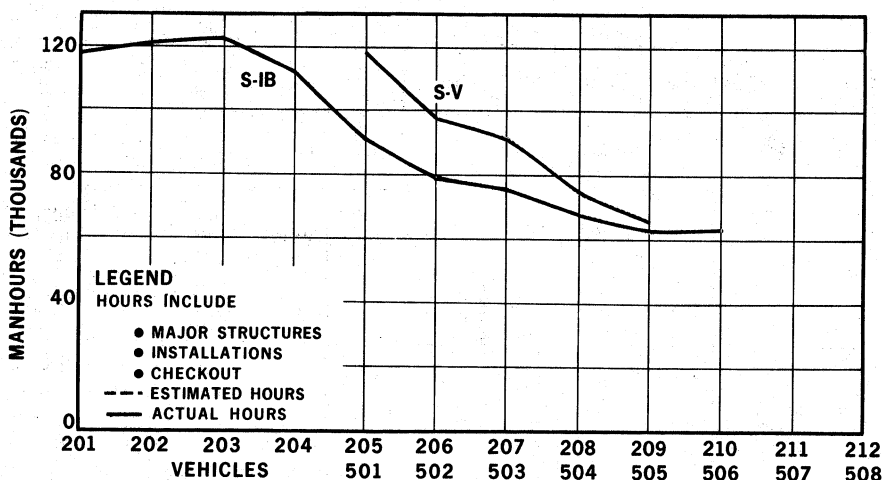


FIGURE 13

this program is an excellent one. These are all actual points, particularly on Saturn V. We started out using about 120,000 man hours per stage. We have expressed a good learning curve; we are down here now, at about 60,000. Saturn V has come closer to the IB than we thought possible; all in all I think it represents an excellent performance.

Now, the ground test program (fig. 14). We have spent an awful lot of money on ground tests and I think it's well justified. I think it's responsible for the wonderful record that the Saturn/Apollo program has had to date in flight. Our program—our component test program—has a total of about 1,132 tests. Each one of these tests could be composed of anywhere between 10 to 30 separate tests of a given component: shock, vibration, cold, heat, vacuum, salt spray, and other things, and combinations of these things. We are roughly at the 92 or 93 percent level. Tests on all of the vehicle-associated things are either finished or very shortly will be. If you will remember, last year we showed you how, before the 201 launch about 60 percent of the program was required to be complete. We have proceeded on these flight associated tests (fig. 15) to be complete by the 501 launch: all the things that were required for the 204 are done; as were all the things that were required for the 503 static fire. We have about three open items before we qualify 501 for launch. The remaining 10 percent of the test program is associated with miscellaneous GSE tests and the reliability-quality maintenance program that was just initiated, which will continually test various components in the program. These programs stretch out now. But the testing effort is largely behind us.

As you know, we have flown three of the uprated Saturn I's (fig. 16). About all you can say is that all three flights were superb.

SATURN S-IVB COMPONENT TEST PROGRAMS

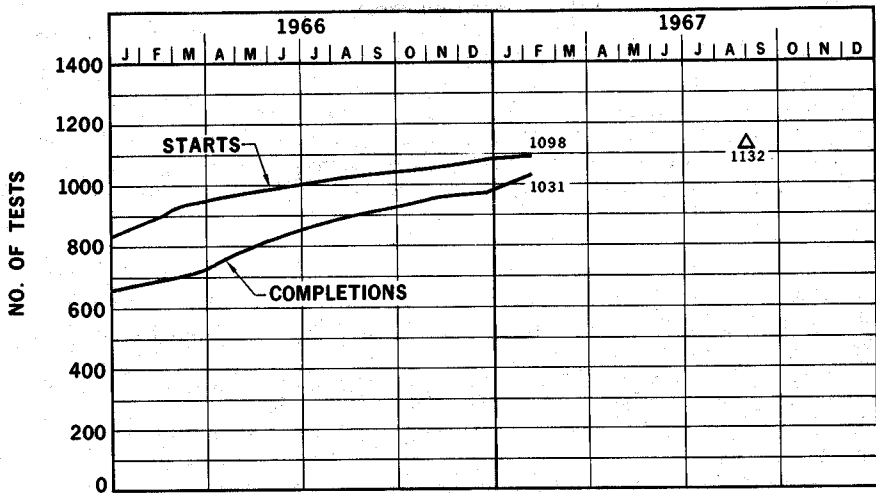


FIGURE 14

SATURN S-IVB QUALIFICATION TEST PROGRAM MILESTONES

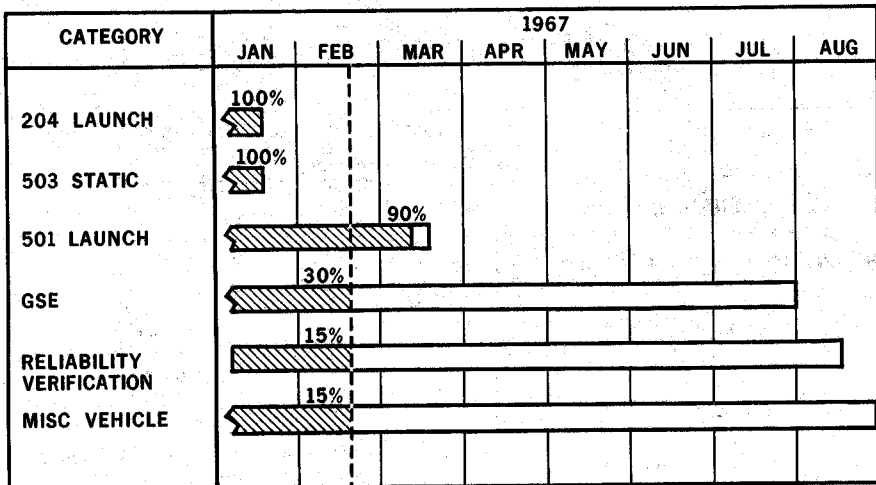


FIGURE 15

Any parameter you want to look at is so close to nominal, it is scarcely worth talking about. In thrust, impulse, propellant consumption, orbital parameters—everything was so close that it just goes into the records as perfect.

Now, turning to the manpower picture on the S-IVB. If you recall, last February we showed you our fiscal 1967 requirements. Looking at the authorized program (fig. 17), which was the four Saturn IB stages and six Saturn V's, we had a basic program estimated at almost \$141 million. We were expecting \$5 million additional tasks to come into the program. We were expecting to finalize a launch-site effort of about \$17 million and we were expecting to finalize the Saturn V follow-on for stages 507 through 515, with requirements of about \$33 million, for a total of about \$195 million. In that year, since you were here last, we have substantially underrun the basic program to the tune of about \$8 million. More scope has come into the program than we had expected; about \$15 million as opposed to \$5 million.

The KSC effort has grown by about \$1 million, but this has been reprogramed and the amount actually envisioned now to be spent has been cut about in half, or this program has been reduced by about \$15 million.

However, additional requirements of the follow-on long lead authorization on Saturn I has been authorized to the tune of \$6 million. If it is decided to replace Beta 3 and the 503 stage, additional funding in the amount of \$2 million will be required.

We have included the bonus fees—since 1966 we have negotiated the incentive contract. This represents the Government's total liability and therefore does not represent what we have earned. We have

FLIGHT PERFORMANCE RESULTS

PARAMETER	PERCENT OF PREDICTED RESULTS		
	201 (FINAL)	202	203
AVERAGE ENGINE THRUST (LB)	99.97	102.07	99.34
ENGINE TOTAL IMPULSE (LB-SEC)	100.34	100.59	100.19
PROPELLANT CONSUMPTION	100.09	99.34	99.59
TELEMETRY EFFICIENCY	97.22	99.54	97.3 - 98.0 (POWERED FLT) 96.1 - 97.2 (ORBIT)
CUTOFF ALTITUDE	100.5	98.36	100.00
CUTOFF VELOCITY	100.0	100.00	99.99

FIGURE 16

earned to date about \$3 million of that. But we have been asked to present this all today in terms of the Government's greatest potential liability.

You might remember these manpower curves (fig. 18); the green lines are the estimates that we showed you last year, the red lines indicate our actual performance. It was right in here that we put the heavy emphasis on schedule, and we reloaded our program slightly to get on schedule and to do what the Government has advised us to do—to get ahead of schedule. We allowed our people to staff a little higher than first anticipated to get ahead of schedule and then pulled them off in this fashion. The net result, in addition to getting a couple of months ahead of schedule, actually resulted in about an \$8 million savings in man-hours throughout the year.

The year 1968 looks like this to us (fig. 19), showing the total authorized program through stages 212 and 515. We envision a program with fee and bonus incentive of \$108 million—total bonus available is \$8 million—how much of it we will earn remains to be seen. KSC launch site effort figures figures out at about \$20.9 million. We hope that these additions will come into the program during the year; the IB follow-on would require about \$25 million and the Saturn V follow-on, beyond the 515 stage, would figure out to about \$10 million in 1968. So the total funding requirement envisioned for the next fiscal year, would be \$178 million.

I thought I'd show you our production rate. As you know the facilities here at Douglas were conceived and built to handle 12 stages per year, and the entire Apollo program is geared around 12 per year. Up to here, we are at the 8-stage-per-year level. In the next fiscal year,

SATURN S-IVB 7-101
NASA FY 1967 FUNDING REQUIREMENTS (MILLIONS)

	<u>FEB. 1966 ASSESSMENT</u>		<u>FEB. 1967 ASSESSMENT</u>	
SEPT 26, 1965 BASE		141.591		133.022
201-212				
501-506				
ADDED SCOPE	THRU 12-26-65	5.027	THRU 12-18-66	15.840
KSC ON-SITE EFFORT		17.265		18.128
S-V FOLLOW ON				
507-515		<u>33.847</u>		<u>17.093</u>
FUNDING REQ'TS WITH DECOMMITMENTS		195.130		180.763

ADDED REQ'TS				
BONUS FEE				6.346
S-IB FOLLOW-ON 213-216				6.384
BETA III GSE & FACILITIES				1.500
REPLACEMENT STAGE				<u>.470</u>
TOTAL FY 67 FUNDING				195.463

FIGURE 17

SATURN S-IVB **ALL PLANTS TOTAL - MANPOWER LOADING PROFILE**

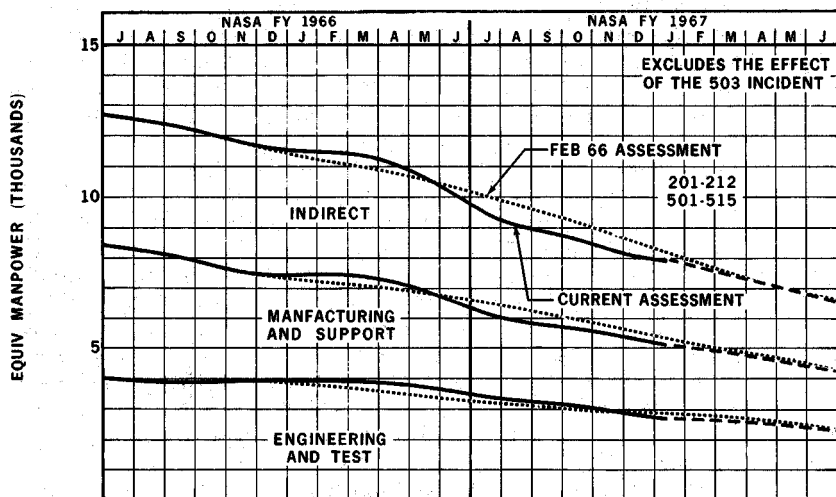


FIGURE 18

SATURN S-IVB 7-101 **NASA FY 1968 FUNDING REQUIREMENTS (MILLIONS)**

AUTHORIZED PROGRAM

S-IB 201-212	108.608
S-V 501-515	
INCENTIVE FEE S-IB AND S-V	8.135

KSC ON-SITE

S-IB 201-212	20.957
S-V 501-515	

SUB TOTAL	137.700
------------------	----------------

PENDING ADDITIONS

S-IB FOLLOW-ON 213-228	25.700
S-V FOLLOW-ON 516-525	10.100
BETA III GSE	.500
REPLACEMENT STAGES	4.200

SUB TOTAL	41.500
------------------	---------------

TOTAL FUNDING AUTHORIZED AND PENDING	178.200
---	----------------

FIGURE 19

if the IB follow-on only is approved, we will be at nine per year. We anticipate (fig. 20) building these Saturn V stages and these Saturn IB's. If the Saturn IB or the Saturn V is not approved, of course, we wouldn't build to 14, we would cut off at eight per year. We would be down to the Saturn V only in the following year and this would be the end of the program. If the Saturn IB's are approved, then we would continue in this fashion and we would have both 1968 and 1969 at nine per year, then drop down to five per year in 1970 and four per year in 1971, and there would be one bird built in 1972.

Now, another option open to NASA is to continue the Saturn V program without the IB. In this case the production rate here at Douglas would look like this (fig. 21). Again, the following year would be seven. There would be no end at 13 or 14. Then the Saturn V would run out in this fashion: five per year in 1969, three in 1970, and three in 1971, and that would be the end of the program. Now if both of these, the Saturn I's and Saturn V's, are authorized, the program would look like this (fig. 22) up to nine for 2 years to 1969, then down to eight, seven, and then we would be down to Saturn V only for 3 more years at three per year.

Mr. DOUGLAS. These programs are the ones that are contingent on the Apollo applications program.

Mr. FRIETAG. Yes, I think the continuing rate is close to four and four per year, for Saturn IB's and Saturn V's.

Mr. SMITH. Yes; I didn't know whether these charts (figs. 20, 21, and 22) were going to make sense or not, but basically, they show how the various production options would affect us here at Douglas, keeping in mind the fact that we are really facilitated and quite capable of higher production than this. Even with the program envisioned, we will only be at a percentage of our capacity.

S-IVB STAGES PRODUCTION RATES BASIC PROGRAM PLUS S-IB (213-228) ONLY

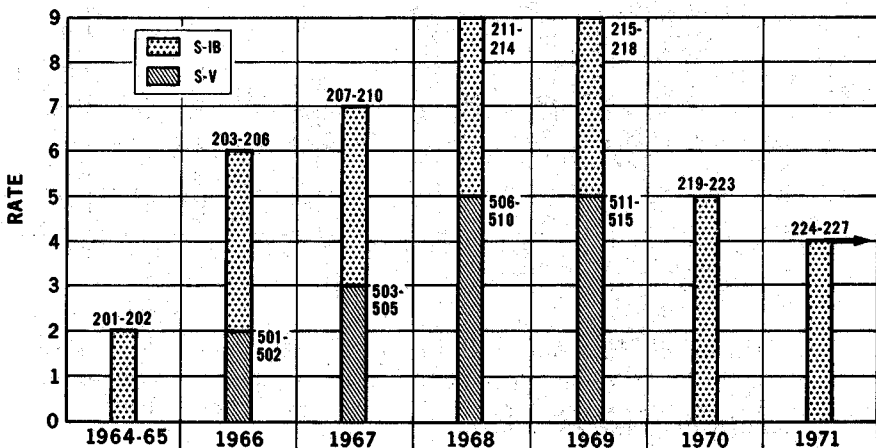


FIGURE 20

S-IVB STAGES PRODUCTION RATES BASIC PROGRAM PLUS S-V (516-528) ONLY

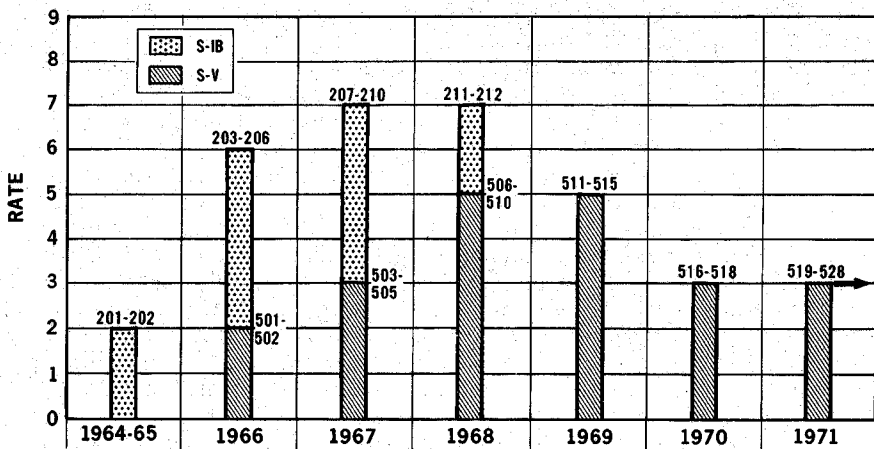


FIGURE 21

S-IVB STAGES PRODUCTION RATES COMBINED PROGRAMS

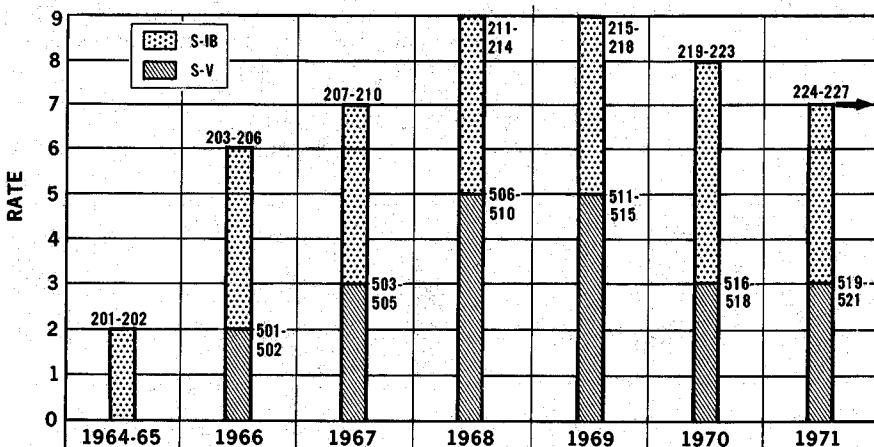


FIGURE 22

Mr. PETTIS. Mr. Chairman, before you go into that may I ask a question? What is the modus operandi for working with prime contractors above you and below you on the birds—as far as mating?

Mr. SMITH. The interfacing?

Mr. PETTIS. The interfacing, with the other companies? I'm ignorant of this, being a newcomer. How do you work with North American?

Mr. SMITH. The vehicle itself, of course, is all contracted by Marshall Space Flight Center. The Boeing S-IC, the North American S-II, and the Douglas S-IVB are built under separate contracts from Marshall.

We have working group meetings, and the interface documents are controlled by the Government. Anyone who makes a change or a request for a change, which would effect an interface, has a set procedure that we go through. Various testing programs are put together with joint participation of the contractors and the Government. I mentioned on the tour that we have tested the structural joints between the S-II and S-IVB here at Douglas, and I assume there are similar programs between North American and Boeing.

We have been involved and we have tested in our 39-foot space simulator chamber the complete Saturn instrument unit, the IBM instrument unit, and its interface with S-IVB upper skirt. They share a common thermoconditioning system. The instrument unit provides a refrigerant fluid that circulates through the cold plates that cool all the S-IVB electronics.

Mr. DOUGLAS. Well, is it true, too, that we make the master tools as a part of that interfacing?

Mr. SMITH. Yes, that's part of the interface, Don, and part of the implementation. An interface drawing is made and controlled by Marshall. Then they contract that out. Somebody makes the tool and they make a duplicate master. One goes to North American and one goes to us.

Mr. TEAGUE. Well, Ted, what about the part General Electric plays in this? In the checkout?

Mr. SMITH. Well, that is at the Cape.

Mr. TEAGUE. They are only at the Cape?

Mr. SMITH. Yes, actually the independence of the three stages is quite complete.

Mr. FREITAG. I think I might make one comment here, in addition to the contract that produces the first stage, Boeing also has a contract for certain total integration responsibilities.

Mr. SMITH. That's true.

Mr. FREITAG. The preparation of much of the common interface documentation and checkout list and so on, is a contract that Boeing has for the Saturn V. Chrysler has a similar contract on the IB. Marshall has the basic responsibility, but Boeing and Chrysler support Marshall in this area.

Mr. ABLE. It's worth pointing out too, Ted, that during qualification testing, where some peculiar phenomena comes out at any one of the contractors, the data is made immediately available to all of the contractors on the Saturn stack.

Mr. PETTIS. Behind my question, being a business type and knowing the fierceness of competition between corporate entities, I just wonder how you have the great grand love affair you see here.

Mr. ABLE. It wasn't to begin with, Jerry. Courting took place and it got better and better.

Mr. PETTIS. I see.

Mr. ABLE. Really, we have had an awful lot of experience with this through our Air Force programs. We have been quite used to the

associate contractor relationship, for a number of years. We all have everything to gain if we make a vehicle work, and everything to lose if we don't make it work.

Mr. PETTIS. That's the real key, then.

Mr. DORRENBACHER. I think it is fair to say that the fierceness is there when you are still competing for a contract. But, once the contract is awarded, then you better work together or you're cutting each other's throats and your own too.

Mr. SMITH. Also pertinent is that for the real integration job on these large programs the responsibility has to go back to the Government. They hired Boeing and Chrysler to help them with their task, but basically, we get our direction from the Government rather than another contractor.

Mr. HALL. Ted, I might say that also from the Government viewpoint, we are very much interested in this type of cooperation. I think in the Apollo program, more than any other program, it has forced this mass integration between prime contractors. It's something they each desire to do, and we are very cognizant of any problems in this local area. We maintain a very close interface between the NASA people at North American, at Rocketdyne, and ourselves. We encourage the exchange of information, and the contractors on both sides are very anxious to do that.

Mr. DOUGLAS. Besides that, we have our Apollo executive council, where frankly we wash everybody's linen in front of everybody else. We happened to have been sitting in council when they had this unfortunate accident at the cape. There are no holds barred at these meetings. There is a list of critical items; it may have a Boeing item, a Douglas item, a North American item, or anybody else's. We all know what all the problems are.

Mr. PETTIS. This is something I haven't come across. Thank you.

Mr. SMITH. There is a tremendous integration task, and it is being handled in a very efficient manner.

Now, let's go on to the Apollo Applications program, and orbital workshop. If the primary objectives of the Apollo program are successful enough it's planned that the first Apollo Applications mission will be a four-bird mission with the spent-stage workshop. The way it is presently envisioned (fig. 23), if and when the birds are converted for this purpose, it's first a dual launch, where Saturn I will carry an Apollo command and service module with a mapping and survey module payload. They would go into orbit at the 125-mile level, perform a 4-day mapping and survey mission. Four or five days later another Saturn I would launch the spent stage with an airlock, and various experiments with the equipment to be used in the spent-stage workshop activity (fig. 24).

Mr. TEAGUE. Ted, excuse me 1 minute. Anybody want him to go through this again? Some of us have seen that chart, Ted, but done in a different way. Jerry and I have seen this chart, and Larry and Earl have seen others not quite the same.

Mr. SMITH. I'll rip through this very quickly then, if you are that familiar with it. I would like to point out the participation that we at Douglas are either doing or hope to do (fig. 25).

ORBITAL WORKSHOP & SOLAR OBSERVATORY 1968-ASSEMBLY, ACTIVATION & INITIAL USE

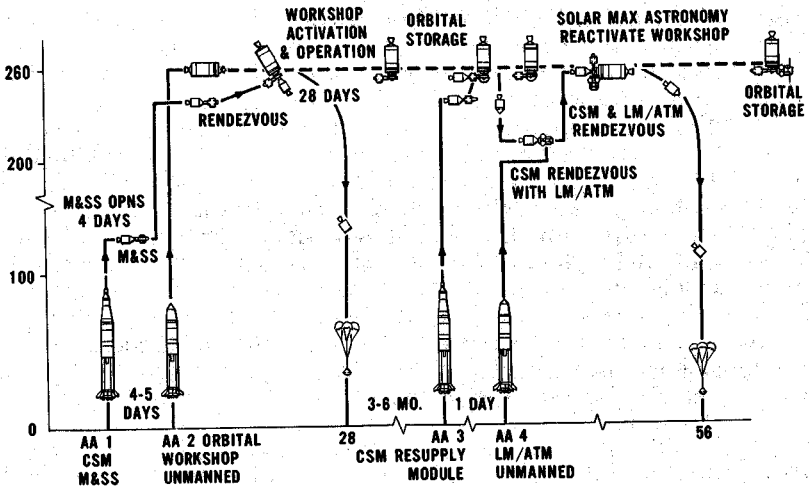


FIGURE 23

NASA DETAIL OF ORBITAL WORKSHOP

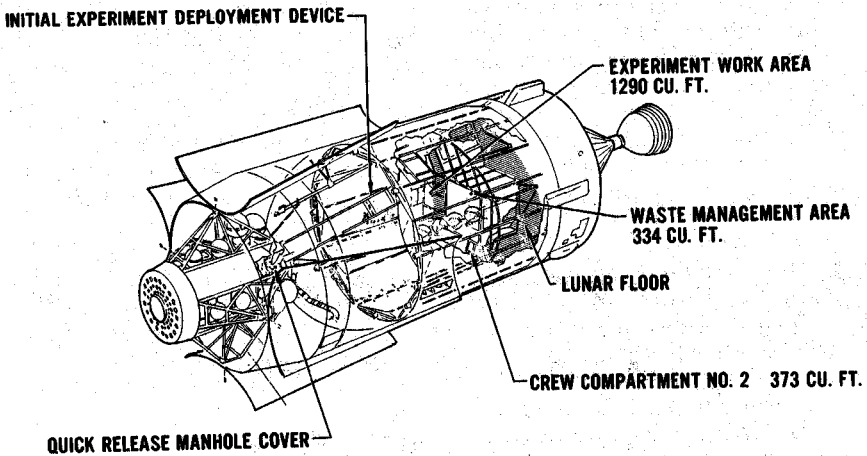


FIGURE 24

Let me go through in this order. One of the three things that we are presently participating in is the passivation system. The first thing the astronauts have to do, before they climb into this spent-stage tank, is to make sure it is safe and that involves venting down, and so forth. The passivation system (fig. 26) now is conceived as an automatic operation. It will be programed into the sequencer in the instrument unit and then automatically the tanks will be vented down. The command destruct system will be deactivated. All of the gas bottles will be depressurized, as well as the gas supplies in the auxiliary propulsion system, to make the tank safe for the astronauts to enter.

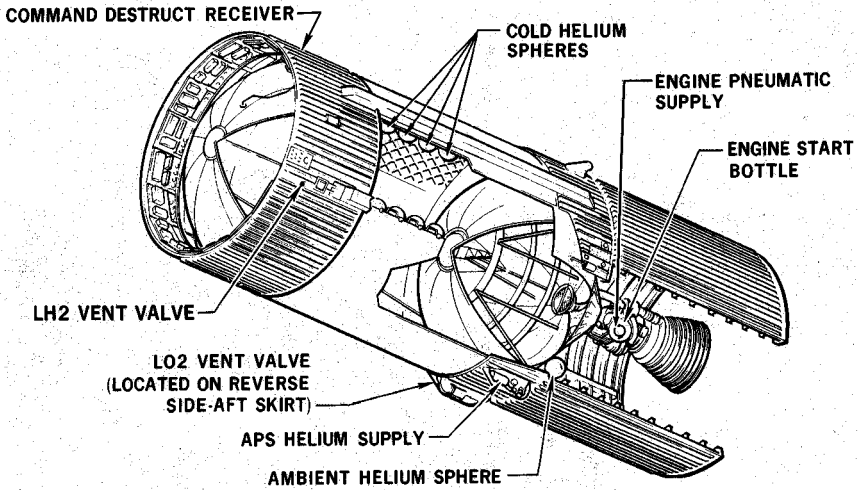
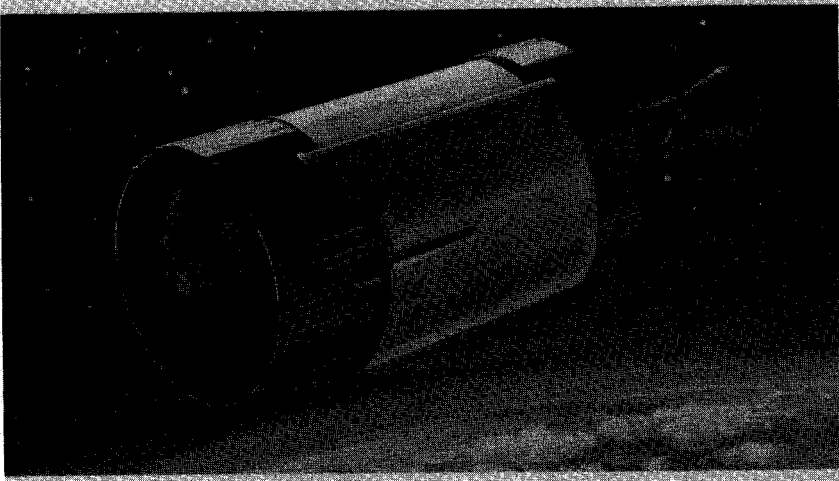
If this thing is to stay in orbit a year, most people feel that some type of meteoroid protection will be needed around the spent stage (fig. 27). We are doing a study and will make a proposal to Marshall. The scheme we like best is the very thin micrometeoroid bumper which wraps around the stage with straps during boost. The straps are disposed of by explosive bolts, after it's out of the atmosphere; the bumper springs out to the optimum distance of 5 inches after you get the thing in orbit, and will provide micrometeoroid protection. It is not completely clear whether or not this is going to be required. We are just looking at various means to do it.

The second thing is a hatch. The Gemini experience has indicated that you don't want to have astronauts undoing 150 half-inch bolts. As we conceive it opening the door is a power-assisted operation (fig. 28). Figure 29 is an artist's likeness of an astronaut opening the hatch. The astronaut would be in the body of the airlock. His only

ORBITAL WORKSHOP TASKS

- PASSIVATION SYSTEMS
- METEOROID PROTECTION
- QUICK OPENING DOOR (HATCH)
- FIRE RETARDANT LINER
- STRUCTURAL INSTALLATIONS

FIGURE 25

STAGE PASSIVATION FOR ASTRONAUT SAFETY**FIGURE 26****METEOROID BUMPER
EXTENDED & COLLAPSED POSITION****FIGURE 27**

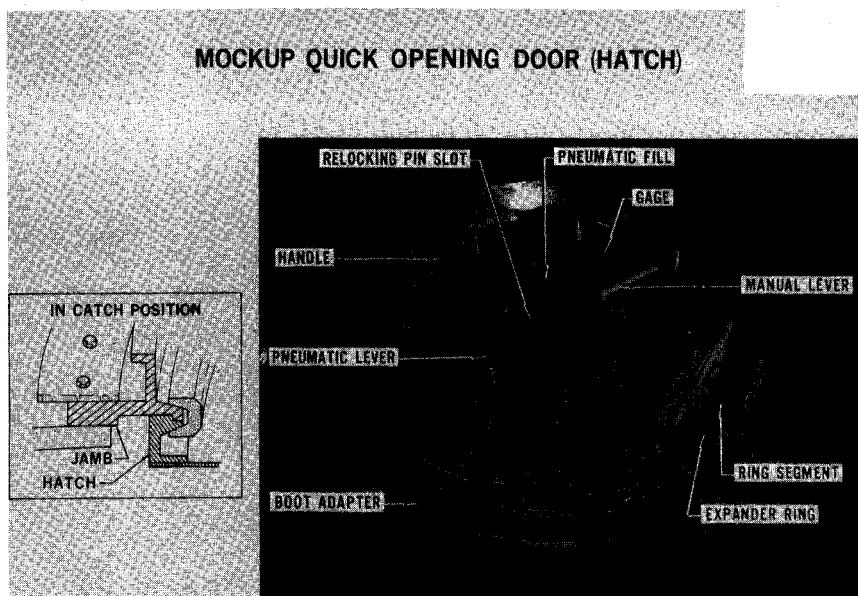


FIGURE 28

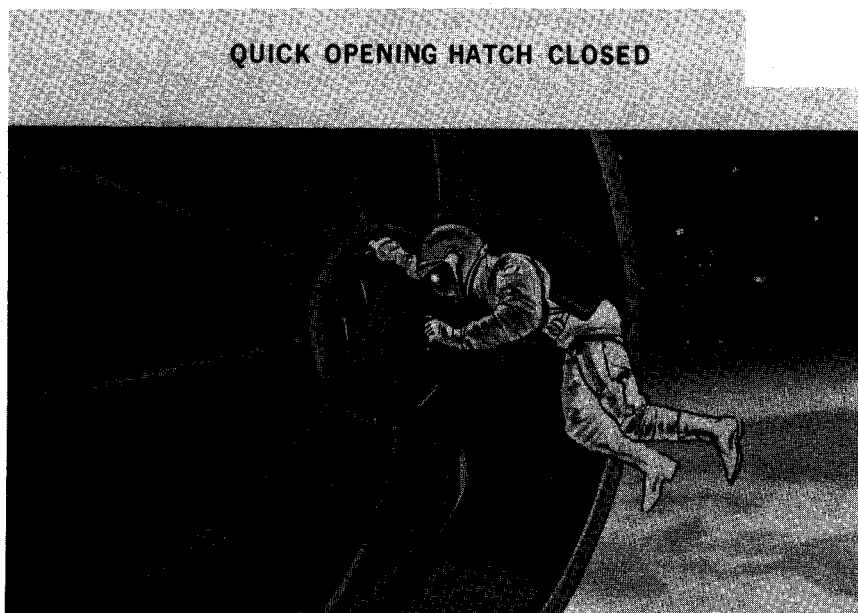


FIGURE 29

action would be to pull a locking pin and actuate a pneumatic lever handle which compresses a split ring which forms the seal between the tank and manhole cover. With the cover of the hatch removed, you can see the source of the power (fig. 30). We have a stored gas bottle, a valve, and an actuator that does the shrinking and allows the hatch to be opened.

The fire retardant liner we looked at in stage 211 this morning. This is an internal shot (fig. 31) of the 8-foot test tank we showed you as we were driving through the building. We have insulated this tank, lined it with aluminum, had it at Sacramento, run multiple cryogenic loadings under full pressure, and checked many different coatings in the tank and determined that the foil was the optimum liner. We are now going ahead and lining the 211 bird.

Perhaps our most basic job is to provide mountings within the tank that various equipments can be attached to the floor, sleeping quarters, and so forth. Each place that the waffle pattern ribs in the tank skin intersect, there is a boss (fig. 32); there is enough metal there that we can insert a stud.

We put about 200 of these in each stage that has a possibility of being used as a workshop, so that there will be a kind of pegboard arrangement that has great flexibility in installing equipment.

Mr. PERRIS. Does the floor for the work area and living quarters attach to these points?

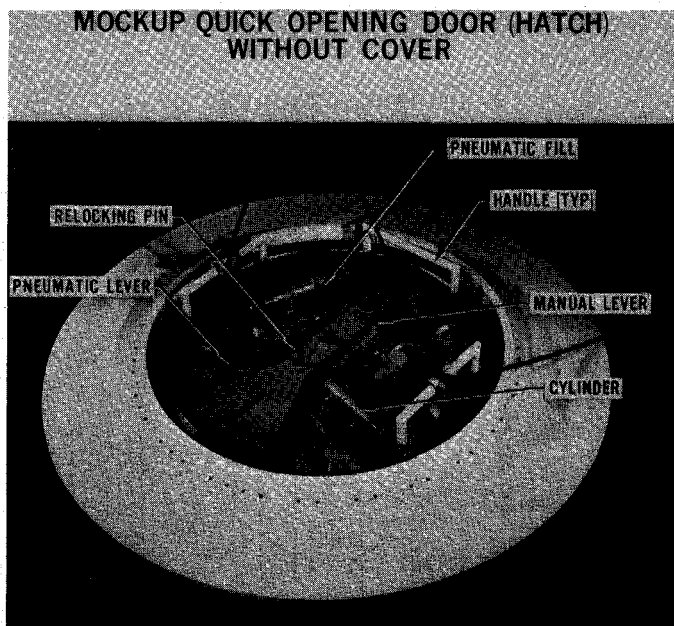


FIGURE 30

FIRE RETARDANT LINER APPLICATION 8 FT TANK

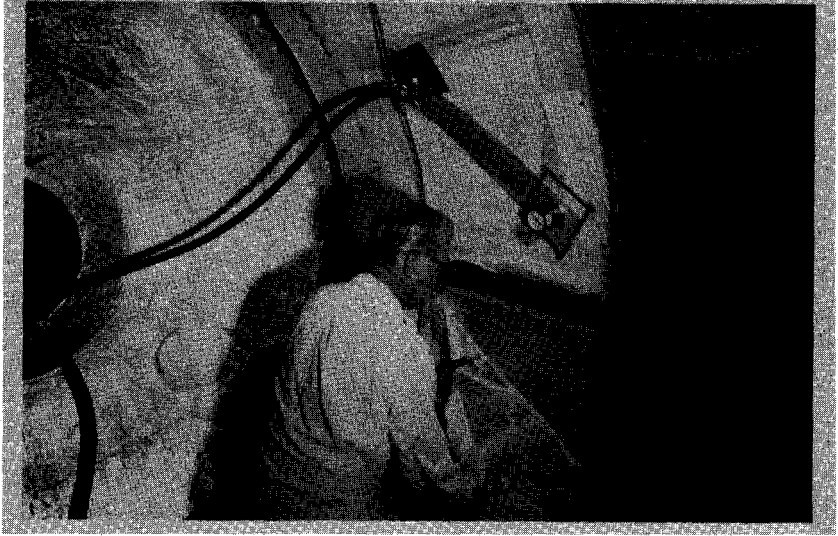


FIGURE 31

ORBITAL WORKSHOP ATTACHMENT DETAIL

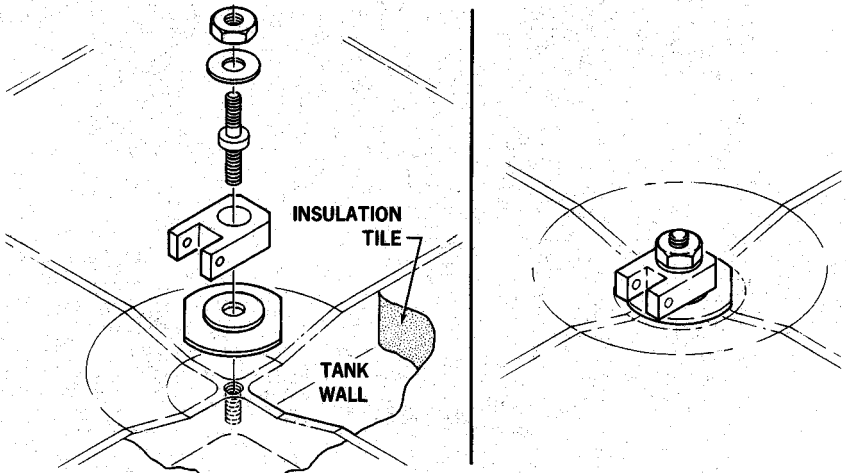


FIGURE 32

Mr. SMITH. Yes. This is shown in figure 33. The crew quarters and work area are toward the bottom of the liquid hydrogen tank. The following series of slides, figures 34 through 39, show some of the experiments and their locations within the stage. These are the presently proposed experiments. Our primary involvement in this program is how these experiments and the associated hardware attach into the tank area.

ORBITAL WORKSHOP WORK AREA & LIVING QUARTERS

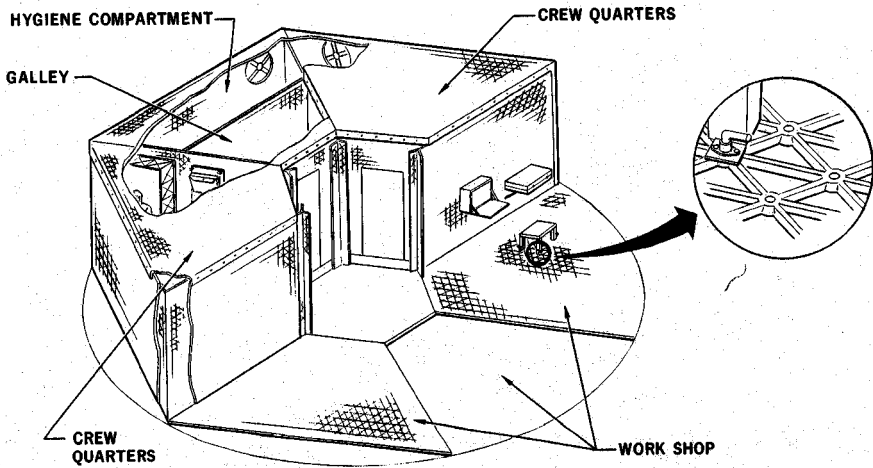


FIGURE 33

WORK AREA

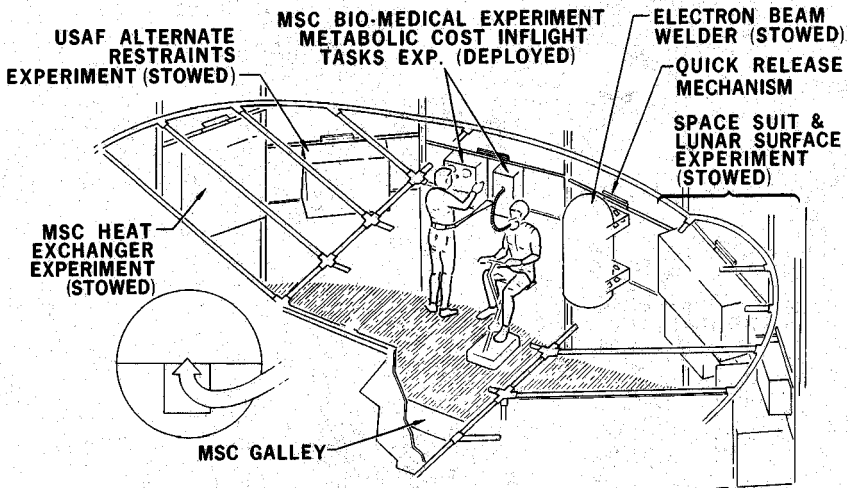


FIGURE 34

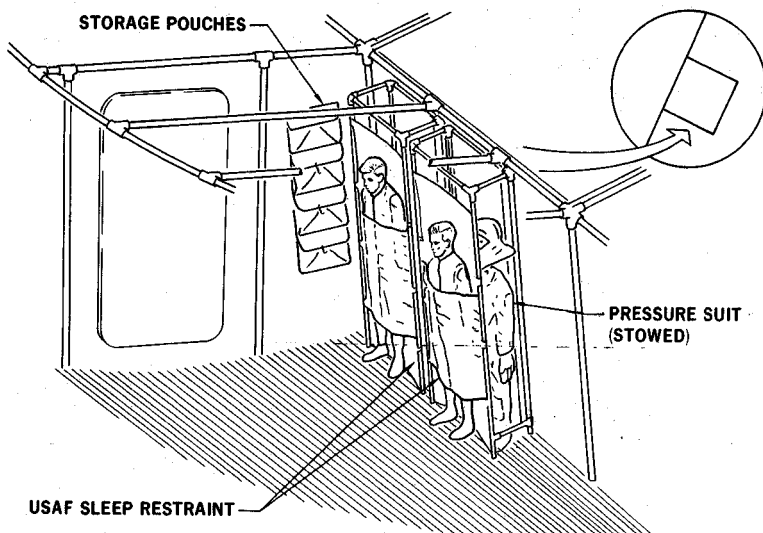
CREW COMPARTMENT NO. 2

FIGURE 35

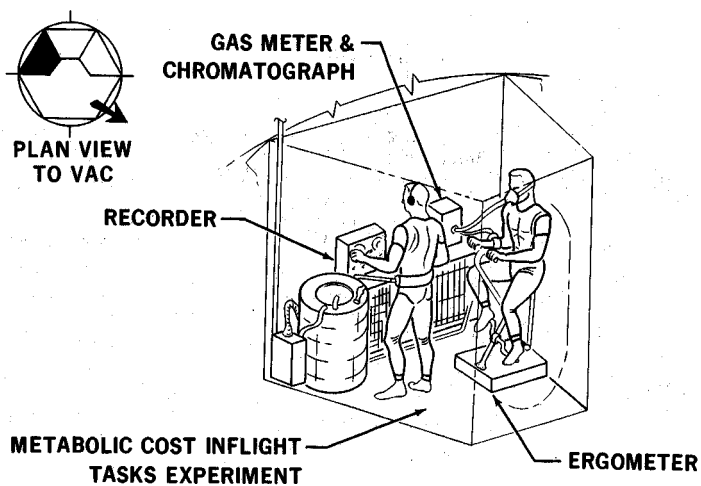
BIO-LAB UTILIZATION (HABITABILITY)
240 CU. FT. ENCLOSED VOL. CPT.

FIGURE 36

BIO-LAB UTILIZATION (HABITABILITY)

240 CU. FT. ENCLOSED VOL. CPT.

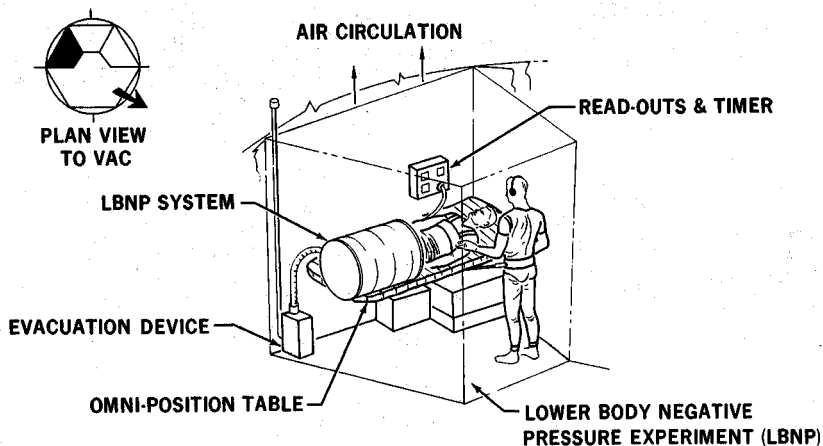


FIGURE 37

ORBITAL WORKSHOP

HIGH PRESSURE GAS EXPULSION EXPERIMENT ZERO 'G'

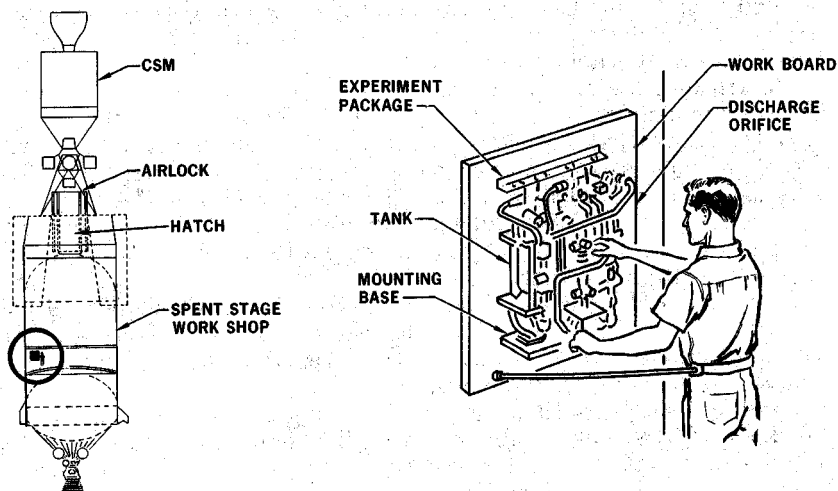


FIGURE 38

ORBITAL WORKSHOP **HEAT EXCHANGER SERVICE EXPERIMENT ZERO 'G'**

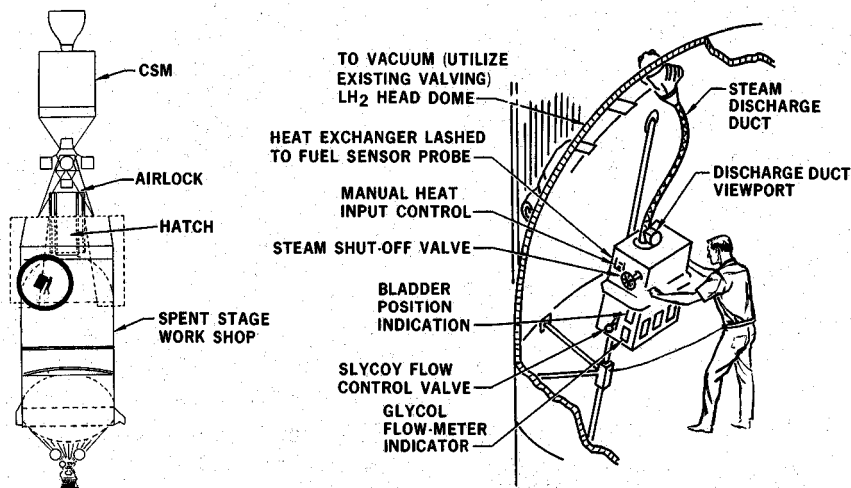


FIGURE 39

Now the one other thing that we have been asked to look at by Huntsville, is what does it take to make the Saturn V suitable for a synchronous orbit? A synchronous orbit is 22,000 miles. An orbiting body rotates at the same rate the Earth turns and you can make a payload hover over a given spot, or over a figure eight area crossing the equator, if it is nonequatorial.

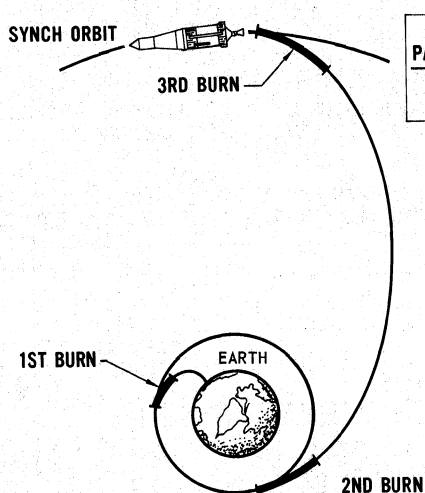
We are in a 2-month study to see what we would have to do, and most of the changes would have to be in the S-IVB. We have completed a study that indicates that the best way to get into a synchronous orbit is a three-burn mode (fig. 40). We burn into earth orbit as we do in a lunar mission. But we don't use all of the remaining propellants as we would on a lunar mission, in going into the transfer orbit. Then we relight the engine for a third burn to inject into the synchronous orbit.

There is a 13-hour coast time for the S-IVB in this mode and you can see the payloads that can be achieved in the synchronous orbit for whatever missions are approved. Our net working payload varies between 60,000 and 70,000 pounds.

To date, it appears that outside of making the engine capable of a third start (it is now capable of two), the changes necessary for this mission are relatively minor and inexpensive (fig. 41). We would have to have some battery changes for capacity; we would have to have a little more high pressure gas capacity; and minor modifications to the J2 engine. Additional slosh baffles would be needed in the hydrogen tank; a little different and longer duration thermal protection system for the electronics. It looks as though the auxiliary propulsion system would need a little more propellant and a very minor

SYNCHRONOUS ORBIT

THREE BURN S-IVB, S-IVB INJECTION



PAYLOAD	EQUAT $i=0^\circ$	INCLINED	
		$i=28.5^\circ$	$i=64^\circ$
MAX WT IN SYNCH ORBIT	95,000	103,100	97,000
NET WT ABOVE IU	59,800	67,900	61,800

HOVER POINT SELECTION

COMPLETE EARTH COVERAGE

NUMBER OF S-IVB ENGINE STARTS

THREE

S-IVB COAST TIME

13 HOURS

FIGURE 40

SYNCHRONOUS ORBIT

SIGNIFICANT HARDWARE MODIFICATIONS

- ADD 1 BATTERY AND CHANGE 1 BATTERY IN FORWARD SKIRT
- ADD 2 BATTERIES AND CHANGE 2 BATTERIES IN AFT SKIRT
- ADD 2 COLD HELIUM BOTTLES
- ADD J-2 ENGINE RECHARGE LINE IN ENGINE AREA
- ADD LH₂ AND LOX SLOSH BAFFLES
- ADD ACTIVE AND PASSIVE ELECTRONICS THERMAL PROTECTIVE SYSTEMS
- ADD AUXILIARY FUEL TANK TO APS
- REPLACE TRANSMITTER AND AMPLIFIER AND ADD A COAX SWITCH

FIGURE 41

change in the communication gear. But, all in all, it looks as though this hardware is extremely versatile with very minor changes.

The conclusion (fig. 42) of the S-IVB program report—just to repeat a few points I would like to make—is that we are experiencing substantial underruns in manpower, under what we predicted last year. Discounting the effects of the 503 incident, in general, we are either on schedule or ahead of schedule in delivering stages for the Government need date. We have had a failure, we have determined the cause, and have taken preventive action. We can meet our commitments to Cape Kennedy.

If the program is to continue to run in an efficient manner, we will need timely contract authorization for the follow-on stages in the coming year.

Generally, it looks as though the S-IVB is a very versatile piece of hardware, that with minor modifications can be made to do many other missions than the current Apollo mission.

CONCLUSIONS

- SUBSTANTIAL UNDERRUN FOR FY '67 COST AND MANPOWER PROJECTIONS PREPARED LAST YEAR
- PROGRAM DELIVERIES IN ADVANCE OF CONTRACT REQUIREMENTS
- CAUSE OF 503 INCIDENT DETERMINED AND CORRECTIVE ACTION BEING TAKEN
- KSC STAGE REQUIREMENTS CAN GENERALLY BE MET
- TIMELY CONTRACT AUTHORIZATION FOR FOLLOW-ON PROCUREMENT REQUIRED
- S-IVB STAGES ADAPTABLE TO ADVANCE MISSIONS, SUCH AS ORBITAL WORKSHOP AND SYNCHRONOUS ORBIT

FIGURE 42

ADVANCED TECHNOLOGY

(Remarks by C. R. Able, Group Vice President, Missile and Space Systems)

Our next topic is advanced technology. The space-directed programs within the Missile and Space Systems Division's area of future interest are the responsibility of our Advanced Systems and Technology directorate.

We often describe this entire advanced technology operation as analogous to working with technical building blocks. In effect, the AS&T engineering staff creates the building blocks that will eventually comprise a space system. In practice, as each building block requirement is identified, every aspect is researched and engineered until it becomes technically practical.

This activity is supported by our own Independent Research and Development (IRAD) program and by Contract Research and Development (CRAD) funding. The projects and programs undertaken are relevant to and directed toward a matrix of selected end-point systems. Typically, they are study contracts or technical building blocks experimental contracts that range in funded cost from a few thousand dollars to as much as \$3 million. The total effort in our Advanced Systems and Technology activity now exceeds \$30 million a year.

Since 1961-62, when we established a separate program for manned spacecraft, the considerable expenditure that we have made advanced our technological capability until we were able to bid for and win the contract to design and build the Manned Orbiting Laboratory. Our "homework," these IRAD and CRAD funded studies and experiments, was the most important factor contributing to that success.

By identifying what the general needs of the manned space station business were, and by doing our homework, Douglas has become qualified to lead the way in the development of manned space stations. Through these processes, we have been able to systematically resolve the technical problems that were critical to the space station development. We are still conducting studies and experiments that will lead to the eventual development of increasingly sophisticated space stations.

Looking ahead to a more diversified manned space program, we are now conducting studies of problems ranging from those associated with the approaching need for reusable spacecraft and launch vehicles, to the development of nuclear stages and new concepts for providing secondary power. Our belief that maneuverable spacecraft and lifting-body entry vehicles will constitute important steps in the evolution of reusable spacecraft has prompted us to supplement our contracted studies in this area with company-funded studies.

In a similar manner, our Advanced Systems and Technology operation is also concerned with missiles.

Obviously, when operations become as complex as those concerned with manned space and sophisticated missile programs, it is vital to identify goals that will contribute most to the mainstream technical requirements and which are most compatible with the company's technical and financial capability. The net result of this kind of logic is an orderly progression of building block capabilities.

These are not, however, easy goals to achieve. They preclude the "shotgun" approach. Instead, they make it necessary to take careful aim at well defined objectives that have as an end product a specific building block immediately related to the requirements of the company goals.

The importance of being selective in AS&T activities, and the need to build a high degree of technical competence have become more and more pronounced as systems continue to reach higher levels of sophistication.

This trend is continuing. Today, competition is so strong because all of the organizations that can legitimately compete for major contracts have had to follow courses similar to the one we have taken. Capabilities have to be achieved before definitive descriptions of future systems are available. Established capability in the required disciplines has become so important that no organization can be considered capable of designing and building the future space systems unless it has had previous recognition and contract support from the Government's technical laboratories. It is highly impractical for a proposing contractor to bid on a future system unless he has done his homework through related study contracts and experiments. The work and cost required to attain this kind of capability makes it almost imperative that the contractor win the majority of those competitions for which he has worked to qualify.

Our next speaker, Jim Dorrenbacher is responsible for the direction of MSSD's research and development activities that lead to the major system contracts. As vice president in charge of the Advanced Systems and Technology organization, he is most qualified to describe our space-directed programs and projects, how they influence Douglas as a contractor and what they contribute to the future of the United States in space.

Jim directs an engineering team that consists of over 1,000 highly qualified engineers, each a specialist in one or more aspects of advanced technology—this group is separate from our Development Engineering Department. The members of this group are chartered to concentrate their efforts on systems and technology programs that will be realized as state of the art developments 3 to 10 years in the future.

ADVANCED SYSTEMS TECHNOLOGY REVIEW

(Presented by C. J. Dorrenbacher, Vice President, Advanced Systems and Technology, Missile & Space Systems Division)

I kind of feel like the dog in the dog and pony show—I've talked to members of your committee three times before, Mr. Chairman, like Ted Smith. They are probably getting tired of seeing us.

Mr. TEAGUE. No, sir, Jim, I don't think so.

Mr. DORRENBACHER. Everytime I stand before you, I feel kind of humble, because I'm really trying to talk on a subject which is much broader than any one contractor—namely, what does the future look like?

Today, rather than bore you with a lot of pet concepts, I will try to use some suggested concepts as a way of putting into perspective what we believe the next 20 years of the space program should hold.

You have to start by talking about cost and effectiveness, in whatever context our national space goals appear.

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 personnel 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 pre-

dominate, as opposed to simple Government utilization for experimental purposes.

Now, in that broad context of cost and effectivity, the discussion today should be broken into two parts: first, the near-term problem—the decisions that must be made now and in the next 2 or 3 years to provide us with the next 10 years of capability. The second part is the long-term problem—those decisions for which the technological work must be done within the next 5 years, to allow us to make decisions on 5- to 15-year hardware programs after the 5 years.

Starting with the near-term problem, it seems clear that our efforts and decisions will fall in four general categories (fig. 43). First, there is the need to develop an Earth orbital operations capability for civilian and scientific use. Second, depending upon what man finds when he lands on the lunar surface, decisions will have to be made that will establish the follow-on lunar exploration tasks. The third category of decisionmaking for the near-term future is concerned with the need for an improved transportation capability. These improvements will be needed to accommodate the increased demands for Earth orbital capabilities, lunar exploration, and the unmanned planetary program. The fourth category, unmanned planetary missions, will provide the information required to make decisions concerning the future of manned planetary missions.

One of the first priority considerations to be faced in the near-term future is the function and mission capability of manned earth orbital space stations. In this area, many configurations and functions have been proposed. The S-IVB cluster (S-IVB workshop) shown in figure 44 is a typical example of an early configuration. It utilizes a spent S-IVB stage as the manned workshop area and incorporates adapter systems to accommodate docking other spacecraft. This configuration is also designed to incorporate a telescope. Regardless of the configuration, the basic intent of this first Earth orbital program is

NEAR TERM FUTURE (0-10 YEARS)

- EARTH ORBITAL - CIVILIAN AND SCIENTIFIC
- LUNAR EXPLORATION FOLLOW ON
- TRANSPORTATION IMPROVEMENTS
- UNMANNED PLANETARY

FIGURE 43

S-IVB CLUSTER

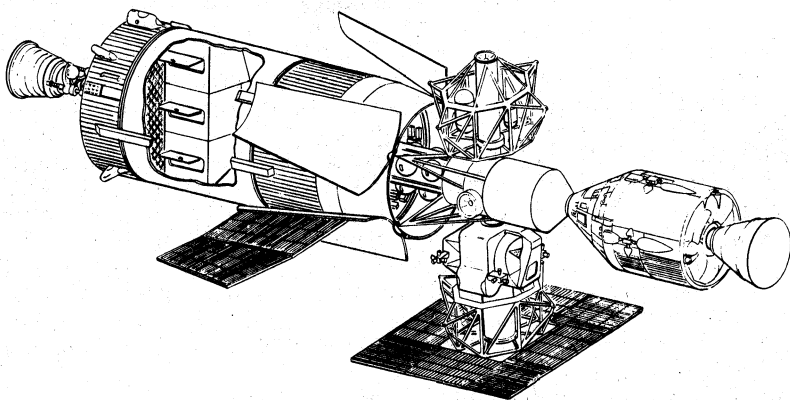


FIGURE 44

to accomplish a variety of specific tasks that will provide basic information about what can be expected in terms of the economic utilization of space by civilian and scientific personnel. The Manned Orbiting Laboratory contract that we have here at Douglas also marks a beginning step in this direction.

Basically, the near-term future space station goals must be concerned with the need to appraise what can be accomplished with multispectral sensors; and find out about the psychological and physiological reaction of men when they are subjected to the space environment for long periods of time. These first step requirements are comparable to the utilization of Gemini to develop rendezvous techniques.

The psychological and physiological aspects of this initial program will contribute much to the science of medicine and human behavior. The use of Earth sensors will demonstrate the potential value of space stations as platforms for geographical, topographical, national resource, and weather surveys. The proposed communications experiments will help to determine the utility of using manned space stations as relay and transmission systems. The economic aspects of these applications are readily apparent. To achieve economic utilization of space, there is an important requirement for developing methods of resupply. Problems such as the difficulty of transferring liquids in space must be resolved. Without this capability, the very important economic advantages that are anticipated cannot be achieved. The accomplishments of these and related near-term goals will provide the increased efficiency that had been extrapolated for the long-term future.

Ultimately, it will be necessary to get the scientist to the space station where he can operate his own testing equipment. With that purpose in view, within 10 years an astronomer on board the space station will look through a 100-200-inch telescope into space. When that day comes, this scientist is going to learn more in the first year than

has been learned since mankind first began to watch the stars in the sky.

Learning to meet the scientific and logistic requirements of space station operation will supply the fundamental knowledge required for Earth orbital operations. This is the challenge now. In a sense, this Nation has arrived at the second milestone in its space program.

In fiscal 1968 two tests must be faced: now that the latest designs are beginning to come together as hardware, the effectiveness of this hardware for use in future missions must be appraised; then it must be decided whether to maintain that capability or whether to continue to improve the ability to operate in space. Merely permitting the status quo to continue during fiscal 1968 will amount to a negative decision, and will be as though this Nation had deliberately elected to stop improving its space mission capability. If nothing is done, industry's technological capabilities, in terms of experience, and available technical manpower, will have deteriorated by 20 to 30 percent by the end of fiscal 1968. Because most space directed funding is going into hardware, the developmental technologies are not being utilized at their most effective level.

This developmental technology is a most important facet of the industry's capability; it is the leading edge of our Nation's competence to achieve and maintain a dominant international role in space and planetary exploitation. Among the next steps that must be taken to maintain this capability is the development of self-contained space station packages that can rendezvous in space. Then, a more sophisticated device, still in the "brute force" category, will be needed. An example of this kind of system (fig. 45) is an S-IVB stage completely equipped before it is launched, as opposed to rendezvous and

S-V DRY LAUNCH

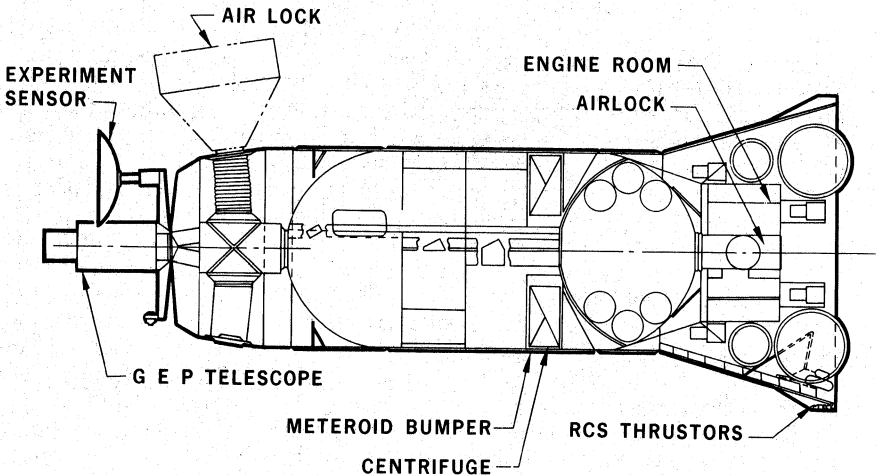


FIGURE 45

furbishment after the stage is in orbit. Something similar to this example is the next logical step. This is merely one concept. For example, the same purpose can be accomplished by clustering manned space stations and launching them on a Saturn V. In this late concept, the clustered laboratories would be deployed in a spoke configuration, or in other configurations, depending upon the nature of the mission. The basic difference between orbiting a number of space station components and then rendezvousing and assembling them in space, or orbiting a completely equipped laboratory system, primarily involves the sophistication level of the sensing and observing equipment that can be employed. In the first instance, sophistication is limited by the size and weight of equipment that can be delivered to rendezvous and connected. At present it is quite difficult and expensive to perform interconnections and manufacturing operations in space. Tools and techniques for this purpose are still in the rudimentary stages of development. As a consequence of these limitations, it is not possible to employ large, complex sensing and observing equipment. To achieve that capability, it is necessary to accept the increased complexity of having to orbit larger payloads and support larger crews.

This second step, orbiting large payloads, is more useful but it is still part of the brute-force method in that no attempt is made to improve the logistics cost pattern. However, the most acceptable approach has always been to keep the investment cost as low as possible while the programs are in the early development stages, even though a penalty accrues in the cost of operations. Although the step 1 system is assembled in orbit and the step 2 system is furnished and launched from the ground intact, both are brute-force systems. First these systems will be used in lower orbits; then they will be used in synchronous orbits. The data obtained from these missions will provide the information leading to the development of long duration space station operations.

Essentially, the approach to lunar exploration will follow the same growth pattern that has been assumed for Earth orbital missions. For lunar explorations, first there were the photographic orbiter missions, then, a soft landed photographic mission on the Moon. Soon, the Apollo lunar orbiting and landing mission will be undertaken. What should come next in the logical progression appears to closely parallel the missions that will probably be assigned to the Earth orbiting space stations mission. At this junction, it appears advantageous to orbit a sophisticated payload around the Moon to complement the Apollo landing capability. The lunar applications of spent stage-orbital (LASSO) survey mission shown in figure 46 is a typical example of this kind of support capability. Again, the precise configuration is not the important consideration.

What is important is that, through extensions of the existing Apollo hardware, it is possible by this method to obtain the capability to map the lunar surface from an orbiting vehicle. This capability, in conjunction with lunar surface activities, will greatly improve the capability to explore the lunar surface.

In reply to those who doubt the scientific and economic worth of lunar exploration, I should like to say that I believe that by ex-

LASSO SURVEY MISSION

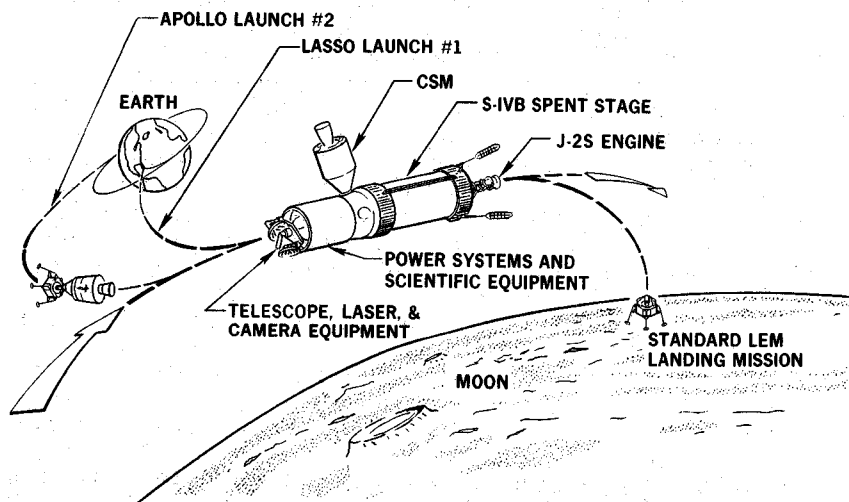


FIGURE 46

ploring the Moon, this Nation will learn enough about the origin and structure of the Earth to more than pay for the effort. Many other kinds of information and scientific opportunities will present themselves during this era. And although I will not list them here, I am personally sure that each of them will, in time, return far more than the cost of the initial adventures.

After the first missions to the Moon, when follow-on missions such as lunar applications survey are undertaken, a situation will exist which is similar to the one extrapolated for the Earth orbiting space stations. It will be necessary to have an expanded capability beyond that of the initial Apollo configuration in order to accommodate the requirements of the scientific observers who will necessarily accompany the astronaut-pilots on these missions. To meet this requirement, payloads must be greatly increased and the transportation system will have to be modified.

It appears entirely feasible to expand the basic capabilities of the Apollo hardware to facilitate greater lunar landing payloads. One possible configuration is shown in figure. 47. The figure illustrates a lunar application for spent stages (LASS). This configuration can be achieved by adding two throttleable engines to, for example, the S-IVB stage. By utilizing such a system it will be possible to land appreciably larger payloads on the lunar surface. Achievement of that capability will have accomplished a large part of the objective of accommodating scientific investigators on the Moon.

The general pattern of Earth orbital activities, extended lunar orbiting, and lunar surface operations appears to be the most feasible direction to take in the near term future. The configurations of the hard-

LASS OPERATIONS

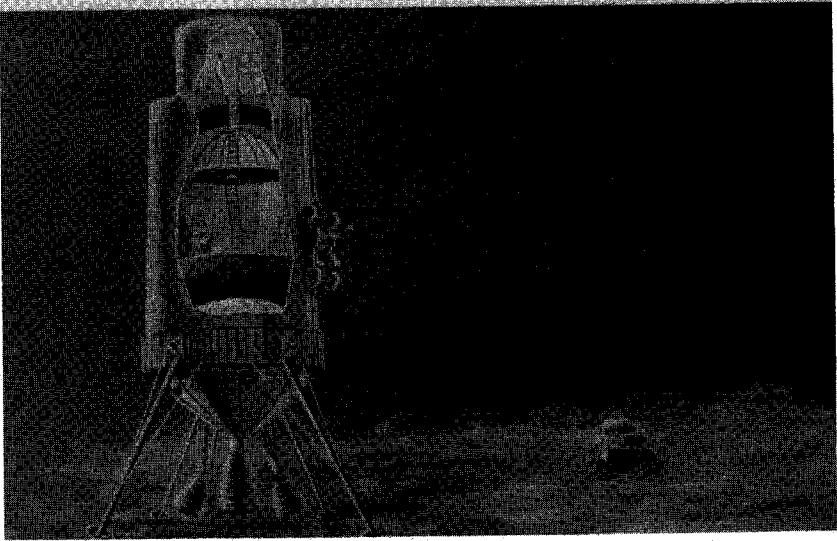


FIGURE 47

ware required to accomplish this purpose are not the most immediate considerations. What is important are the decisions that have to be made in the immediate future in order to support this kind of progressive increase in space operations capability. Progressing in this fashion will make it possible to maintain the required level of industrial competence and provide for a smooth transition from the Apollo hardware configurations and capabilities to the eventual capability that will be available when a reusable transportation system has been achieved. The hardware that will be available if this kind of transition is undertaken will provide a usable base for about 10 years.

While it will not be feasible during this transition period to significantly change the efficiency of the transport system, it will be possible to deliver larger and larger payloads. Using the Thor and Delta systems as an example, the payload capabilities have been increased by a factor of 4 or 5 over the original configurations, at essentially no increase in launch cost. When we described that progression at one of our previous conferences, we said that we were studying a similar pattern to increase the efficiency of the Saturn vehicle.

A possible candidate growth pattern for the uprated Saturn I is shown in figure 48. The corresponding cost pattern as a function of this growth pattern is shown in figure 49. It looks very similar to the corresponding cost pattern that we showed you at our last meeting. If we propose to follow a growth pattern similar to that of the Thor, the incremental increase in payload capability will be obtained in a similar manner. As payload requirements increase, the Saturn vehicle can be uprated to match. Assuming that payload requirements con-

UPDATED SATURN I - GROWTH CONFIGURATION

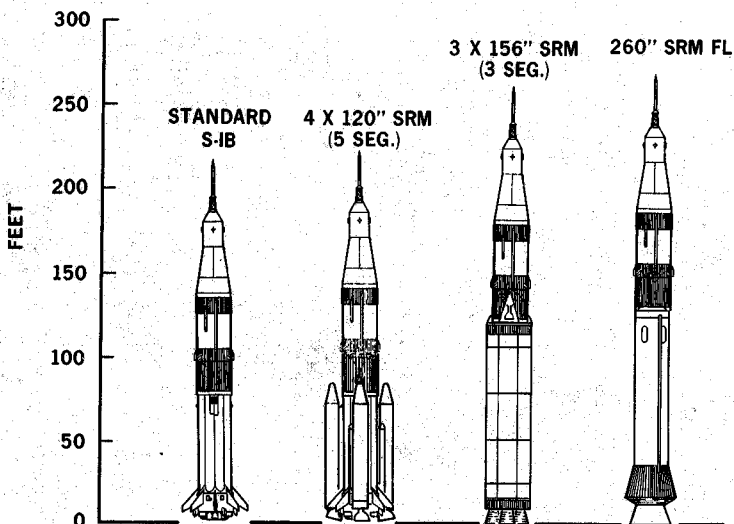


FIGURE 48

UPDATED SATURN I - OPERATING COST

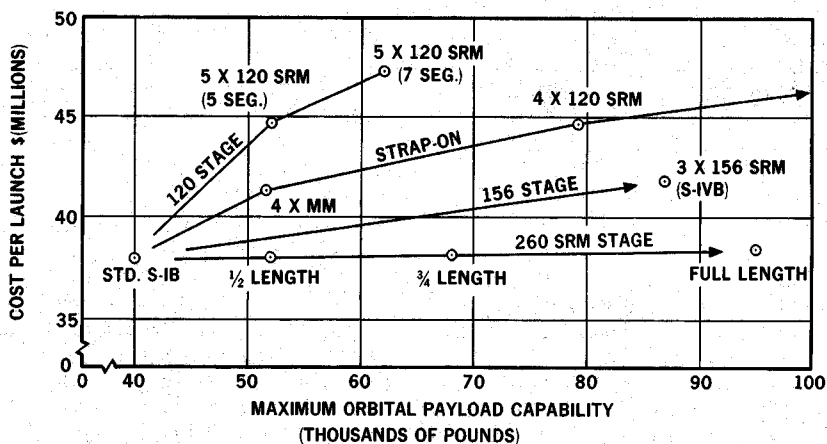


FIGURE 49

tinue to follow the pattern that has been established in the past, the first uprated configuration will utilize strapon booster elements. In the second uprating cycle, solid basement stages comprised of 156- to 260-inch motors will be employed. This uprating option is limited at about 100,000 pounds.

The decision to uprate the Saturn IB does not have to be made until after specific payload requirements have been established. However, it is important to insure that funding is available for development options to meet increased payload requirements. Except that there are more options available, the Saturn V uprating would follow a pattern similar to Saturn I (fig. 50). There is an additional option because it is possible to use a higher pressure engine. Again, where the payload capabilities can be increased by a factor of 2 or more, the cost pattern (fig. 51) is similar to the one shown for Saturn I. Essentially, operating costs remain constant. As with Saturn I, the precise pattern of growth is not the major consideration. However, it is important to anticipate operating requirements so that they can be accommodated when specific payload requirements have been established.

Increased payload capabilities and uprated booster systems constitute the general growth pattern that we believe will be the most practical approach to improvement in the near term future. We believe that it is possible to increase transportation efficiency by a factor of 2 or 3, both in the Saturn I and Saturn V class of hardware. This kind of increase is the first step toward achieving the 50-fold improvement in system effectiveness which I have proposed can be achieved within the next 20 years.

Certainly, the uprating philosophy applies to the projected hardware for manned planetary systems. The same uprated transportation system, assembled as shown in figure 52, can be employed for manned planetary flyby missions. Accompanied by unmanned probes

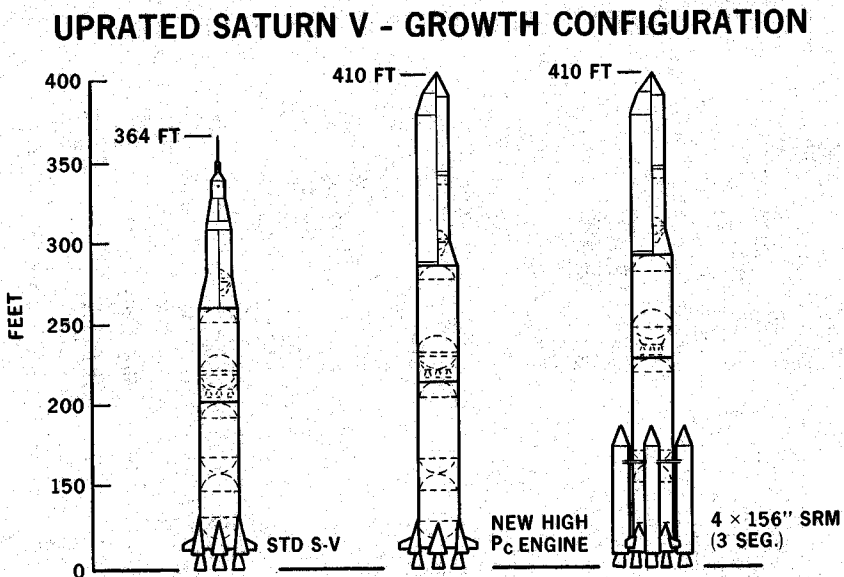


FIGURE 50

capable of planetary sampling, this form of transport can be feasibly employed in the near-term future. The configuration (fig. 52) employs the Saturn V vehicle and terminates in an orbital assembly which consists of three S-IVC stages and a payload. The S-IVC stage is a modified version of the S-IVB. It employs the same engine,

UPDATED SATURN V - OPERATING COST

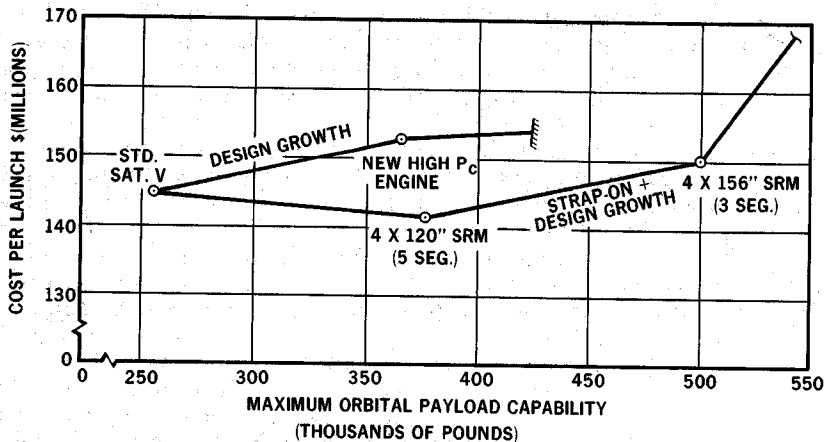


FIGURE 51

PLANETARY ORBITAL LAUNCH VEHICLE

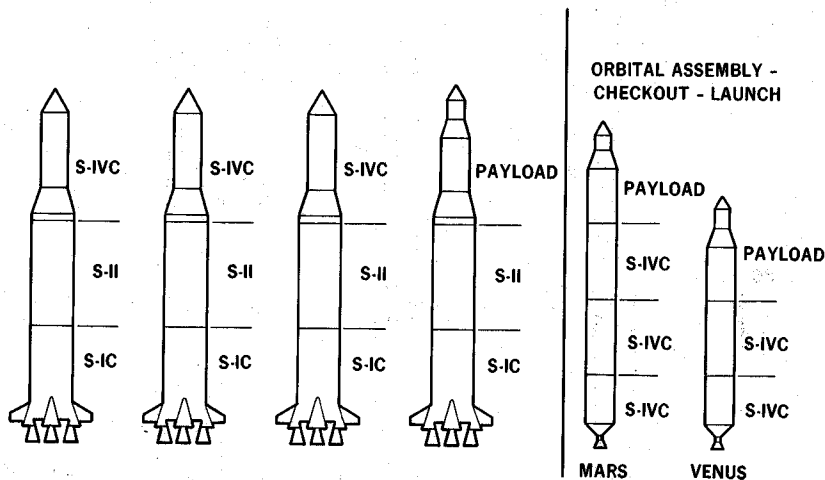


FIGURE 52

but is capable of sustaining longer coast periods and it can be assembled, checked out, and launched from orbit. This version incorporating three S-IVC stages could deliver a 200,000-pound payload to Mars. A two-stack version could deliver the same payload to Venus. These systems, used for planetary flyby missions, could obtain a sufficient quantity and quality of data to permit a decision to be made relative to manned planetary landing missions. If the data thus obtained supports the feasibility of a manned planetary landing, and if the decision is made to support such a program, the transition to nuclear stage hardware will have to be undertaken. Meanwhile, merely by modifying existing hardware, it will be possible to accommodate the required missions leading to a planetary landing decision.

These then are the near-term future decisions that must be made: goals for civilian and scientific utilization of space must be established during the next 10 years, there must be definitions of the follow-on lunar exploration missions, the sequence of transportation improvements must be established, and the requirements for manned planetary exploration must be defined.

Concurrent to the problem of defining the goals for the immediate and near-term future are the additional problems inherent to the long-term decisions that must also be considered. At present, it is not necessary to commit hardware or to define specific long-range programs, but there is a very real need to commit Government and industry to the task of acquiring the advanced technologies that will have to be available in the future. At Douglas we are firmly convinced that there are five major elements which we can identify as keys to the future of our space program (fig. 53). There is urgency and need to commit ourselves to the task of acquiring the advanced technologies that will contribute to realization of these long-term building block capabilities.

LONG TERM BUILDING BLOCKS (5 TO 20 YEARS)

- LONG DURATION ORBITAL EXPERIENCE
- REUSABLE SPACECRAFT
- REUSABLE LAUNCH VEHICLES
- NUCLEAR STAGES
- SECONDARY POWER

FIGURE 53

Long duration Earth orbital capability has been identified as one of the major long-term building block capabilities that must be acquired within 5 to 20 years. Obtaining this experience will begin with the first orbiting workshop. The end product of that experience will be the accumulation of data to describe a space station that will function with optimum efficiency in Earth orbit or on planetary missions.

Many concepts for permanent orbiting space stations have been advanced. The configuration shown in figure 54 is one which both NASA and Douglas have studied extensively. The most unique feature of this concept consists of the optimization of subsystems to reduce resupply requirements. In this instance, resupply requirements were reduced by incorporating a sophisticated environmental control system which, because of its closed cycle operation, reduces the logistics requirement for that subsystem by a factor of three. The other subsystems amenable to that kind of approach are also designed to reduce resupply requirements to a minimum. The size of the vehicle is limited to a level which affords sufficient space to accommodate the mission-required equipment and personnel, but which is no larger than necessary to perform the functions for which it was intended. Again, with optimized logistics requirements as a basic design constraint, the vehicle is as small as possible in order to limit the amount of drag; additional drag increases the amount of propellant that must be resupplied to maintain the station in orbit.

When these permanent space stations have been orbited, they will make it possible to consider methods for employing scientific and engineering personnel who are not astronauts or pilots. When this has

ORL INBOARD PROFILE

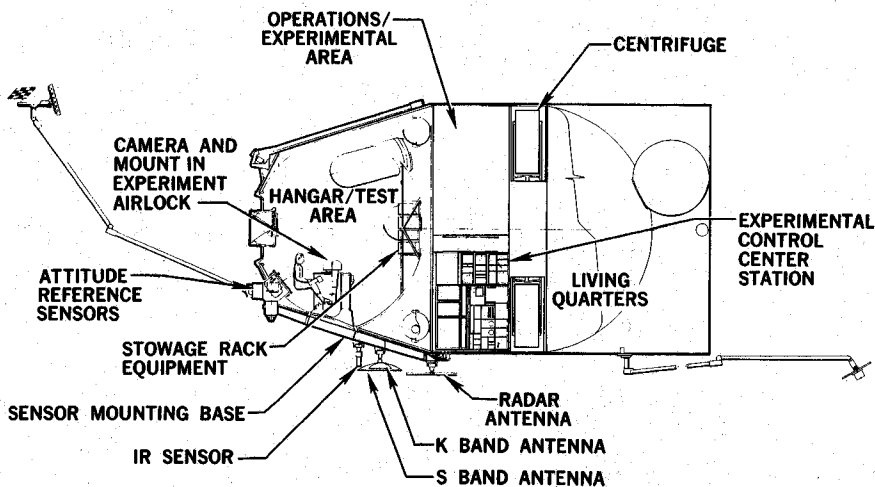


FIGURE 54

been achieved, the effectivity of the space station for scientific purposes will have been multiplied by a factor of 3.

In this early era of space station utilization, it is extremely important that transport and orbital systems be derived that can support scientific personnel who are not trained as astronauts. Even with a space station functioning in orbit, and even though it is manned by astronauts who have had competent scientific training, it is not possible to achieve maximum effectiveness and utilization until members of all of the disciplines in the scientific fraternity are able to conduct their experiments and make their observations on board the space station. Although information can be obtained by astronauts and relayed to the earth, most scientists will not be satisfied with this method of observation. The scientific method of investigation cannot tolerate "second hand information," no matter how qualified the relaying observer may be. If scientific information cannot be accommodated, the scientific community will be less than enthusiastic about what must be considered as "remote" testing and observation. To achieve this end, it will be necessary to improve the transportation systems.

Attainment of this permanent orbital capability is dependent upon the amount of support that the affected technologies receive, as shown in figure 55. At least 2 years of technological work has yet to be accomplished and, after that, about 5½ years of development work must be completed before that kind of orbiting laboratory capability can be achieved. While it is not yet time to make the decision to implement an orbiting laboratory having such a high degree of sophistication, the required technology should be available by the time that

BUILDING BLOCK DEVELOPMENT TIME

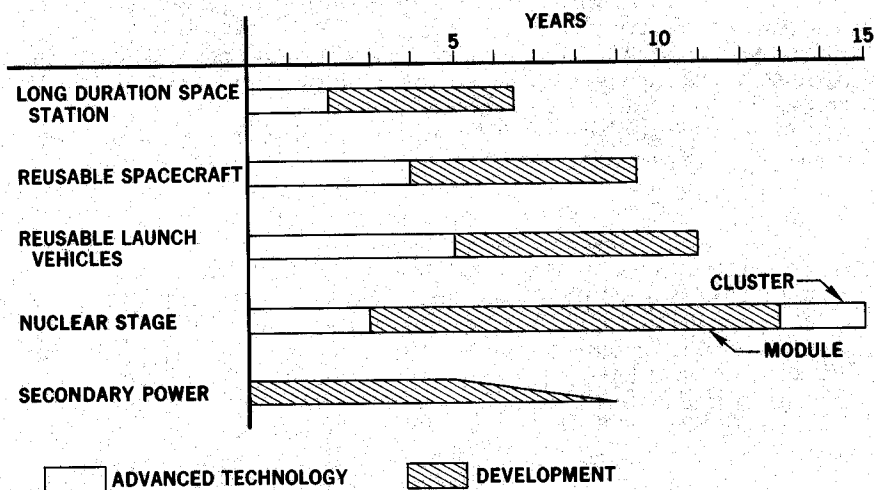


FIGURE 55

the earlier programs show that more sophisticated laboratories are required.

Studies investigating possible uses for more complex operational stations are being conducted and, while no definitive conclusions are possible, preliminary results indicate that sufficient requirements will be available to make their employment economically feasible within the next 20 years. Already, there is much evidence to support the probability that the greater part of the communications service and most of the surveillance of natural resources will be done from space. The economic logic has already been demonstrated by the commercial communications satellites now in operation. It remains to be seen what part of the communications load will need to be carried by manned satellite systems and, as yet, there is no conclusive evidence that will either substantiate or preclude the need for permanently manned stations to do resource tracking. There are also the attendant questions about the possibility of intermittently manned substations and of operating them remotely for the majority of the time. A concurrent problem is proposed by the need to define the configurations and functions of the devices that would be used to accomplish the communications and tracking tasks. This requirement, too, is dependent upon whether or not the station is manned.

However, assuming that space stations prove to be functionally feasible, the problem of transport has still to be resolved. Again it appears that present systems are not equal to the foreseeable personnel transport and resupply task. It is unreasonable to suppose that more than a few scientific investigators, maintenance crewmen, or station operators will be willing to tolerate the transportation environment to which astronauts are now subjected. Obviously some astronaut-scientists will always be available. However, the pure scientist and the development engineer will need a more stable transportation environment. To fill that need, and to afford the cost of resupply, reusable spacecraft will have to be developed.

The utility of reusable spacecraft is not questioned. It increases operational efficiency and, once it is achieved, spacecraft operating costs will be reduced by a factor of 2 to 4. This advantage will accrue even though expendable boosters are used in conjunction with the reusable spacecraft.

At this time, while various space transport configurations are still being investigated, there is a wide variety of opinion about what the optimum reusable spacecraft should look like. One school of thought has it that a reusable spacecraft should resemble the Apollo in its fundamental landing characteristics, others propose a spacecraft that looks like a hypersonic or supersonic airplane (fig. 56). This controversy may continue for some time. However, so far as we are concerned here at Douglas, a logical consideration of cost/effectiveness in conjunction with the mission requirements shows that neither the 6-g. device (shown at the right of fig. 56) nor the comforts of the commercial airline approach (shown at left in fig. 56) should be employed. Scientists and engineers who are not trained as astronauts cannot be expected to fly in a 6-g. device. On the other hand, space transports will not be carrying little old ladies from Pasadena, at least not in the immediate future. Consequently, we believe that

the most reasonable solution is a compromise vehicle which has a lifting body configuration and that will operate at a level of approximately 2.g.'s during launch and reentry. A typical configuration for this type of device is shown as it might look when used as a spacecraft payload on the Saturn IB (fig. 57).

SPACECRAFT/CARGO MODULE CONFIGURATIONS

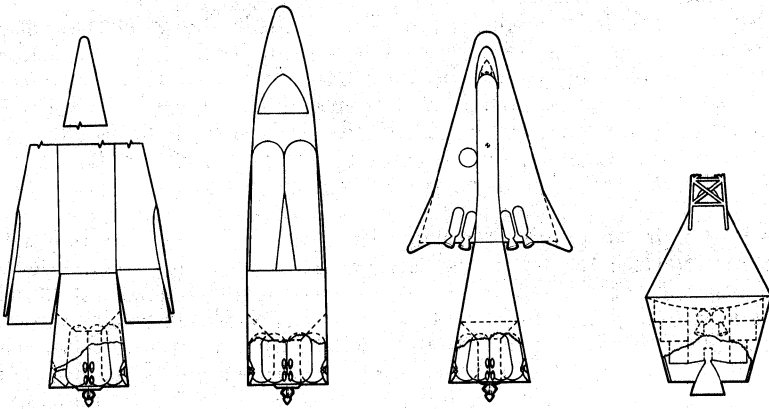


FIGURE 56

EARLY REUSABLE LAUNCH CONFIGURATION

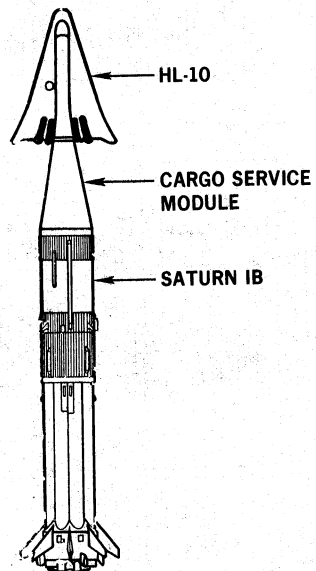


FIGURE 57

Accepting the fact that, eventually, reusable spacecraft will be required, the argument is sometimes advanced that "if we have reusable spacecraft we should achieve reusability from the ground up, making the booster reusable as well." However, there is a fallacy in that argument; first, because the need for a reusable spacecraft is more urgent, it should have priority both in terms of engineering inputs and in terms of funding; then, because the financial commitment that would have to be made to achieve reusability for both the spacecraft and the booster at the same time would be prohibitive. While both of these advancements need to be made, they should be undertaken sequentially.

When reusable transportation is discussed, there is always disagreement about whether the vehicle should be designed to take off and land horizontally or take off vertically and land horizontally. No matter whether the horizontal or vertical takeoff system (figure 58) is eventually adopted as the standard configuration, it is clear that the horizontal takeoff vehicle cannot be operational until the end of the 20-year period that we are talking about today. Also, no matter when it is built, a horizontal takeoff/horizontal landing vehicle is going to be initially and operationally more expensive than one which takes off vertically and lands horizontally. The only rationale that could support the need for a horizontal takeoff/horizontal landing vehicle would be a requirement for a widely variable launch azimuth capability. If such a requirement were imposed, it would be necessary to fly in the atmosphere to reach the proper position for ejection into orbit. At this time, there is no reason to believe that this requirement exists. That kind of operational flexibility is a luxury that is difficult to afford; particularly since space destinations are known and launch sites have been established to match them.

HTOHL & VTOHL CONFIGURATIONS

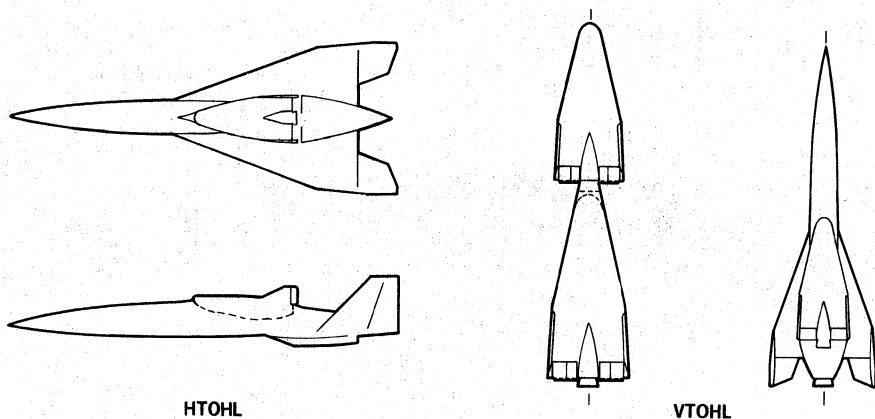


FIGURE 58

Another reason for postponing construction of a reusable booster system, until after the requirements for spacecraft capability have been met, is that merely making booster systems reusable will not improve conditions for the pilot or the crew.

When the time comes and a reusable booster capability is acquired, efficiency will increase, logistics cost will further decrease, and another improvement factor of 2 to 4 will have been achieved, thus beginning to approach the increase in transportation efficiency that we predict for the space system evolution in the next 20 years. The remainder of the efficiency increase that can be obtained will be the result of the increased capability to carry larger payloads and more sophisticated equipment. Employing the new sensor technologies that are becoming available will provide more and better equipment per pound of payload. At least equally important is the fact that, with reusable spacecraft, it will be feasible to bring payloads back to earth, improve them, or repair them if required, and send them back to orbit again. This is the pattern that is beginning to evolve, and this is why it is possible to propose that, in the next 20 years, improvements will increase the return on dollars invested by as much as 50 times more than is available today.

Assume that the decision to achieve a reusable spacecraft and launch vehicle capability were made today: then, if the decision to proceed with the technologies that must be advanced in order to arrive at these long term building block capabilities were made immediately, the lead time required to achieve them would be approximately 4 to 5 years (fig. 55). After that the program leadtime required to obtain them would be approximately 10 to 12 years. It must be remembered that there is no need to commit a hardware program. The important task is to support the technologies that will provide the capability to make a commitment decision at the right time.

The nuclear stage that I briefly mentioned earlier will be required if the decision is made to have manned landings on the planets. It is almost impossible to accomplish those missions using chemical propulsion systems. Again it is important to have the technological capability at hand when the decision is made. The leadtime required to improve the nuclear technology to the point where the development of a nuclear stage is feasible will be approximately 3 years. Once again there is a need to obtain a building block capability. A great deal of work toward the development of the engine portion of the nuclear powered vehicle has been completed. Far too little work has been done leading to the vehicle design. One concept for a nuclear stage module cluster is shown in figure 59.

The progress that has been made in engine design has left the vehicle design with somewhat of a technology gap. The vehicle technology is at the state-of-the-art level available in 1960; and, at the other end, engine sophistication is approaching 1975 technology. This situation is beginning to change, but it is still a technology problem. Now, for example, it is necessary to look at titanium alloys for use in the development of the large pressure vessel. This requires new concepts in design and manufacturing.

By maintaining the proper technological readiness, industry will be prepared for whatever new direction is prescribed. For example,

NUCLEAR STAGE MODULE - CLUSTER

BASIC PROPULSION MODULE

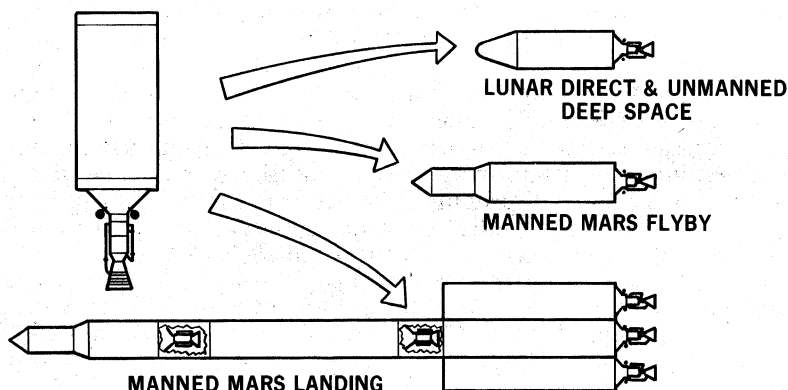


FIGURE 59

if lunar activities became profitable, and it was worthwhile to transport larger and larger payloads, a modular system of nuclear stages could be employed. That utilization would reduce the cost of the transportation system by a factor of about 3. The same modules could accomplish the Mars flyby mission in a more economical fashion. A five module cluster would accomplish the manned Mars landing mission; however about 15 years in leadtime would be required to achieve this mission capability (see fig. 55). Beyond the 3 to 4 years still required for technology improvements, are about 10 more years of development and integration before a basic module can be produced. Then 2 to 3 more years would pass before a cluster capability could be achieved.

These leadtime requirements reinforce the need to begin to advance the basic technologies now. It is still not necessary to make decisions about what kind of hardware to build. And not all of the advance technology requirements have to be resolved at the same time. The urgency, then, is in the need to pursue the technologies for which the most leadtime is required.

Underlying all of the technological requirements for spacecraft and booster systems is the requirement for secondary power. The usefulness of any of the proposed space systems is limited by the availability of secondary power and by the reliability of that subsystem. Spacecraft life depends on secondary power for environmental control, for operating experiments, and for all of the electrical functions associated with spacecraft electronics subsystems. The various sources of secondary power are shown in figure 60.

They are displayed against scales which relate power level (in kilowatts of electricity) to the length of time that each source may be expected to operate.

A great deal of work has been done with batteries and fuel cells. However, because of the short duration operating time and limited power levels, they are not practicable for long duration mission application. For the new generation of space activity, secondary power systems must be available that can produce from 10 to 100 kilowatts and that will operate for as long as 5 years. Obviously, a reactor system will provide the highest power level and survive for the longest period of time. However, the prohibitive weight of the reactor system shielding will deny access to the reactor's advantages during the foreseeable future. Unless radical changes occur in this technology, isotope dynamic and thermionic systems will most likely be employed. These systems weigh less and are approximately twice as efficient as the solar-cell battery or isotope thermoelectric power system. For these reasons, Douglas is concentrating on the development of these systems. For some applications, the system can be derated to supply low level power needs; for other applications, it can be used in multiple to supply the highest demand for secondary power.

Since we (Douglas) believe in the necessity for a nuclear stage, and because we are committed to the proposition that long-term future secondary power requirements cannot be met without employing reactor or isotope systems, Douglas has committed extensive resources to the task of developing a strong nuclear capability. We believe so strongly that nuclear power is going to be required during the next 15 years, that, in conjunction with operating the plutonium production reactor facilities at Hanford, Wash., we have constructed a nuclear laboratory nearby in Richland (fig. 61). We have just occupied that facility. The laboratory represents a \$2 million investment; the laboratory equipment cost another \$1.5 million; and currently, the staff of nearly 100 now has a payroll of about \$2 million a year.

SECONDARY POWER SYSTEM APPLICATIONS

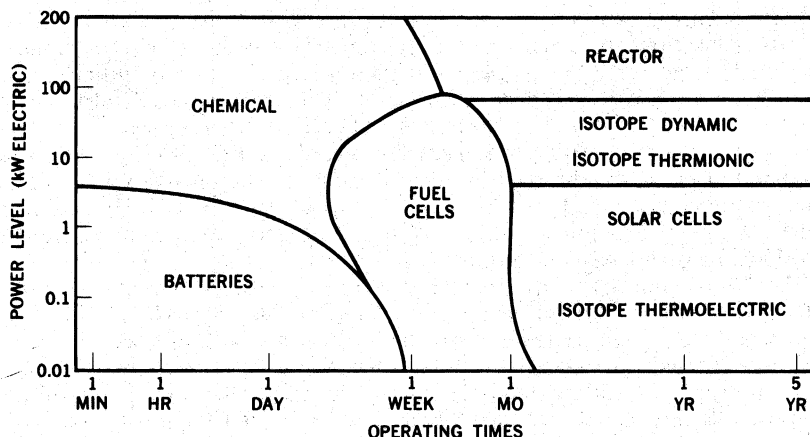


FIGURE 60

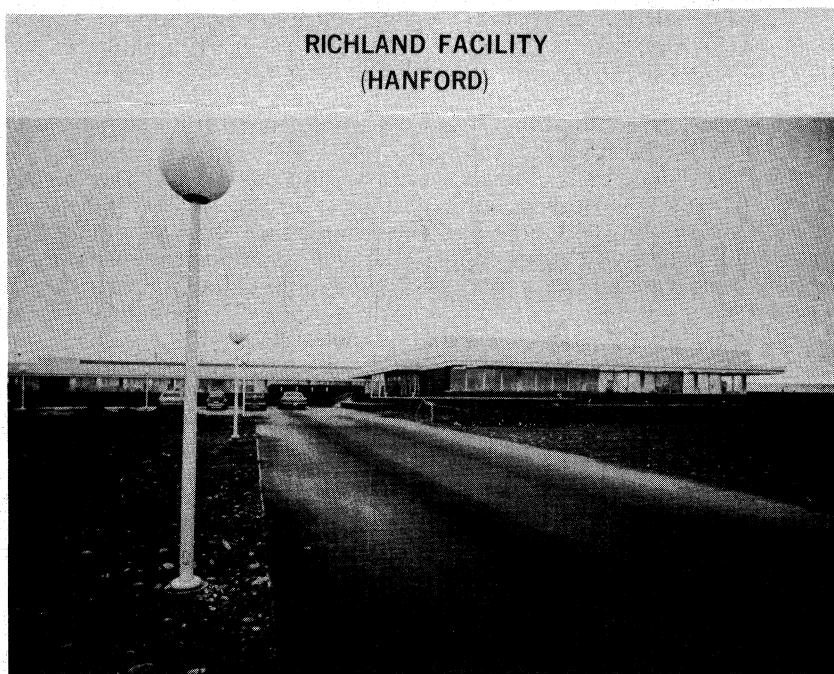


FIGURE 61

Mr. ABLE. We believe so strongly in the future of both the nuclear stage and isotope secondary power that we made an aggressive effort and won the contract to operate the plutonium production facility at Hanford. Essentially, the work involved in that contract is routine. However, we believe that it contributes much to our technology capability because it gives us a continual opportunity to work with radioactive materials and to become experts at the task of reactor operations. This activity has firmly established Douglas as a member of the nuclear community. We constructed the laboratory at Richland so that we could use the tremendous reservoir of technical ability that exists in that area. What we learn from that advance technology, and from our operations at Richland, will give us the stature and experience required to qualify us as prime competitors when the decision is made to build a nuclear stage. We are already experienced in the production of space vehicles.

Mr. DORRENBACHER. In summary, there are a number of decisions affecting the fiscal year 1968 budget that must be made if the continuity of the space program is to be maintained. The general orientation required to meet near-term future goals, and to provide the technological capability needed to maintain the direction of continuity is shown in figures 43 and 55. These are the tasks that must be undertaken in order to have the option, 5 or 6 years from now, to describe future missions, and to insure the attainment of the hardware capability required for those missions. If the go-ahead to support these

advance technologies is available now, it will be possible to exercise our national options, after which, operational equipment can be available in 10 to 20 years. By that time, our space program will become commercially profitable and self-sustaining.

We are all aware of the difficult problem imposed by financial limitations. However, this Nation has already made a very large investment in people. The reservoir of scientific and engineering experience that these people represent is a national resource of incalculable value. It is unthinkable to allow a situation to occur that would dissipate that resource. It is a practical fact that any significant reduction in the technical population of the space community will create a gap in our technological capability that will be extremely difficult to repair. This is a national problem; but industry is affected in the same way. For example, a 25-percent reduction in the technical population at Douglas would disrupt the continuity of the company's technological capability to an extent that could not be repaired for years.

There is no way to rebuild the lost capability except through a time-consuming training program. The people who are lost by any company cannot simply be hired back. They will take other employment and many of them will move to positions outside the aerospace business, and thus be lost to the entire industry. If the technical population is reduced now, and 2 years later it is necessary to build it up again, irreparable damage will have been done. Consequently, Congress is faced with the problem of having to decide at what level the technical population should be sustained; if that level is less than what it is today the space program will have to be adjusted accordingly. But if a reduction is not what is planned, then a 20- to 30-percent loss in population must not be permitted to occur by default. Default, in this instance, will occur because the Apollo program technology, and the technologies of other programs now reaching the hardware stage, are nearing completion. With no new advanced technology programs to undertake, a de facto reduction in the technical population is going to occur.

This Nation's reasons for going into space are well known. Those of us who have dedicated our professional lifetimes to that pursuit, confidently anticipate that the space business will be commercially profitable. I believe that both Government planners and management in the space industry are in basic agreement about what has to be done to put the exploitation of space on a paying basis. I believe that, in 20 years, work being done from space platforms will be accomplished on a paying basis. The sequence of events that I have just described will lead to that conclusion. Beyond 20 years, changes in orders of magnitude will be achieved.

Mr. TEAGUE. Jim, have you read the progress report from the advisory board, the President's Science Advisory Committee (PSAC) report?

Mr. DORRENBACHER. No, I have not. I have heard of it but I haven't had an opportunity to read it.

Mr. FREITAG. In that report, for example, the committee members agree that the orbiting workshop effort should be continued, but they also say that we should take a long look at what we do after the first workshop. An important point is that costs will have to be reduced

before the scientific community can achieve as much as they want by way of scientific information. Mainly, the scientists are concerned with the cost of transportation; they'd rather put more emphasis on missions and operations. However, the report agrees that it is necessary to have the workshop capability in order to learn to operate the space vehicles required for those missions.

Mr. DORRENBACHER. I think their hesitancy is almost entirely based upon this problem of transportation cost. If the scientists can't look at the workshop as a place where they can conduct their own experiments, eventually they will be inclined to prefer to take the less precise but more immediate information that they can get from less expensive, unmanned orbiters and probes. They think of the information that they get back from astronauts, or even from astronaut/scientists, as essentially remote reporting. That is why they are just as willing to accept information from sensors in unmanned vehicles.

Mr. GURNEY. In your references to scientists, who do you mean, specifically, people like astronomers?

Mr. DORRENBACHER. Astronomers are good examples. But basically, I am referring to any scientist who feels that his discipline has applications in space. I believe that these people will contribute immensely to our national well-being and scientific advancement. We know that the science of astronomy will improve by an order of magnitude when we can get the astronomer and his telescope to work in space. Surveillance of our natural resources can hardly be accomplished in any other way. Even now we are paying far too much for weather survey stations and probes scattered about on the surface of the Earth.

Mr. GURNEY. How is industry communicating with scientists in projecting the importance of their role in space?

Mr. DORRENBACHER. Initially, that communication was poor. However, it has been greatly improved. The efforts of our NASA program have begun to produce results during the past year. Four years ago, few scientists knew what they would be able to do in space. Consequently many of them were apathetic to the scientific aspects of the space program. Today, they are quite enthusiastic. When we can tell them that we can transport them in a 2 g. vehicle, and that they will have the tools they need in a space station, and that they can operate their own equipment and conduct their own experiments, we will have their complete cooperation. Even now, with the astronauts operating the equipment that the scientists would rather operate themselves, they are still quite pleased with the information that they are getting.

Mr. TEAGUE. We have some scientists with astronaut training now.

Mr. FREITAG. We have five. These people are scientists who were recruited as astronauts. Five more are regular pilot-astronauts who have scientific training through the doctorate degree. That gives us 10 people, already in the program, who have professional academic training through a doctorate degree and who have had professional experience in their major fields.

Mr. DORRENBACHER. Certainly that is a step in the right direction. The scientific community has confidence in those people. But, in general, in spite of their education, those astronauts are not thought as of practicing scientists in the purest sense.

Mr. GURNEY. What about the leaders in the various scientific fields? Do industries such as Douglas, for example, brief those people the way you are briefing us?

Mr. DORRENBACHER. Where we have some specific requirements, NASA has built some direct lines of communication. In particular, astronomy has received much attention, and that segment of the scientific community is informed and fully cooperative. The cooperation is beginning to pay large dividends in the form of specific requirements for equipment that the scientists most urgently need in the space vehicles. Industry can define scientific requirements on paper but, in the final analysis, it is imperative that the user-scientist make specific recommendations.

Mr. ABLE. Adding to that, Douglas has a corporate scientific advisory board. The people who staff this board are outstanding scientists. For example, Dr. Libby, the Nobel Prize winner, is a member of this board, and he is also a member of the Douglas board of directors. The members of this corporate scientific advisory board meet with the officers and directors of Douglas; they are thoroughly familiar with our work, and they are very enthusiastic about it. Because of their enthusiasm, they devote a lot of effort to keeping the rest of the scientific community informed. If you remember, this kind of enthusiasm is what we predicted over 2 years ago. Now it has become easier to get scientific cooperation.

Mr. FREITAG. I think that the President's Scientific Advisory Committee itself is an excellent example of the improvement that has come about. I believe that its membership consists of nearly 100 of the top scientists in this country. They devoted all of last year to many, many briefings, conferences, and subgroup meetings in the process of making a critical appraisal of all aspects of the space program. The PSAC report that we are talking about represents their collective opinion about where the program stands from a scientific point of view. This is really a big step forward from 2 years ago.

Mr. DOUGLAS. Right here, at Huntington Beach, we are supporting a fairly expensive program of pure science; our corporate research organization is essentially autonomous. It has a charter to investigate all kinds of scientific phenomena. For example, one of our scientists, who is a rock expert, can hardly wait to get to the Moon. He has a technique for getting water out of the rocks. The day that he can get out on the Moon with his rock pick, and make a practical experiment in water recovery, and when other scientists like him have and opportunity to exercise their disciplines, the entire scientific community will have been enlisted in the cause of manned planetary exploration.

Mr. FREITAG. One of the important factors in this change of attitude on the part of the scientific community has been the change in the emphasis of investigation that was brought about by the advent of the space age. Ten years ago, the scientists in positions of greatest authority were extremely competent specialists in their own field, but since the space activity was so new their specializations did not include space-oriented activity; those scientists did not have time to go back and become specialists in space. Now, however, younger men are beginning to fill the influential positions in the scientific community.

These scientists have grown up with the space program, and the universities where they were trained were also adjusted to the new science. These new scientists are from 30 to 40 years old. They now have 10 years of experience and a thorough understanding of the potentialities of space. The educational process was a natural evolution and now its effects are beginning to appear.

Mr. GURNEY. Take the Earth sensors as an example. This is a new concept, to use space to aid in the management of our water and food resources. What was the source of that concept? Is it a product of the scientific community, industry, or the Government?

Mr. ABLE. A combination of all of them. Crude sensing devices were first produced for military application; then more sophisticated sensors were developed for the space program. Now their capabilities have improved so substantially that we are able to project many economically productive applications for their use in space. This is a brand new field, and we are just on the threshold.

Mr. DORRENBACHER. Still on the subject of Earth sensors and how they relate to the surveillance of our natural resources on a national or global scale, we see this kind of evolution: from 30 years ago, when we had crude weather prediction sensing devices and nothing more, we progressed to somewhat more sophisticated sensors, and better correlation and reporting systems, to the use of sensors in aircraft. The first aircraft systems were used to survey larger surface areas than had ever been surveyed before. It was then possible to conduct large area surveys in a very short period of time. Looking at color differences on the surface of the Earth gave us a whole new category of intelligence. From the first use—to detect camouflage—the science was advanced to include surveys of vegetation and the prediction of food resources. This capability led to an increase in our economic well-being. The problem is that it is expensive, prohibitively so, if we want to repetitively survey large areas of the Earth's surface. If we wanted to cover a single county in California once every 10 years, we could do it from an airplane. However, if we need continuous surveillance of the total pattern of how water pollution, air movement, and smog effect groundcover and other natural resources, aircraft surveys are totally impractical and cannot provide complete continuity. That kind of task has to be done by sensors from a space platform. Few people would contradict this logic.

The Tiros satellites are relatively unsophisticated systems. However, studies now show that the economic benefits that they provide, range to millions of dollars per year, and are responsible for saving a number of lives. Yet the data that we get from Tiros is very crude in comparison to what we can expect from an orbiting laboratory. Today, differences of opinion are mainly concerned with whether similar tasks can be accomplished sufficiently well from unmanned satellites or whether manned satellites can provide a great enough degree of increased sophistication to maintain an attractive ratio of cost effectiveness. Our opinion here at Douglas is that it can.

Mr. ABLE. Well, gentlemen, we're winding this up right on schedule. The one element that goes through all that we have shown you today is that existing space hardware has future applications and

modifications, and existing technology has even greater application in the future.

The hardware and technology developed in present programs allows a program like MOL to go forward without reinventing the wheel. The experienced people who learned and were good engineers on Saturn are moving over on other programs, and there is a tremendous payoff from their experience.

That is why, if we can keep this thing going then, as Jim has said, you don't need to increase the space budget. If you hold the budget level, you can still bring in a tremendous increase in the return, while the cost becomes smaller as a percentage of the gross national product. One of the big strengths of the NASA program has been the stability of its budget since its beginning.

Mr. DOUGLAS. Yes, but if we don't get the follow-on orders that are planned in the present budget, then our manpower is going to come off pretty fast.

Mr. DORRENBACHER. And for every man that leaves the space program, whether he goes into an ordnance program or whether he goes to oceanography, it's going to take 5 years to replace him when the realization comes that we should have kept him on the job. The money already spent in the combined military/NASA space programs is money spent on education.

Mr. ABLE. Mr. Teague, we certainly appreciate the interest that you and the members of your committee show in the part that Douglas plays in the space program. Thank you for coming here today.

APPENDIX F

HEARINGS OF THE SUBCOMMITTEE ON MANNED SPACE FLIGHT, MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA, FEBRUARY 9, 1967.

STATEMENT OF DR. WERNHER VON BRAUN

ADMINISTRATIVE OPERATIONS AND CONSTRUCTION OF FACILITIES

Mr. Chairman, Gentlemen: I would like to welcome you on behalf of the staff of the Marshall Space Flight Center, Huntsville, Ala. We have prepared a briefing this evening on some of our Center activities. Tomorrow we will visit a number of our facilities and hold other briefings. Before I delve into details, I would like to present our proposed agenda.

This is essentially the subject that I propose to cover tonight: Marshall Space Flight Center Management, Administrative Operations and Construction of Facilities. Tomorrow, General O'Connor will present to you the Saturn apollo program, and I propose to discuss the Apollo Applications program and the general future outlook of Manned Space Flight. We are prepared to put what I will say today on record. In addition, you sent us a number of questions and we have prepared a report, ready for insertion into the Congressional Record.

My next chart shows the organization of the National Aeronautics and Space Administration. On top we have the Administrator, Mr. James Webb, and his Deputy, Dr. Robert Seamans. There are four program offices under the Administrator: the Manned Space Flight Office, the Space Science and Applications Office, Advanced Research and Technology Office, and the fourth one, Tracking and Data Acquisition, which is essentially the running of the worldwide net supporting the three others. The head of the Manned Space Flight Program Office: George E. Mueller; Space Science and Applications: Dr. Homer Newell; and Advanced Research and Technology: Dr. Mac C. Adams.

The Marshall Space Flight Center is one of the three centers reporting to the Office of Manned Space Flight, the others being the Manned Spacecraft Center, in Houston, and the Kennedy Space Center, at Cape Kennedy, Fla. In somewhat simplified terms, the Manned Spacecraft Center, in Houston, is in charge of spacecraft development, astronaut training, mission planning, and also mission control for manned space flights. The Marshall Space Flight Center furnishes the large booster rockets for the Apollo program, particularly the uprated Saturn I and the Saturn V rockets. The Saturn I can carry an Apollo spacecraft into low Earth orbit. Saturn V can

MANNED SPACE FLIGHT SUBCOMMITTEE

Hearing Schedule at MSFC in Huntsville

February 9 and 10, 1967

TONIGHT

MSFC Management

Administrative Operations

Construction of Facilities

(von Braun)

TOMORROW

R&D: Saturn/Apollo Program (O'Connor)

R&D: AAP and Future (von Braun)

CHART 1

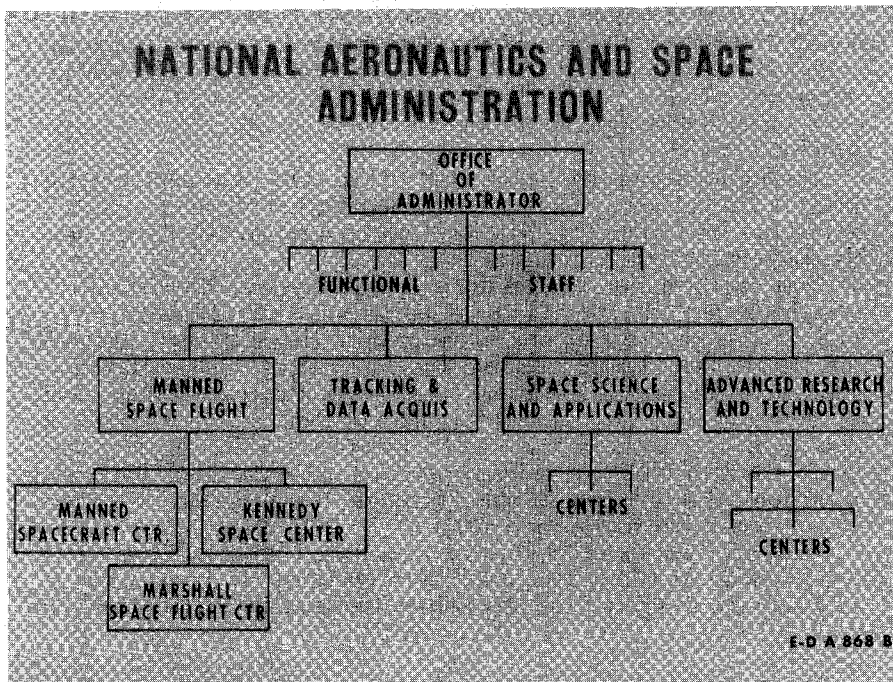


CHART 2

carry it to the Moon. The Kennedy Space Center is in essence the launch center, where the various modules or stages of spacecraft meet with the launch vehicle, and are stacked one on top of the other. The whole thing is then checked out against elaborate ground support equipment and launched.

Although we report to Manned Space Flight, we nevertheless conducted about \$23.7 million worth of business in fiscal year 1967 for the three other program offices.

Let me now come to the internal organization of the Marshall Space Flight Center. I brought two charts. The one to your right is the organization of the Center as it looked when we submitted materials to your committee last year. The chart to the left shows today's status, and the elements marked in blue involve changes between last year and this year.

Starting from the top, Dr. Lange went over to the Army and has become chief scientist for the Nike X program. Dave Newby took over this job, as assistant director for scientific and technical analysis. We have established the patent counsel as an entity separate from the chief counsel's office, and we have established a new Saturn Apollo Applications Office in Industrial Operations and have moved the former head of the engine program, Lee Belew, to head this office. Lee's former deputy, Bill Brown, has become head of the engine program office. We closed out the Saturn IB/Centaur program office because this program was terminated. Thus, the total number of program offices in Industrial Operations is the same as it used to be.

Another important change is that Lee James, who was our program director for the Saturn I-IB program, became deputy to General Phillips in Washington. Bill Teir, who had been deputy to James, took over his job.

Another important change is in Research and Development Operations. With the activation of the Saturn/Apollo Applications program, our involvement in experiments to be conducted in space vehicles and space stations of course had to be expanded, so we established an Experiments Office in Research and Development Operations. At the same time, we closed out the Technical Staff.

Another important change is that Mr. Fred Cline, who had been running the Propulsion and Vehicle Engineering Laboratory, under Research and Development Operations, has been replaced by Dr. Lucas. Mr. Cline went back to industry.

Those are the major changes during the past year. Now let me discuss the basic philosophy of our organization. The Marshall Space Flight Center is made up of two major operating elements: Research and Development Operations and Industrial Operations. Maybe we should call Industrial Operations the Office of Program Management, and Research and Development the Office of Penetration in Depth, including operating our own in-house laboratories. Most of the money that we are spending in industry goes to the director of industrial operations, Ed O'Connor, who, through his program managers, administers these four programs.

There are two major facilities attached to Industrial Operations. The Michoud Assembly Facility, in New Orleans, which you will visit Saturday morning, and the Mississippi Test Facility, which you will

GEORGE C. MARSHALL SPACE FLIGHT CENTER

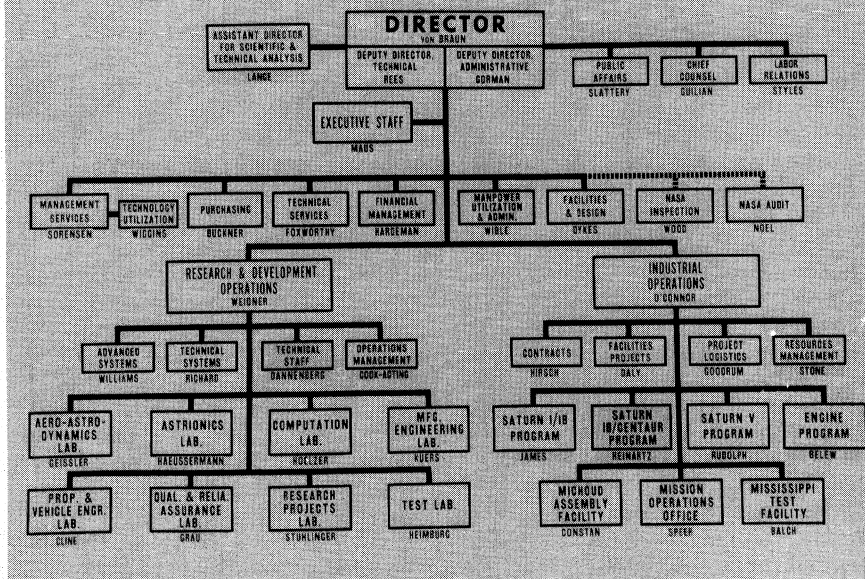


CHART 3

GEORGE C. MARSHALL SPACE FLIGHT CENTER

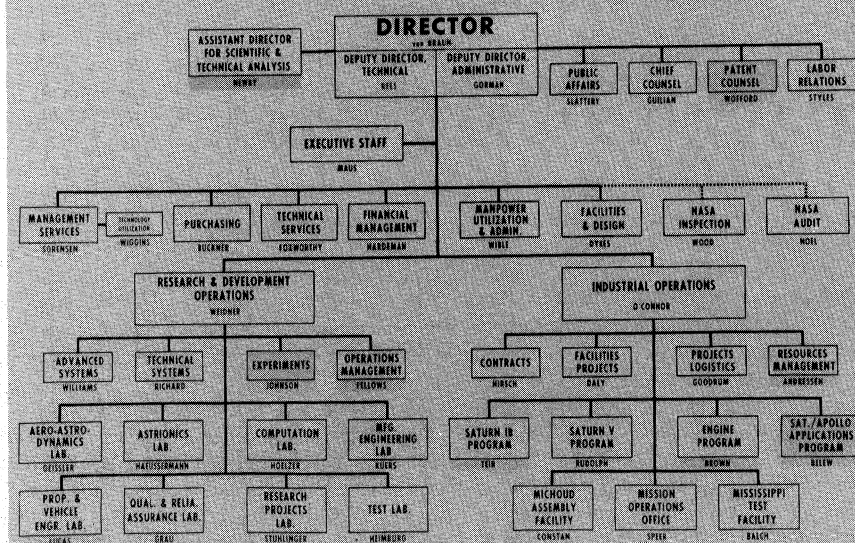


CHART 4

visit Saturday afternoon. Also shown is the Mission Operations Office, which represents the interests of launch vehicle development with the Mission Operations, in Washington, and also with the Mission Control Center, in Houston.

Certain functions are centralized in General O'Connor's staff. He has an expert for large industrial contracts. I would like to mention that the great majority of these contracts are now incentivized. That is, we have an incentive fee arrangement on these contracts which enables the contractor to make a greater profit if he delivers for lower cost, on schedule, and if there are no deficiencies in his deliveries. He can also be penalized for sending something incomplete to the Cape that requires some retrofitting or some rework.

The Facilities Office deals essentially with the building of new program facilities and has shrunk to a relatively small operation now because our facility construction program for Apollo has already been completed.

Project Logistics deals with supplying our facilities, particularly test facilities, with test fuel, such as liquid oxygen. It provides the transportation systems that bring stages from stage assembly plants to test facilities and on to the Cape. We have a fleet of about eight barges operated out of this office that bring the stuff all the way from California, to Mississippi, and down to the Cape. Barges also handle large-stage transportation between Huntsville and the Cape. We also have two over-sized aircraft (converted Stratocruiser airplanes) to fly second stages of Saturn I's and large engines across the country.

Finally, there is a Resources Management Office that deals essentially with the resources in terms of manpower and money in the program. These two things, of course, go closely together. Whenever you want to save money you have to reduce manpower because that is where the money goes, and keeping track of manpower and money, and staying on schedule, is a primary job of Industrial Operations.

Whenever there is a serious technical difficulty in any of the industrial programs here, the program managers may require help. They may require knowledgeable people who can get in there, like firefighters, to put out the fire before it spreads too far. Now our main resources for providing this firefighting service in the Apollo program are the expert scientists, engineers, and technicians in Research and Development Operations.

Research and Development Operations is not organized by programs, but by disciplines. For example, we have an Aero-Astrodynamics Lab. This lab deals with wind tunnels, flight dynamics and trajectories, and the aerodynamic loads created on a vehicle as it passes through turbulent layers in the atmosphere. So the primary orientation of this lab is in the areas like optimization of guidance equations, dynamics, mathematics, aerodynamics, even aerodynamic heating.

Astrionics is another laboratory. Astrionics deals with everything involving electricity, you might say: gyroscopes; electronic computers that fly along in the rocket in flight; electrical checkout equipment; telemeter transmitters that send data from the flying rocket back to the ground to enable engineers on the ground to evaluate the performance of the rocket in flight; and actuators that swivel the rocket

motors and keep the rocket on the flight path. All this is done in Astrionics.

Next is Propulsion and Vehicle Engineering. This is our chief mechanical engineering lab. It deals with propulsion, structures, materials, things that are so important in rockets.

We have a test laboratory here which deals with testing of large rockets on static test stands where the rocket is tied down to the test stand and fired at full throttle so we can fully measure the performance of the rocket prior to flight.

We have a manufacturing engineering lab. The function of this laboratory is not to produce, but to familiarize itself with modern manufacturing techniques used in industry, and at the same time remain astute with respect to adequacy of manufacturing methods. For example, if one of the companies, and this happens to the very best ones, uses an unacceptable welding method, our people move in and virtually show our industrial contractors how you can do a better job. Now, you can do that only if you keep your own fingers dirty, of course, and that is the secret of success in all these laboratories. There must be a certain amount of in-house work going on all the time, so that these men know what they are talking about. I think the fact that all our laboratory directors and their assistants enjoy a great deal of respect with our industrial contractors stems from the fact that time and time again they were able to go in and help them solve a problem.

One contractor said, for example, "Your specifications are too stiff. Nobody can build it so accurate."

We take a piece to them and say, "Here it is; build it just like this. You see, it can be done."

We consider this, our continued ability to keep a yardstick in the hands of the Government to assure that we are getting our money's worth, as one of the most important tools we must have. If you throw your yardstick away, you become the victim of your own contractors. So we consider this a very important capability.

Now, how did we get this capability? Well, that is more a question of history. Before we joined NASA, we were with the Army Ballistic Missile Agency. The Army, at that time, operated to a great extent on the arsenal concept. Thus, we did a lot of development in-house, and one of the reasons why NASA wanted this element from the Army was the realization that, if you want to build big rockets, you must have within the Government knowledgeable people who can judge the quality of what you are buying.

Let me come back to the other elements of our organization. We have a quality and reliability assurance lab which sees to it that the necessary quality control screens are provided between industry and the Government, and that even industry protects itself with adequate screens between contractors. For instance, as it happened to us a major aerospace contractor buys some titanium bottles from a vendor, who, in turn, buys welding rods from another vendor, and this latter vendor sends the wrong welding rod to the vendor that makes the titanium bottles, and as a result a bottle blows and with it a whole Saturn V stage, causing several million dollars' worth of damage, then you have a case where the quality assurance system in industry has not worked properly. Now, it is probably too much to ask that the Government

itself provide quality assurance penetration down to the third, and fourth, and fifth tier subcontractor. But, nevertheless, it is our job and the job of this quality and reliability laboratory to provide a quality assurance network throughout our industrial organization to make sure that we are really getting our money's worth and to avoid to the extent humanly possible the kind of incident I have just cited. This is a very difficult thing to do because our lunar program is low-density fabrication in industrial terms. We are not building millions of something. We are building only a dozen or so pieces of a very expensive commodity in this program, and a space vehicle can meet with catastrophic failure if only one nut or bolt is inadequate.

Now, how do we protect our prime contractors from using some wrong material when they cannot possibly control their vendors' quality procedures with the necessary depth? For example, shall we tell a prime contractor, "You can never buy anything from Company X because we don't know whether their product is adequately tested"?

Well, we make it the contractual duty of our primes to either assure themselves that the product delivered to them gets special treatment or, if that is technically impossible, to assure themselves by acceptance control, that nothing slips into their system that is unacceptable. The continuous surveillance of these techniques, processes and standards comprise the main function of our quality laboratory. Of course, our Apollo program has many thousands of quality inspectors throughout industry trying to protect our program from a little oversight that can have major and disastrous consequences.

The Research Projects Laboratory deals with the application of new research ideas to the over-all program. After we froze our design for Apollo, this Research Projects Lab took a back seat for a while because we had committed ourselves so heavily to a major development effort for Saturn that there was very little room to experiment with new ideas. But now that the Apollo Applications program is moving into the foreground, and we are trying to use Apollo hardware for new scientific objectives, the Research Projects Lab will again play an increasingly important role in Center operations.

Finally, I would like to mention the Computation Laboratory which is a large electronic computation center, one of the largest in the country. This lab serves not only all elements of the research and development operations, but also industrial operations and the supporting staff offices of the Center.

As to the center-level staff offices, these are normal organizations that a facility of this size would require, and I shall not discuss them in detail.

My next chart shows our permanent manpower positions. At the end of fiscal year 1966, we had 7,271 permanent manpower positions at the Marshall Center. We shall fall off to 7,030 by the end of fiscal year 1967, about 240 spaces. This reduction is due to economy measures we have taken. In 1968 we would remain at the fiscal year 1967 level.

You may have one question in connection with our stability here. You know that in many areas the total Apollo Program is over the manpower hump. Most stages and major elements of the program are on the assembly floor and there is no need to keep our industrial com-

plements up to the peak levels of about a year ago. However, the civil service work force cannot follow that same trend. In fact, as we reduce the manpower provided by industry, in any of our contractors' plants, we must retain a highly skilled engineering team just to shoulder the burden to meet unforeseen emergencies.

Let me explain this by using our engine program as an example. More than one-half, in fact about two-thirds of all rocket engines in our programs, both for the Saturn I and Saturn V, have already been delivered. They are in various assembly plants waiting to be put into stages. Many have already been placed into stages. So, obviously, we have to reduce the manpower at Rocketdyne, the manufacturer of these engines. But suppose we suddenly have a setback in a flight and we must fix these engines, or we have to retrofit something, or we have to change something. Who would evaluate all this? Who would implement the changes, if we have sent everybody home? To the extent that we reduce the ability of our contractor to take care of these problems, we ourselves in the Government must shoulder the burden. We must retain a well-balanced skilled work force to see the Apollo Program through to a successful conclusion.

A small number of our people have been assigned to our Apollo Applications follow-on efforts to prepare for Apollo Applications and

MARSHALL SPACE FLIGHT CENTER

MANPOWER

Permanent Positions

<u>End Of:</u>	<u>Ceiling</u>
FY - 66	7271
FY - 67	7030
FY - 68	7030

other programs in the event authorization is obtained. In view of lower funding for these programs, Dr. Seamans has estimated that the percentage of work going out-of-house NASA-wide will drop from more than 90 percent to about 85 percent. What Dr. Seamans is saying here is that, as we go into AAP, we estimate that henceforth we will only spend 85 cents out of the dollar in industry and 15 cents in the Government. We are certainly not going back to the arsenal concept. We are just shifting the ratio a bit.

My next slide deals with the distribution of our people by product. It summarizes the numbers given to the Congress in our Fiscal Year 1968 Budget Book. You see a gradual decline in the total ceiling as shown on the previous chart. You see that the vast majority of the people; namely, the white area, is still in Saturn Apollo. There is a comparatively slight increase in what we call nonmainstream work, including the staffing of management organizations for this work. Finally, you see that at the administrative level we have dropped about a hundred people during the past 2 years.

My next chart deals with our civil service distribution by class. The chart depicts classification of Marshall Space Flight Center manpower since the start of the Center in 1960, and reflects a gradual reclassification of our work force from essentially an in-house operation in 1961 to our present highly professional staffing pattern. We also show our projection to the end of fiscal year 1968.

Note that our wage board complement—some people call them blue collar—has been continuously decreasing as our professional groups have increased. And, of course, to the extent that our program management job has expanded, both business, professional and the clerical categories have also increased. Steps taken in 1963 and 1964 in the manpower management area allowed us not only to staff up to oversee the work of contractors in our mainstream program, but it also laid the groundwork for the manpower capability we need for post-Apollo activities.

We have a policy of continuously assessing our manpower skill profiles and gradually adjusting our skill areas through new hires and updating our know-how to meet future needs. Knowledge is being updated through retraining and graduate education programs. A total of 350 Marshall people are today pursuing graduate degrees. Twenty are pursuing master's degrees and 10 will receive Ph. D. degrees at the end of this school year. About 1,500 people attended seminars and noncredit courses in the past year to further update their knowledge.

This chart reflects that since the Marshall Center was formed in 1960 we have used support contractors in the Huntsville area. There are, in essence, two reasons for this. Support contractors provide you with a certain flexibility in manpower management to take care of the unavoidable peaks and valleys as you go into a commitment such as Apollo and the landing of a man on the moon against a hard schedule. Secondly, certain skills were simply not available in house. Our support contractor force increased between 1961 and 1964 as the complement of the Marshall Space Flight Center itself increased. In 1964, a peak year, we had a total of 39 contractors holding 77 support contracts in the Huntsville area. In 1964, we changed our policy and

adopted the so-called single support contractor concept. This means that each of our laboratories and certain staff offices requiring help in their respective areas were authorized one contractor to provide this support. For example, Astrionics could go into competition and select one and only one contractor to support that entire laboratory. I think we fared very well with this scheme. It turned out to be a more manageable scheme than the large number of contractors we had before. In fiscal year 1967, our total contractor support cost at Marshall in Huntsville will come to about \$58.8 million and this is buying about 5,200 man-years of effort. This is down from about 6,100 man-years in fiscal year 1965. So we are generally declining in this level of support and this trend will continue in fiscal year 1968. I would like to distinguish between housekeeping contractors and engineering support contractors. The engineering support contractors support our laboratories. The housekeeping support people run our motor pool, provide janitorial services, administrative support service and the like.

Here we have identified our 11 support contractors and the organization each is serving. For example, Northrop supports Aero-Astro Lab; Sperry Rand—Astrionics Lab; Computer Sciences—Comp Lab; Hayes of Birmingham—Manufacturing Engineering Lab; Brown Engineering—P. & V. E. Lab; SPACO, a small company in Huntsville—Quality and Reliability Assurance Lab; again Brown Engineering—Research Projects Lab; and Vitro—the Test Lab.

MARSHALL SPACE FLIGHT CENTER PROGRAM DISTRIBUTION OF MANPOWER

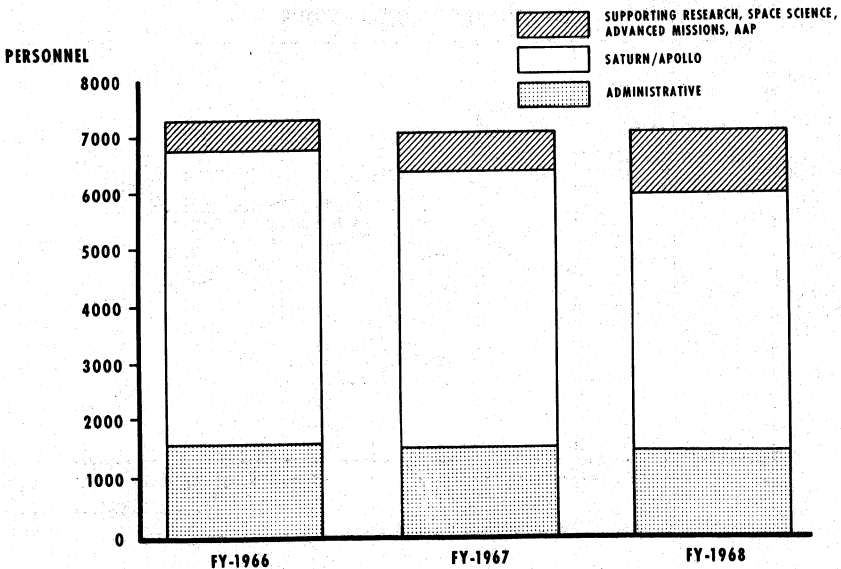
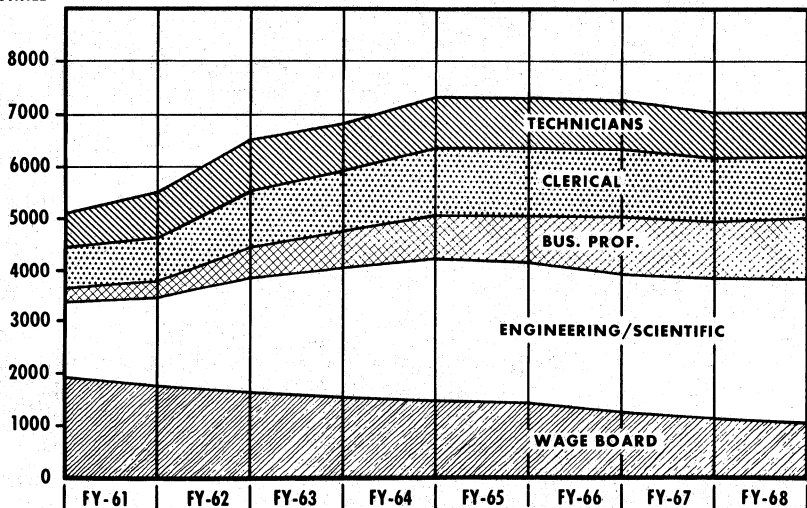


CHART 6

MSFC MANPOWER RESOURCES
CIVIL SERVICE DISTRIBUTION BY CLASS

PERSONNEL

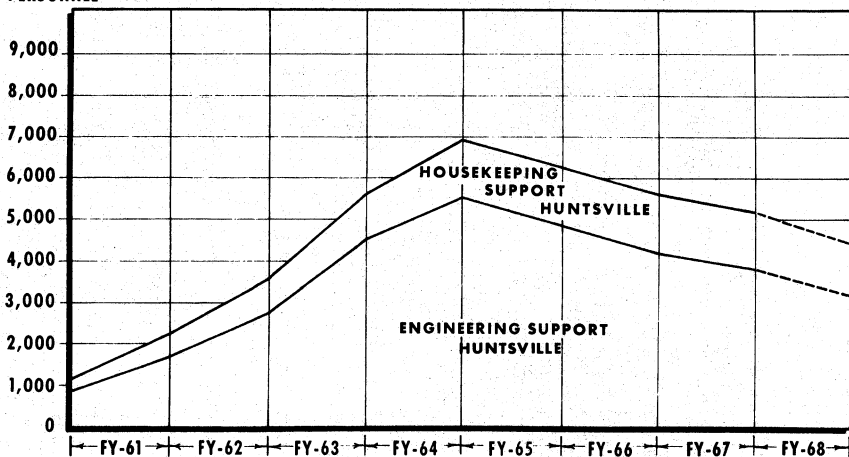


2/7/67 E-D A 533U

CHART 7

MARSHALL SPACE FLIGHT CENTER
SUPPORT CONTRACTORS

PERSONNEL



1/31/67 E-D A500-12B

CHART 8

In the housekeeping support area, it's RCA for management services, Management Services of Knoxville for technical services, and Rust Engineering for facilities and design.

The principle of contracting used at Marshall is that all work to be performed by contractors will go out through normal competitive procurement channels except that work which cannot be sufficiently described and packaged within the time allowed for the work to be performed. It is only this latter type of work that will be performed by our support contractors. But even task assignments to support contractors are performed under full contractor management responsibility.

Mr. TEAGUE. Doctor, would you take one of those laboratories and tell us, for example, what support does Sperry Rand furnish?

Dr. VON BRAUN. Yes, maybe Dr. Haeussermann, you can help me a bit here.

Dr. HAEUSSERMANN. They give engineering support in our laboratory, manufacturing support particularly for our pilot manufacturing group, and support in various areas of scientific development. All tasks given to the contractor are clearly defined in advance.

Dr. VON BRAUN. Maybe I can say a few more words about the mode of operation. Attributes of our single-support contractor concept are the following: The office management of each laboratory directs the respective support contractor, and retains full control of dollars and manpower. The functions and task assignments of each support contractor are exactly specified. The system provides continuity

GEORGE C. MARSHALL SPACE FLIGHT CENTER

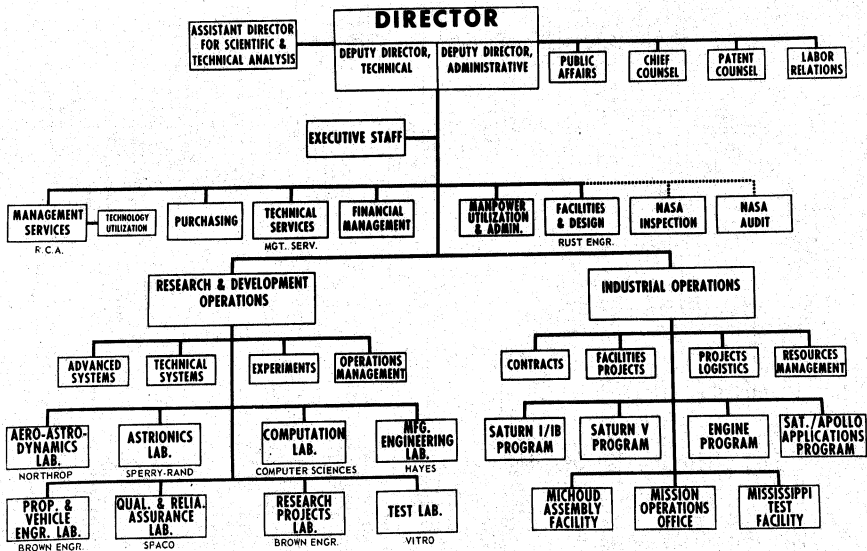


CHART 9

throughout the program, with each contractor holding a 1-year contract with an option to renew for a total of 5 years. These contracts are award-fee contracts.

Our experience shows we are getting better work for less money under this approach. The laboratory support contractors are under the management surveillance of Mr. Cook, who is deputy director of research and development operations. The entire single support structure is under the top management surveillance of Mr. Gorman, who is my deputy director, administrative. He also serves as the fee-determining official in all cases.

This chart shows Marshall funding level by appropriation for fiscal year 1967 and the proposed fiscal year 1968 budget in the President's budget. The total funding level for fiscal year 1968 would be about \$59 million higher than in 1967—\$59 million higher for the Marshall Center.

Mr. WAGGONER. What brings that added cost, Doctor? In research and development, is it Apollo applications?

Dr. von BRAUN. Yes, it is predominantly in the area of the Apollo applications program. As you see, we are dropping off slightly in administrative operations. Construction of facilities is slightly increased, but not very much. The big increase is in research and development and we shall discuss that in detail tomorrow. Tonight I will concentrate on administrative operations and construction of facilities. But before we do this, I'd like to show you a summary of our fiscal year 1967 obligation and cost pictures.

MARSHALL SPACE FLIGHT CENTER

FUNDING LEVELS BY APPROPRIATION

(In Millions of Dollars)

<u>Appropriation</u>	<u>FY - 1967</u>	<u>Proposed FY - 1968</u>
Administrative Operations	\$ 127.8	\$ 126.3
Construction of Facilities	1.7	2.9
Research and Development	1377.7	1437.4
TOTAL	\$1507.2	\$1566.6

This chart shows our obligation plan for Marshall's total program in fiscal 1967 and our actual progress against this plan. We are pretty well on target, as you can see. We are right now at this point here. I think we can state flatly that we shall achieve our planned obligation level by the end of the fiscal year with the possible exception of a small number of technology tasks involving only a few thousand dollars. Our problems with obligations in this particular field usually are with research institutes or universities, because they don't have the professional administrative staffs for contract handling you will find in industry. But then the amounts of money are quite small so it doesn't affect the big picture.

My next chart shows our cost plan for Marshall's total program in fiscal 1967 and progress to date. I don't know how familiar you are with these obligation and cost figures. "Obligations" means, essentially, we have firmly committed this money to the contractor. He has the green light to spend it. "Cost" means, in essence, we have paid the bill. So actual expenditures always trail obligations timewise. If we have obligated every penny in a given fiscal year, the difference between cost and obligations is the carryover into the next fiscal year. Some carryover is necessary for the continuity of the operation, of course, just like a man should have a little carryover on his checking account between two successive paychecks. But in our Apollo program there is little left for comfortable carryovers. The outlook for Marshall's meeting cost targets is uncomfortably good. I think

MARSHALL SPACE FLIGHT CENTER
FY-67 OBLIGATIONS, PLANNED AND ACTUAL
ALL APPROPRIATIONS-AO, R & D, AND C OF F

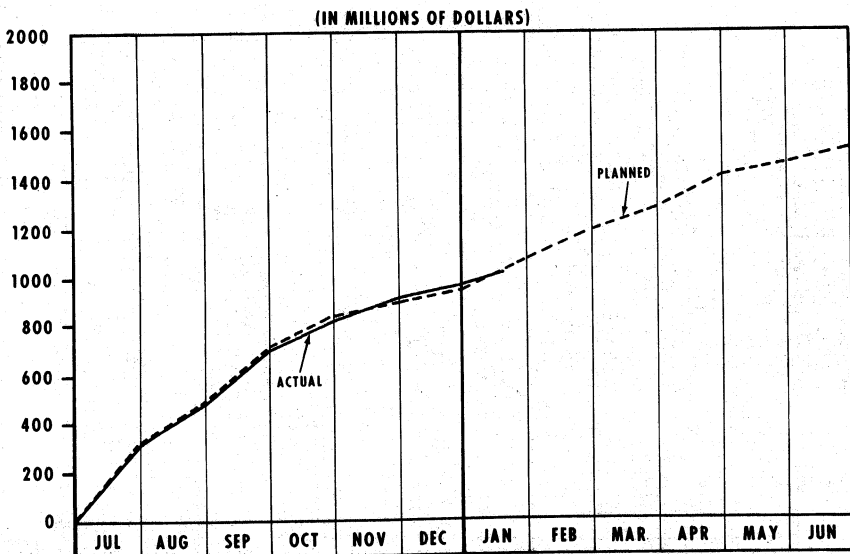


CHART 11

General O'Connor will discuss this carryover question tomorrow. It is a very important aspect in our program. In fact, we feel in the Apollo program we are shaving things pretty tightly going with very, very thin reserves over into the next fiscal year.

Mr. TEAGUE. Doctor, are we shaving it too close?

Dr. VON BRAUN. I wouldn't say "too close." We are shaving it close.

Mr. TEAGUE. Do you have sufficient money for doing testing so that you have no question when the vehicle leaves here that you are satisfied with it? Would you test more if you had more money?

Dr. VON BRAUN. We are shaving things a little tight and we have to cut some corners. I have to admit that. With more money we could do a more thorough job. There is no question about it.

Mr. WILSON. I asked a company a couple of days ago that builds an airplane that also builds a very important part of the Apollo program, and they told me that they did not test the Apollo part as much as they tested the plane which they were building for the commercial market. This rather disturbed me. They said they just didn't have the money to do it.

Dr. VON BRAUN. There is no question that in many areas one could do a more thorough job with greater resources. But when you look at the program in its totality, you will find that most program elements are coming along quite well, while there are always a few things on what we call the critical path. These are the pacing items, the parts

**MARSHALL SPACE FLIGHT CENTER
FY-67 COSTS, PLANNED AND ACTUAL
ALL APPROPRIATIONS-AO, R & D, AND C OF F**

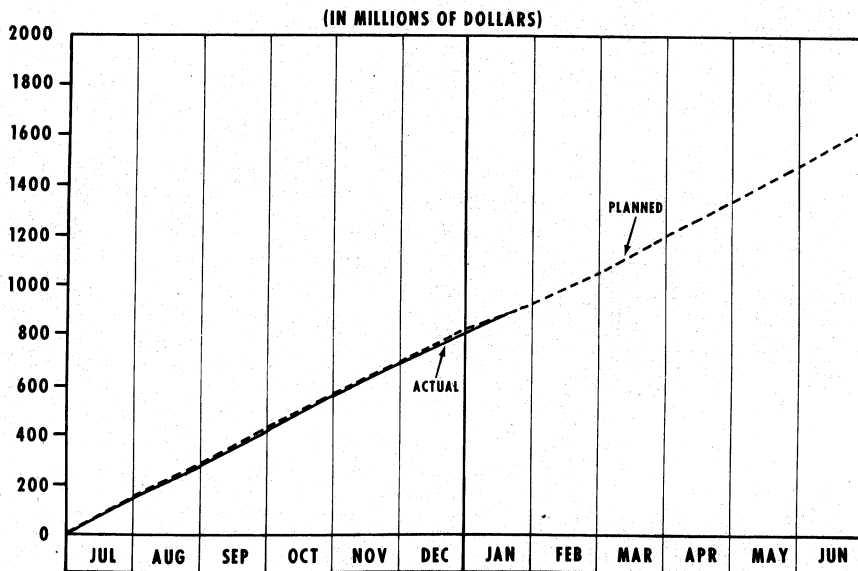


CHART 12

everybody is waiting for. If an item is on the critical path, you really have an incentive to rush it through as fast as you can and it is here where you are tempted to cut corners. There is no question that in such cases more money and more time would help. In many areas we are testing enough; in some areas we would feel more comfortable if we could test a little more. Let me put it this way.

My next chart shows our Marshall cost-reduction program. We were given a goal of \$43 million in fiscal year 1966 and actually accomplished cost reductions of \$60.4 million. In fiscal year 1967 the goal we were given was again \$43 million. We accomplished \$48.6 million through the second quarter. We are not yet at the end of the year.

NASA's cost-reduction program reaches out into its contractor plants. The way NASA administers this part of the program is by assigning certain contractors to each NASA Center. For example, we were asked to run the cost-reduction program for Boeing, Brown Engineering, Chrysler, Douglas, GE, and the other companies listed here. Some of these companies do not hold major contracts with the Marshall Center. For example, United Aircraft. Most of the business United Aircraft has with NASA is actually in the space suit and life-support-equipment area and fuel cells for spacecraft. But we were given the job of running that cost-reduction program, too.

MSFC COST REDUCTION PROGRAM

● MSFC In-House

● FY - 66

Actual	\$60.4 Million
Goal	\$43.0 Million

● FY - 67

Actual	\$48.6 Million (through 2nd Quarter)
Goal	\$43.0 Million

● Contractors Monitored by MSFC

● 12 Contractors

Boeing, Brown Engr., Chrysler, Douglas, G.E., Hayes, IBM, Mason-Rust, Spaco, Sperry-Rand, Vitro, United Aircraft

● <u>FY - 66</u>	\$99.5 Million
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My next chart introduces our discussion of administrative operations. This chart shows Marshall's portion of the administrative operations appropriation for fiscal years 1967 and 1968 broken down into the three principal items that comprise the administrative operations area. In the center column, you find the figures in the President's budget for fiscal year 1968. Total administrative operations for fiscal year 1968 would be \$11½ million less than in fiscal year 1967, shown in the column on the left. We asked originally for the amounts listed on the right. Between NASA and the Bureau of the Budget, these figures were scrubbed down to the ones shown in the center column, so that's actually what you'll find in the President's budget.

Mr. WAGGONER. Dr. von Braun, how do they figure with 7,032 personnel, the same number as last year, and in-grade pay increases, they can reduce future personnel compensation? Have you got that much turnover in personnel?

Dr. VON BRAUN. Harry Gorman, will you answer the question?

Mr. GORMAN. Apparently they have figured about 100 fewer man-years of effort due to the fact that in fiscal year 1967 we are gradually reducing from 7,271 to 7,030, whereas in 1968 we shall remain on the 7,030 level throughout the year.

Mr. WAGGONER. Do you agree that the lapses they might have anticipated are in line with what your experience has been?

Mr. GORMAN. No, we think that the personnel compensation is going to be closer to 89.1.

Dr. VON BRAUN. Personnel compensation between fiscal year 1967 and fiscal year 1968 would drop about \$900,000 from 88.0 to 87.1 million. Operation of installations would drop about \$600,000 from the

MARSHALL SPACE FLIGHT CENTER

ADMINISTRATIVE OPERATIONS

FY-67 & FY-68

(In Millions of Dollars)

<u>Item</u>	<u>FY-1967</u>	<u>Proposed FY-1968</u>	<u>MSFC FY-68 Request</u>
Personnel Compensation	\$ 88.0	\$ 87.1	\$ 89.1
Travel	3.3	3.3	3.3
Operation of Installations	36.5	35.9	39.5
TOTAL	\$127.8	\$126.3	\$131.9

CHART 14

1967 figure and is a full \$3.6 million below our request. This item includes such things as communications, utilities, supplies and materials, maintenance, and, particularly, computer rentals.

The next chart shows in some detail why we are so concerned about this very tight situation in the administrative operations area. The proposed budget for administrative operations, as you saw on the previous chart, is 3.6 million under our requirements.

The first is travel. The amount budgeted is the absolute minimum figure in view of the critical period we are entering in the Saturn program. Let me give you an illustration here. We are confronted with a very major problem with our second Saturn V stage, particularly in the manufacturing and quality control areas. So we have, at the present time, a firefighting team of approximately 30 of our research and development experts in the structural, propulsion and the quality control fields, and so forth, out at the contractor's assembly plant at Seal Beach, Calif. These men will stay there at our resident office until this problem is ironed out. These people are in travel status. Now, if travel funds are curtailed, or limited, our ability to take these emergency measures is reduced. The effect is like with-

MARSHALL SPACE FLIGHT CENTER

ADMINISTRATIVE OPERATIONS

AREAS OF CONCERN

- Travel
- Work Force Considerations
- Paid Overtime
- Summer Student Program
- Conversion to Third-Generation Computers

holding gasoline from the fire department. Your fire trucks don't do any good if you can't move your fire engines out. The amount of money involved in travel is relatively small, \$3.3 million a year. The President's budget recommends the same figure we proposed at Marshall and I hope the final figure appropriated will not be cut at all.

Then there are work-force considerations. Our total personnel compensation money is \$900,000 less than we have requested. This means, first of all, we must reduce the number of promotions. This could have a morale impact and affect our ability to retain critically needed good people. It could also reduce our flexibility to attract good people to join the Marshall team because we shall not be able to offer salary levels commensurate with the kinds of talents we are seeking. As we get closer to the wire and the moment of truth in the activation of our Apollo hardware, it is all the more important that we retain first-class staffs. A relatively minor saving in personnel compensation can hurt us in keeping the critical kind of people we need to bring success to the program.

Next, paid overtime. We are already following a very rigid overtime policy. We are employing compensatory time features, but we shall have to watch this area very carefully. Now, overtime is the kind of a subject that lends itself to many motherhood statements, such as, in a well-planned organization you don't need overtime. But in a program like ours, where setbacks suddenly strike, where one item is suddenly critical and thousands of people are waiting for that one item to come back to be delivered, there is just no other solution but to work some people day and night to get that problem out of the fire. Now if you tell people they can do this only by working compensatory time (in other words, they work Saturday and Sunday, then they do not work Monday and Tuesday) you are not helping the total situation very much. And we just haven't got the money to pay these people overtime. We think this situation can be very wasteful, especially in our closely meshed program where everyone waits for the slow man in the class. So we think the use of paid overtime is helpful in a program like this. It is not wasteful at all; it's actually a savings. And I am afraid we are not in a position to always set our own pace as if we were in the business of making shoes.

Reduced administrative operations funds also impact our summer student program, which means we are going to have fewer summer students which help ease our workload burden during the summer months and have become a very effective source for future recruiting.

A final area of concern is our conversion to third generation computers.

This conversion is a very major undertaking. Third generation computers are essentially computers where the interface between the user of the computer and the machine itself has been vastly improved. In principle, you have a centralized computer and lots of outlets, almost like telephone outlets, to individuals who have direct access to the computer, because their input and output devices are wired to the computer. This does away with the need for people to talk to programmers in another building, having to wait in line for service, et cetera. This is a new concept of better use of the inherent capabilities of these very high-speed electronic computers. It resolves the problem

of communication between slow man and fast computer that has restricted full utilization of these high-speed computers. The industry has made a major effort in the so-called third generation computers to improve that interface. The result is that for less money you get a lot more computation capability. Now, we are converting from our present second generation computer to third generation in phases. And we can phase out the second generation computer only after the third generation system is really completely on stream. Our lack of funds in this area will not allow us to run these parallel operations and could delay the introduction of the third generation computers. We are actually paying more for the older computers with less results, so we would like to make this move now in order to save money. That's the message.

Specifically, fiscal years 1968 and 1969 are actually the conversion periods during which we had planned to continue the second generation computers while phasing into third generation. Although there would be higher additional cost during this temporary period of parallel use, substantial economies in subsequent years could be expected. And the conversion cost would easily be amortized in 1970 and from then on it would be money in the bank.

This chart shows the program facilities in support of that part of the Apollo program that is run out of Marshall Space Flight Center. You see the Huntsville test facilities, and the Mississippi Test Facility, and the Michoud Facility which we are going to visit on Saturday. On the West Coast is Rocketdyne's Canoga Park rocket engine manufacturing facility, with engine testing at nearby Edwards Air Force

MARSHALL SPACE FLIGHT CENTER

THIRD GENERATION COMPUTER SYSTEM

● Principle

Centralized high-speed data processing and storage;
decentralized input - output devices.

● Reasons for Change-over

- Greater capacity
- Improved service to users
- Greater economy of total operation

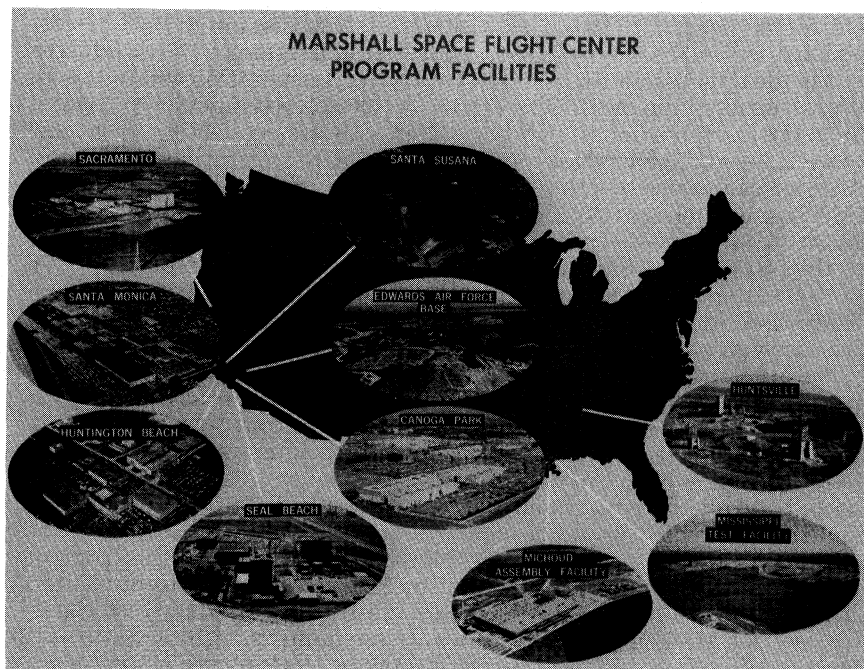


CHART 17

Base. Then there is North American's Seal Beach assembly facility where the Saturn V second stage is being assembled, and Douglas' Huntington Beach Facility, where the S-IVB is built. This stage serves as the second stage of the Saturn I and also the third stage of the Saturn V. In Santa Monica, Douglas manufactures parts that go into assembly at Huntington Beach. At Sacramento is the static testing facility where the S-IVB's are static tested.

Since 1960, the Congress has appropriated more than one-half billion of construction of facilities dollars for the facilities that you see here at these various locations. This is about one-third of the total construction of facilities program for Manned Space Flight. This investment is testimony to the vision of this subcommittee in building a national space flight capability. As Mr. Webb stated recently, the Nation has invested \$2½ billion at Michoud, Mississippi Test Facility, Huntsville, Houston, and Cape Kennedy, to give the country a basic capability to operate its space program for the next 50 to 100 years. As to our own facility here in Huntsville, we have a broad capability to support research, manufacturing, assembly, and testing of sophisticated flight articles up to a relatively large size. These facilities, although largely created for Apollo, provide a versatility for adaptation to follow-on programs.

Although you will not see it in our request for fiscal year 1968, we foresee the need to modernize that portion of the Marshall plant which consists primarily of obsolete World War II facilities which we adapted for interim use. In addition, certain specialized environmental and development testing facilities are needed to complete the rounding of our capability for future programs. The scope of these

additional needs will be minor when compared to investments today at Marshall. We are currently considering this matter for inclusion in the fiscal 1969 budget. Fiscal year 1969 is the very latest we should begin work on the facilities we shall need for that follow-on period. Our facilities people are working closely with our future programs planning people to identify those future needs as precisely as possible. We are now taking inventory of facilities both here in Huntsville and throughout the country to see what facilities will be available for this future work.

My next chart presents construction of facility funding approved by the Congress for each fiscal year since 1961, when Marshall began. These figures include all of the locations shown on the previous chart. You see that we peaked in fiscal year 1963. Facilities, of course, must precede the hardware that you are going to build in those facilities or that you are going to test on these facilities. The building of these facilities had to precede the operations on the assembly floor. You see a rapid dropoff in our facilities program. We feel our entire facilities program was very successfully and effectively executed. As Mr. Webb said the other day, "A billion-dollar building program and no scandal."

This next chart presents a thumbnail status of our facility planning, design, and construction at all locations. Projects approved in 1964 and prior have been completed. The overall status of our facilities work from fiscal year 1965 to the present is indicated in the columns listed here. No problems.

Here are the construction of facilities projects we are requesting in the fiscal 1968 budget.

There is a water pollution control item for Huntsville that would provide holding basins and flow control devices to control disposal of our industrial waste into the Tennessee River.

MARSHALL SPACE FLIGHT CENTER
CONSTRUCTION OF FACILITIES
(IN MILLIONS OF DOLLARS)

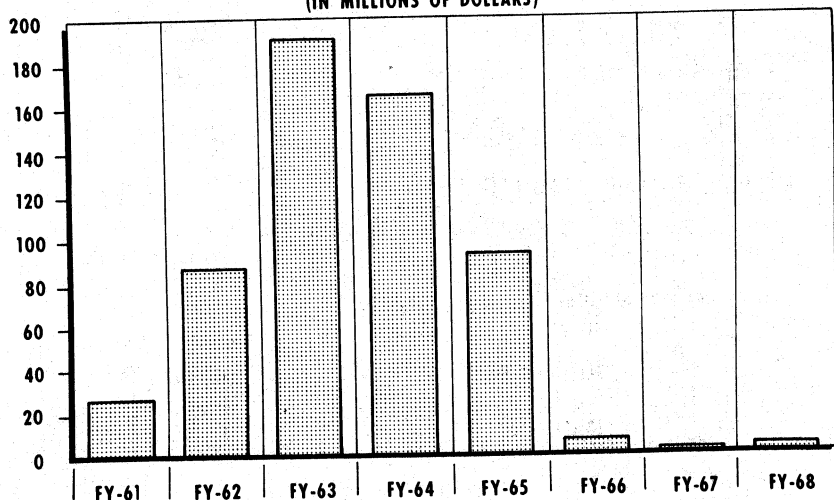


CHART 18

MARSHALL SPACE FLIGHT CENTER

STATUS OF FACILITY PLANNING, DESIGN AND CONSTRUCTION

(All Locations)

SUMMARY

<u>FY</u>	<u>No. of Projects</u>	<u>Planning % Comp</u>	<u>Design % Comp</u>	<u>Construction % Comp</u>
65	18	100	100	96
66	9	100	100	72
67	3	100	58	0
68	4	95	0	0

January 27, 1967

CHART 19

MARSHALL SPACE FLIGHT CENTER

STATUS SUMMARY OF FY-68 C of F BUDGET

(In Thousands of Dollars)

<u>HUNTSVILLE</u>	<u>CONGRESSIONAL BUDGET</u>
Water Pollution Control	\$350
Fire Surveillance System	520
Huntsville Total	<u>\$870</u>
<u>MICHOU D ASSEMBLY FACILITY</u>	
Extension of Saturn Boulevard to State Road System	\$1,130
Repair, Rehabilitation & Improvements	880
Michoud Total	<u>\$2,010</u>
MSFC Total	<u><u>\$2,880</u></u>

January 18, 1967

CHART 20

We are requesting a fire surveillance system which would provide a central fire protection system at Marshall. At Michoud, we have the Saturn Boulevard project. This would provide for the construction of 8,200 feet and two-lane road to connect the Michoud complex to the limited access highway facilities that are being constructed in the area by the State of Louisiana. It would integrate the local traffic pattern into the total area pattern.

The final item at Michoud would cover improvements in such areas as replacement of the 200,000-gallon elevated water storage tank, road repair, replacement of heating and cooling equipment, and replacement of deteriorating lighting and primary electrical systems.

Mr. WAGGONNER. Can you tell us, Dr. von Braun, a little more about this fire surveillance system?

Dr. VON BRAUN. The purpose of the system is to reduce the time for our fire police to reach a station that is in jeopardy. We have a number of hazardous facilities here where the time elapsing between the start of the fire and the arrival of the fire engines may be decisive for saving the entire facility. The system is designed to give us a faster response time. Mr. Dykes, can you comment on this?

Mr. DYKES. The existing fire surveillance system is a manual alarm, telephonic call-in system. The proposed system provides a graphic display panel in the fire hall. As Dr. von Braun says, it cuts the response time by providing direct central alarm. We also have, in some of our older facilities, some fire alarm systems which are energized on the wrong side of the electric power source, and in case of power interruption during a fire these manual systems would not work. This project is, in effect, an across-the-board look at the fire system and revises the individual systems to bring them back or puts them in a condition to allow installation of a central system.

Mr. WAGGONNER. What Government installations have such a system as you proposed at the present time? What military installations? What other NASA installation?

Mr. DYKES. I can't answer that offhand, but we have this information back in the office and I shall submit it for the record.

(The following information was submitted:)

Practically all arsenals and other Government installations with widely dispersed facilities particularly those engaged in research and development and electronics have central fire alarm systems.

Industrial complexes of most large private corporations like Ford Motor Co. and General Shoe Corp. have central fire reporting systems. This lowers fire insurance rates and affords personnel and property protection.

Government agencies known to have central fire reporting systems:

Atlanta General Depot	Mississippi Test Facility, Picayune, Miss.
Warner-Robins SAC Base, Macon, Ga.	Redstone Arsenal-Army Missile Command, Huntsville, Ala.
Fort Gordon Army Base, Augusta, Ga.	Manned Spacecraft Center, Houston, Tex.
Fort Jackson Army Base, Columbia, S.C.	Barksdale AFB-SAC, Shreveport, La.
Dobbins AFB, Marietta, Ga.	Coswell AFB, Fort Worth, Tex.
Turner AFB-SAC, Albany, Ga.	Milan Arsenal, Tenn.
Fort Benning Army Base, Columbus, Ga.	White Sands NASA Test Support, N. Mex.
Charleston AFB, Charleston, S.C.	Fort Sill Army Base, Okla.
Arnold Engineering Dev. Center, Tullahoma, Tenn.	Fort Bliss Army Base, Tex.
Michoud Assembly Facility, New Orleans, La.	

Mr. WAGGONER. Does any NASA installation have such a system?

Mr. DYKES. I think Houston has one.

Mr. WAGGONER. That's all, Doctor.

Mr. HUNT. Dr. von Braun, on your water pollution control, did I hear you correctly when you said this would be something that would be necessary to prevent pollution of the Tennessee River?

Dr. VON BRAUN. That's correct.

Mr. HUNT. Do you have any water pollution control at the present time?

Dr. VON BRAUN. Would you handle this, Mr. Dykes?

Mr. DYKES. Currently we are using a system which is man controlled. But the TVA and the Fish and Wildlife Service—we have a wildlife area immediately adjoining us—have complained on a couple of occasions about accidental dumps of industrial chemicals. Normally, we are able to control these and dilute them adequately but they are still subject to human failure and there have been accidental dumps. This system we are proposing will control the discharge so that we don't contaminate beyond levels acceptable to the Fish and Wildlife Service and TVA.

Mr. HUNT. In other words, they are going to remove danger of a manmade error through an automation process.

Mr. DYKES. In effect, that's so. It retains and dilutes in a detention reservoir so that we can meter the effluent out.

Dr. VON BRAUN. If there are no more questions about this chart, I would like to show you an area map.

This chart gives you a rough orientation of where we are. This is the city of Huntsville. You landed on this strip here and you are presently in this area here. During the committee's last visit, Huntsville had 125,000 people; today, we have about 150,000, so we are still growing pretty rapidly. The Marshall Space Flight Center is imbedded into the larger complex of Redstone Arsenal, all of which was formerly Army land. The Marshall Center, completely surrounded by Army land, occupies a total of 1,800 acres. We have a total of 6,500 people of our 7,000 man complement in Huntsville. The rest is in resident contractor plants and at our Michoud plant and the Mississippi Test Facility. About 200 of our local 6,500 are in downtown buildings at the Huntsville Industrial Center Building (which we call the HIC Building) and the Clinton Street building. In addition, we have a small radio facility on Green Mountain, to the east of the city.

Adjacent to the Redstone Arsenal area is the so-called Research Industrial Park. We drove through this area as you came in from the airport. You saw some modern industrial buildings to your left, and facilities of the Research Center of the University of Alabama on your right. The total research park includes an area of 625 acres which is part of a zoned area of 3,000 acres that the city has zoned solely for this kind of an industrial development. There is a total of 1 million square feet of industrial area under roof in the Industrial Research Park. The total investment of that park is about \$100 million and the work force in this whole area is about 10,000 people. The companies in this park include IBM, Brown, Boeing, Chrysler, Lockheed, Northrop Avco, and six smaller companies.

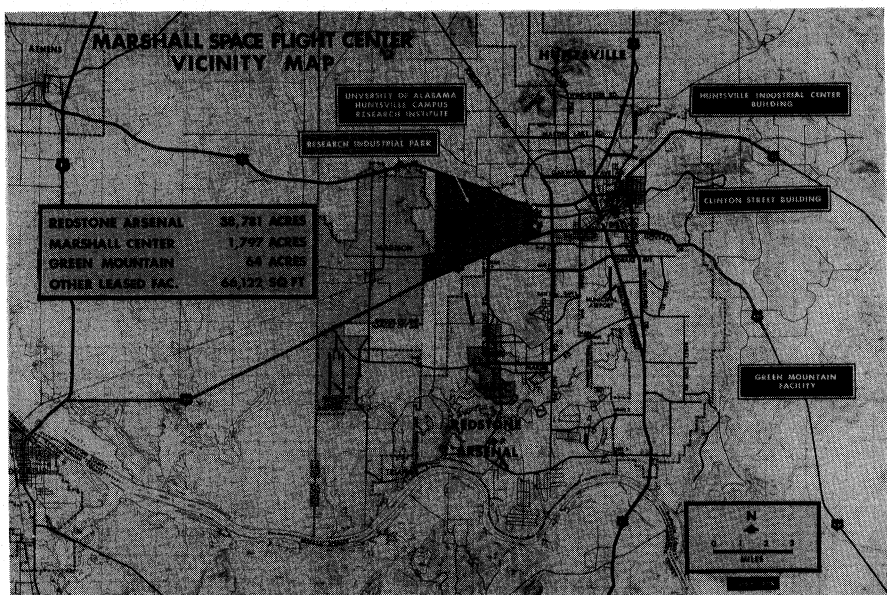


CHART 21

The University of Alabama, Huntsville campus, is located adjacent to this area here. There are about 2,000 students in the Huntsville campus; 25 percent are graduate students. There are undergraduate degrees given by the Huntsville campus in English, history, math, and physics. Advanced degrees of the university in Huntsville include math, physics, aerospace engineering, electrical engineering, mechanical engineering, industrial engineering, and engineering mechanics. I mentioned already the Research Institute of the university campus, right here.

My next chart shows the little green complex imbedded in the Army area in a little more detail. This is the Marshall Center proper—1,800 acres. Utilities and security are provided by the Army, because this area was virtually carved out of Army land and all buildings were supplied with electricity, water, and so forth, by the Army before this portion was given to NASA. It was only logical that we continue security service and utilities by the Army. The Army's cost—

Mr. WAGGONER. Do you reimburse the Army for the services they provide?

Dr. VON BRAUN. Yes, sir. The Army is also policing our main arteries going in and out. In other words, after you have safely passed all the hazards posed by the county and city police when you drive in here you can still get a ticket from the Army. We have leased 49 buildings from the Army outside of this complex. This includes warehouse and storage buildings, igloos, and so forth.

Mr. WAGGONER. Is that what the 66,000 square feet represented that you showed on the previous slide?

Mr. DYKES. No; that was leased space.

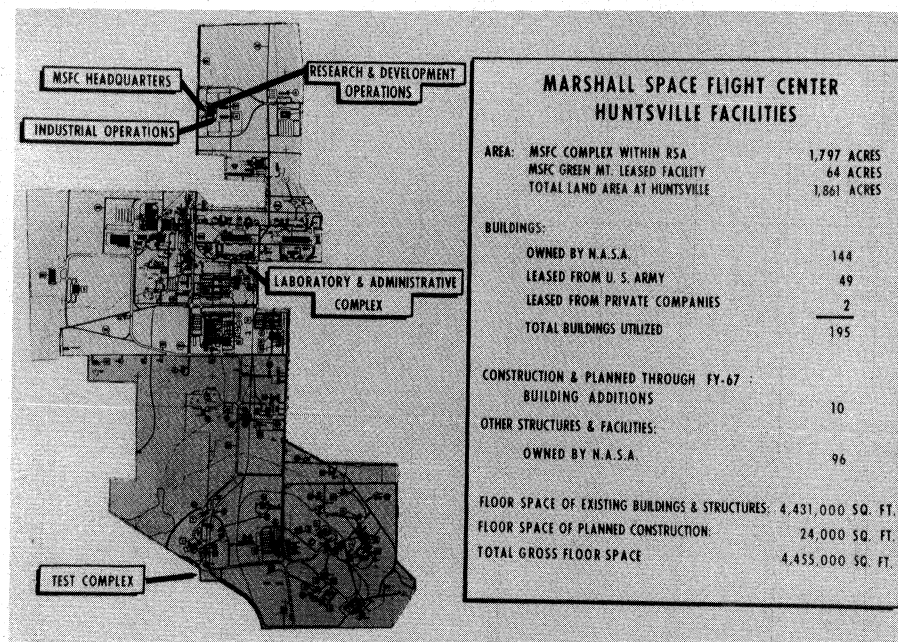


CHART 22

Dr. von BRAUN. That was leased facilities in downtown Huntsville; the Huntsville Industrial Center and the Clinton Street building. These buildings here are leased from the Army and are located on Redstone Arsenal. For example, we have leased some igloos down here to store material. For instance, when the Jupiters were decommissioned in Italy and Turkey, all of our guidance equipment came back from these vehicles and was stored in these facilities. We also have fallout shelters there that have been turned over to Marshall. All this is included in those 49 Army-leased buildings.

My next chart shows the Marshall Space Flight Center complex as seen from the North. You landed here on the strip and drove out in this direction. Tomorrow you will come in here on this road, and, after the tour, we shall go into this tall building, our Center headquarters.

Now, this is our manufacturing engineering complex here. This is Propulsion and Vehicle Engineering. This is the Astrionics Laboratory. Over here is our Research Projects Laboratory and way down here, in the rear, you see the large test stands of our Test Laboratory. Most of the other laboratories are accommodated in these buildings. For example, Astrionics is in here. Industrial Operations sits in this rear building here, and this building accommodates major elements of Research and Development Operations. Mr. Weidner and Mr. Cook, who run Research and Development Operations, share this tall building with my own staff here.

This last chart shows the test area. This test stand in the foreground is the static test facility for static testing of the Saturn V first stage. It can be fired up with all five F-1 engines burning full-duration. This test stand here is a single F-1 engine test stand. Both

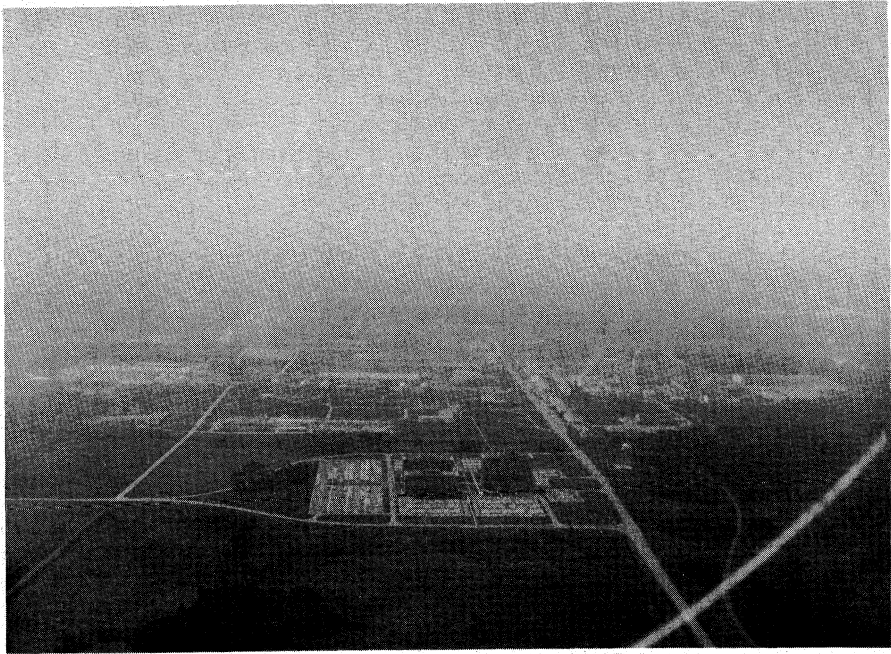


CHART 23

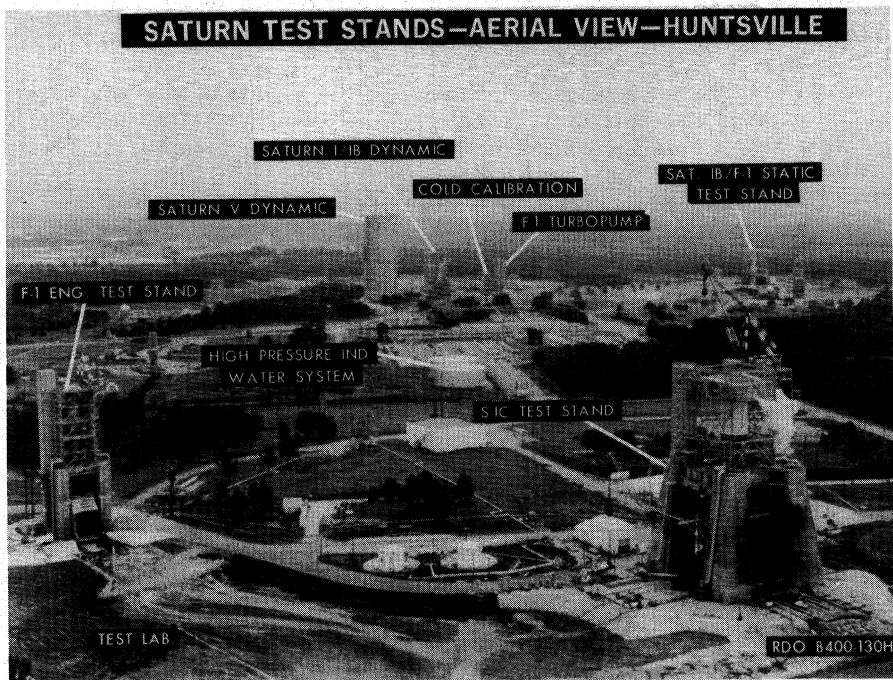


CHART 24

test stands are operated from the same blockhouse. This is a water pump facility to cool the jet deflectors. This is the headquarters area of our Test Laboratory. Here are some older test stands and these are our dynamic test stands where the rockets are not fired up but are subjected to shaking tests to learn their structural behavior under vibration. This, by the way, is an old technique, developed originally for aircraft. You oscillate an airplane or a large space rocket with an eccentric mass, for instance, to see what the resonance pattern is. This gives you a very good clue on structural damping and general structural integrity. It also pinpoints soft spots in the structure. We have evaluated all our space vehicles in this facility.

You will have an opportunity to see the Saturn V full scale in this facility tomorrow and actually see how such a shake test works. We will also see an F-1 engine firing in this test stand. When we visit the test area tomorrow, you will first go into the bottom of this facility where we will see a dynamic test of Saturn V and then we will drive up to the roof of this blockhouse and you will see a test in this test stand. This, Mr. Chairman, ends my presentation.

Mr. PETTIS. Dr. von Braun, one question. May I have the slide back again. The large Saturn V dynamic stand that you indicated was where you subjected it to the vibration, could that also be designed to point up any molecular fatigue in the structural design of the metal? From time to time we have a molecular fatigue which develops in certain types of metal. Now will this particular design of the Saturn V dynamic stand show this up likewise?

Dr. VON BRAUN. It might. But fatigue failures are more likely to show up in our structural load testing program, which is conducted on another facility. The main purpose of the dynamic stand is to learn about the dynamic behavior of the vehicle. How does it vibrate? How does it respond to control forces? How does the space vehicle bend and vibrate, for example, as it penetrates a jet stream in flight, and how does its structure dampen out these oscillations? We need this information not only to check on the integrity of the structure but also to see whether our controls are stable throughout the flight. You can very easily run into a situation where the control system starts "hunting" and may rip a rocket to pieces. One cannot simulate this completely in model tests and so full-scale dynamic testing is necessary.

Mr. PETTIS. Doctor, you made note of a patent office which is a new department at Huntsville. Does this indicate that there is a—maybe this isn't a correct word—commercial or industrial fallout from the research and development that is being done here which has a utilization on the ground for immediate application?

Dr. VON BRAUN. Very much so.

Mr. PETTIS. Which is of benefit not only to the Government but to the people? How does this work?

Dr. VON BRAUN. The problem you just mentioned has quite a few aspects. One is, of course, that some of the things that develop in the program can indeed be patented, either by an employee of the Government, or by a contractor. But since a contractor is under a Government contract the Government has almost unlimited use for our specific applications. But the contractor can, in certain cases, say, "Well, I would like to use this particular patent in connection with something that has nothing to do with Saturn V. Would you release it for my commercial use?"

This brings up a typical legal question that this patent office addresses itself to. But this problem of technological fallout has also another interesting side. Many of the things that come out of our Saturn and Apollo program may not be patentable. You cannot get a patent unless you are presenting a genuinely new idea, but all you may have may be just a new technique. But, although that new technique was developed in conjunction with the Saturn and Apollo program, it may still offer new possibilities in entirely unrelated areas. This is where NASA's technology utilization program comes in. There is a separate office in NASA Headquarters, the Office of Technology Utilization, that has the sole task of continuously scanning the entire industrial and university effort sponsored by NASA and to investigate the possible utility of new products and new techniques for other fields of human endeavor. We have a contract with the University of Indiana under which they make a literature search through papers produced by and for NASA for things of potentially more universal utility. When they find something worthwhile they prepare a paper with a description of the gist of that new idea or method and disseminate it throughout industry.

Mr. WAGGONER. It's a technogram—gives a problem and solution, or spin-off.

Dr. von BRAUN. Let me give you an illustration. We pioneered a technique here at Marshall called the magnetomotive hammer. This is essentially a technique to deform aluminum tubes with an electric power surge. For instance, you can make a female die of a bellows and place a simple aluminum tube into the die. Then you discharge a powerful electrical current through a coil and the resulting magnetomotive force drives the aluminum tube right into the die and forms so it becomes a bellows. We have used magnetomotive forming to solve some of our manufacturing problems. The Office of Technology Utilization found this idea interesting. They wrote a little pamphlet on it and disseminated it all over the world. We have had several thousands of letters of inquiry from people who wanted to know more about this technique. Inquiries came not only from the United States, but from as far away as Europe and the Near East. The real problem for these Technology Utilization people is to be able to detect what has potential for nonspace activities to discover potential industrial diamonds among that vast mass of material that NASA and its associated industrial contractors are handling. Every now and then something really exciting turns up.

Mr. KLINE. Dr. von Braun, do you want to show them the office at Marshall that coordinates it?

Dr. von BRAUN. Marshall's Technology Utilization, under Jim Wiggins, reports to a staff office, called Management Services. There is an office at NASA Headquarters in Washington formerly run by Mr. Kerr, son of the late Senator Kerr. Technology Utilization is one of Mr. Webb's personal projects, and we all in NASA think it's a most valuable thing. Every now and then we see industrial products that obviously borrowed techniques that were developed in conjunction with the Saturn/Apollo.

Mr. ECKHARDT. Would there not be a negative aspect of this Patent Counsel? For instance, you have developed an obvious basic principle that can be adopted in certain industry which might be seized by the first comer and it might be desirable for patent processes to com-

mence with someone who would protect it for the original discoverer or avoid the seizure of this plan inequitably by someone who is building on research done at the expense of Government.

Dr. VON BRAUN. Well, I agree that this potential does exist. I don't believe we ever had any serious abuses here. At least I don't know of any. As I understand this, whenever a contractor develops something for the Government, and in the process of developing this item he runs into some idea or method that he considers patentable, he can file a patent. But the Government by virtue of having financed and sponsored the development program automatically owns the right to use this patent, not only for that particular development, but also for anything else.

Mr. ECKHARDT. That's exactly what I was saying.

Mr. HEBERT. The same thing in universities.

Dr. VON BRAUN. But in some cases a contractor may plan to utilize this patent for something entirely out of our area, and this he can do, with the Government's permission. How is this, Harry?

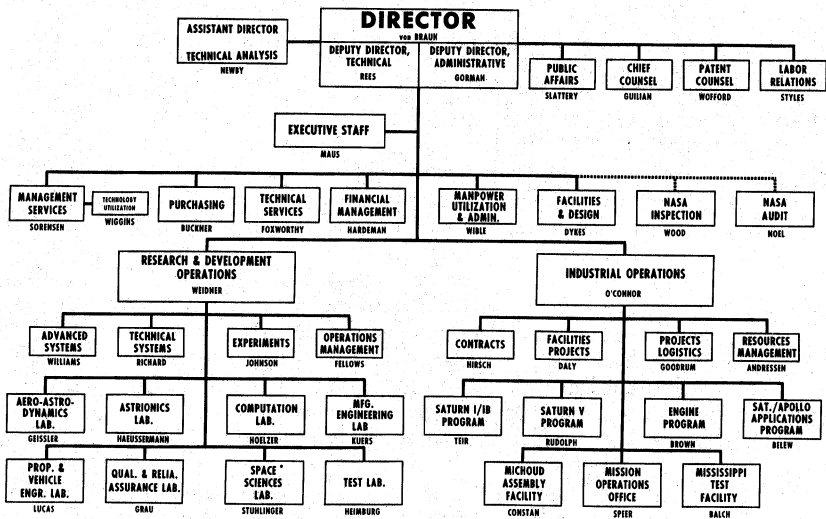
Mr. GORMAN. Our problem is to get the contractors to make their patent disclosures to us. It is a problem for a number of reasons.

Mr. ECKHARDT. There might be a public policy against an individual or contractor patenting a device to the exclusion of other persons, when in fact the original research was initiated by Government. In other words, there can be public policy against restriction of use, and without an active Patent Counsel, it would appear to me that there can be inequitable seizure on ideas actually originally developed by Government.

Mr. GORMAN. Part of the Patent Counsel efforts here are directed toward obtaining the disclosures on the part of the contractors.

Mr. TEAGUE. Doctor, thanks for a very good briefing.

GEORGE C. MARSHALL SPACE FLIGHT CENTER



*PENDING NASA HQS. APPROVAL

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CHART 25

STATEMENT OF BRIG. GEN. EDMUND F. O'CONNOR

PART II. SATURN PROGRAM STATUS

SATURN PROGRAM STATUS

Mr. Chairman, gentlemen, in my briefing this morning and by way of introduction (fig. 1), I will touch on the organization of Industrial Operations to acquaint you with some of our practices and policies. I will cover, as well as I can in the scheduled time, the status of launch vehicles and engine programs. I will highlight some of the more significant program developments; some of these will be accomplishments and a few will be problems.

You asked earlier for an expression of our judgment and experience with incentive contracting, and I will touch upon that along with our funding for fiscal year 1967 and our proposed funding for fiscal year 1968, and close with some summary remarks. I might add further that I have a second part which is not on the outline and will take about 5 minutes. This will be a discussion of the Mississippi-Michoud complex which you will be visiting tomorrow.

Shown here in figure 2 is the Industrial Operations organization which Dr. von Braun described to you last night.

I am General O'Connor, Director of Industrial Operations. The mission of Industrial Operations is to manage the programs—the Up-rated Saturn I, Saturn V, and Engines, and now the Saturn/Apollo Applications Program. The Program Managers are the heart

OUTLINE

- INTRODUCTION
- UP-UPATED SATURN I, SATURN V, AND ENGINES
- PROGRAM DEVELOPMENTS AND PROBLEMS
- CONTRACTING AND FUNDING OUTLOOK
- SUMMARY REMARKS

FIGURE 1

GEORGE C. MARSHALL SPACE FLIGHT CENTER

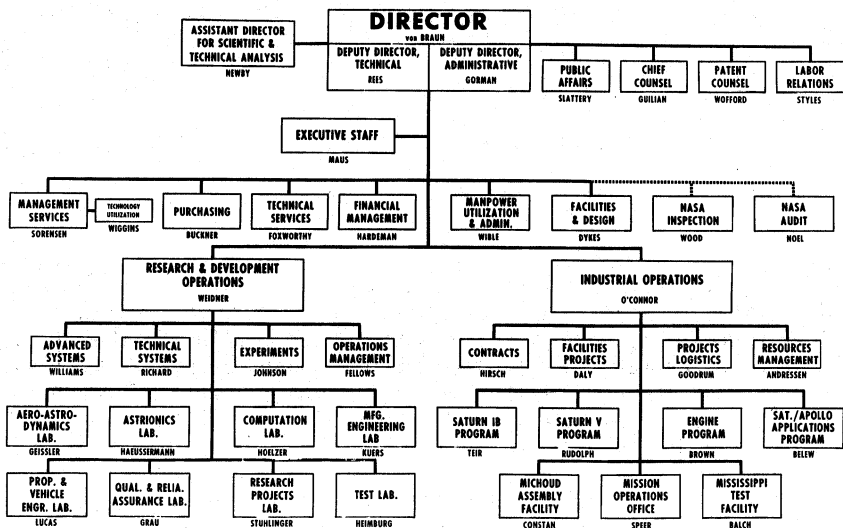


FIGURE 2

of our organization. They are charged with the responsibility for complete control of their programs. The staff elements, i.e., Contracts, Facilities Projects, Projects Logistics, and Resources Management Offices, spend about 20 percent of their time and capability in a staff capacity, while the other 80 percent is spent in working with the Program Managers in all of their functions—contracting, logistics, and so forth.

In our Mission Operations Office is a group of 42 people who primarily support the Program Managers in the launch and flight operations chores and who interface very closely with Kennedy Space Center and the Mission Control Center at Houston.

Here is a pictorial (fig. 3) of how we actually manage our programs and our interfaces with the contractors, Marshall's Research and Development Operations, and other NASA Centers. There are two or three points I would like to make here. One of our obligations and capabilities in program management is to use the Marshall R&D technical competence which exists in depth to the extent of some 4,500 personnel. The point I would like to make is that we really have a "swinging-door" operation through R&DO where I, the Program Managers, and the Project Managers work horizontally and vertically with R&DO staff members and down into the branch level of the laboratories. There is good technical competence in depth in the offices of the Program and Project Managers, but the Reservoir of scientific and engineering support is supplied by Research and Development Operations.

Next, in our day-to-day activities in managing the contractors, which is our primary activity, since over 90 percent of our business is outside, we work basically through our resident managers. This proce-

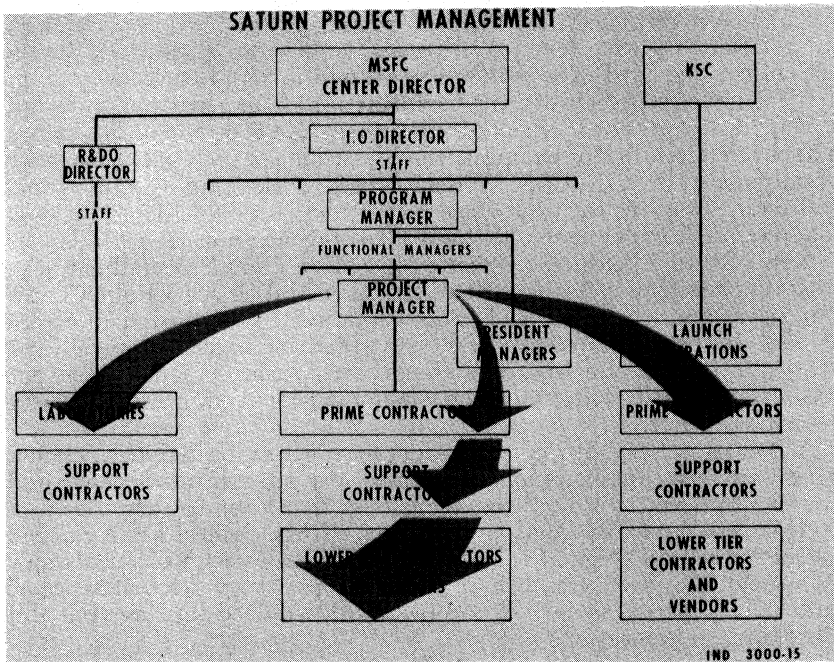


FIGURE 3

ture is followed by both the Program and Project Manager's office, but more so on a day-to-day basis by the Project Manager's office.

I might say right here that we have approximately 20 Project Managers. Were you to compare this to industry, which in one sense perhaps is not fair, it would give you an idea of the responsibility assigned to these people. The Program Manager might be considered as the president of an entire division within industry, whether that be within the aerospace industry or an organization like General Motors; I would consider the Project Manager as the vice president for a particular product. The intricacies and costs of our programs are large enough to require this kind of attention. I will briefly explain the role of a Project Manager.

For each of the three engines we have a Project Manager to oversee the entire engine project. For example, the F-1 Engine Project Manager has been charged with his staff of 27 people to manage all aspects and phases of the F-1 project from design to acceptance test and delivery.

As another example, Dr. Rudolph is the Program Manager for the entire Saturn V launch vehicle. He has Project Managers assigned to each stage or major system such as the Instrument Unit which you saw at IBM this morning. Any one of these projects, and my funding data will disclose this later, is running on an average of \$175 million per year which is the reason for my earlier comparison with industry.

Now, I will explain briefly our interface with other centers using our relationship with Kennedy Space Center as an example. We do not deliver our hardware to the dock at the Cape and back away from

it. We have responsibility for performance of the hardware through our relationship with Kennedy Space Center as an example. We do not deliver our hardware to the dock at the Cape and back away from it. We have responsibility for performance of the hardware through of our hardware must be maintained there for 5 or 6 months before launch. We retain, for example, configuration control and accounting of our hardware at the Cape. This has been worked out by agreements and understanding with the Cape. The point I would like to make is that our traffic or commerce with the Cape is continuous and persistent.

You were told last night that we have some 7,200 Marshall employees. Approximately 10 percent of the Marshall Space Flight Center employees are out in the field in locations such as indicated in figure 4. Of the approximately 1,200 program management people at Marshall, that is, the Industrial Operations group, about 45 percent are out in the field doing the program management job which I briefly described earlier.

A large number, approximately 250 people, are located at Michoud, where we have dual missions—program management and associated functions plus institutional management of that large facility.

At Space and Information Division, North American Aviation, where the second stage of the Saturn V has been designed and is now being manufactured, we have 67 of our people; they are a mixture of Industrial Operations people and technical people from Research and Development Operations.

There are a few places such as Flexonics, Elgin, Ill., where we have only one person. These are quality assurance type individuals who make sure that the products we are getting are to the proper quality standards.

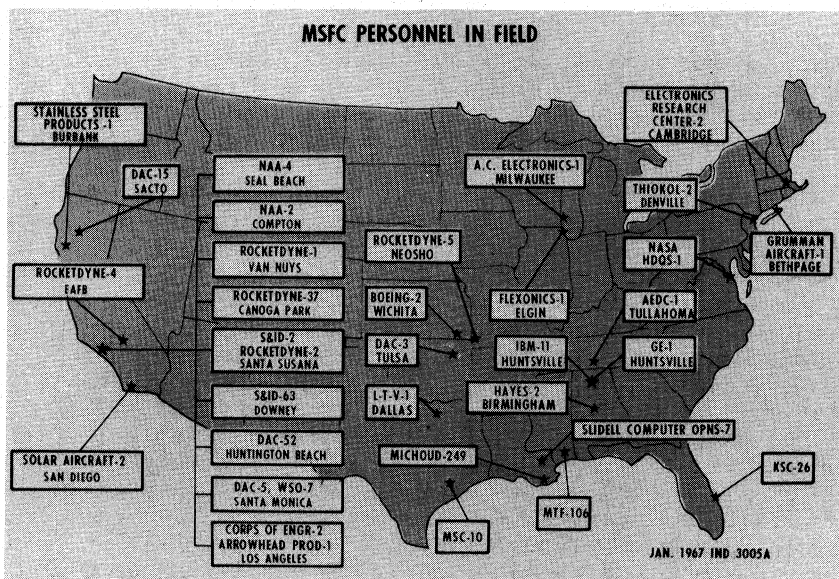


FIGURE 4

We have a few other people assigned to other NASA Center contractors. For example, at Grumman, at the request of Manned Spacecraft Center, we have an individual who is helping survey the Grumman manufacturing operations on Long Island.

Here is a pictorial—figure 5—some of our major contractor interfaces. We have added a few of the Government interfaces such as Manned Spacecraft Center and Kennedy Space Center. However, the importance of these interfaces is not really evident from the chart. We have about 98 active contracts spread out over the United States. For simplicity, which we did not really portray with this chart, we have shown the locations of the 40 contractors who have contracts valued in excess of \$1 million each.

As I proceed with my presentation, I think you are going to see some of the pitfalls of managing a program with hardware being designed and produced all over the country. Were we to take any of these contracts, for example RCA or North American, and break them down through the fourth tier of subcontracting and through their vendor structure, we would have an unintelligible chart. But this is the type of situation the Program Manager is faced with in assuring that the total finished product is adequate.

The troika of Saturn vehicles is represented by—figure 6—the Saturn I, the Uprated Saturn I, and the Saturn V. We could talk all afternoon about the accomplishments in the Saturn I program, but I intend to summarize only. The technology which went into the Saturn I was derived directly from the Jupiter and Redstone technology.

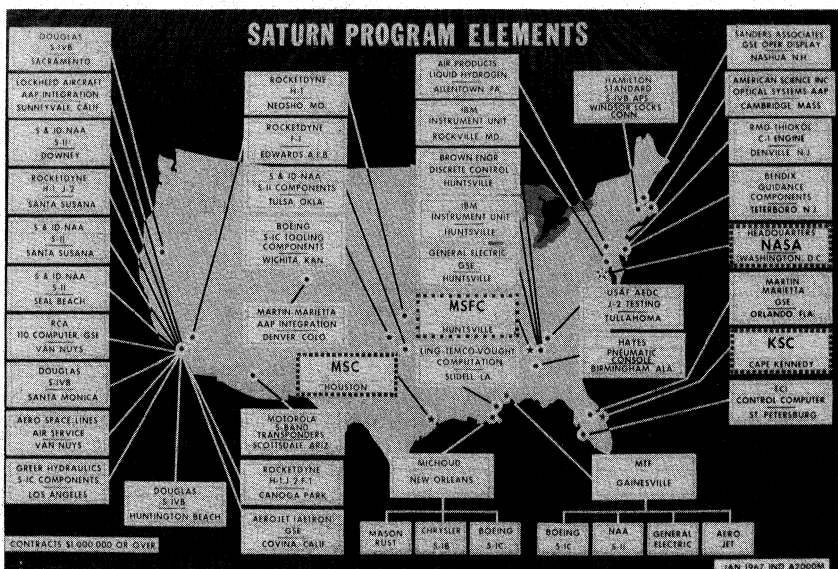


FIGURE 5

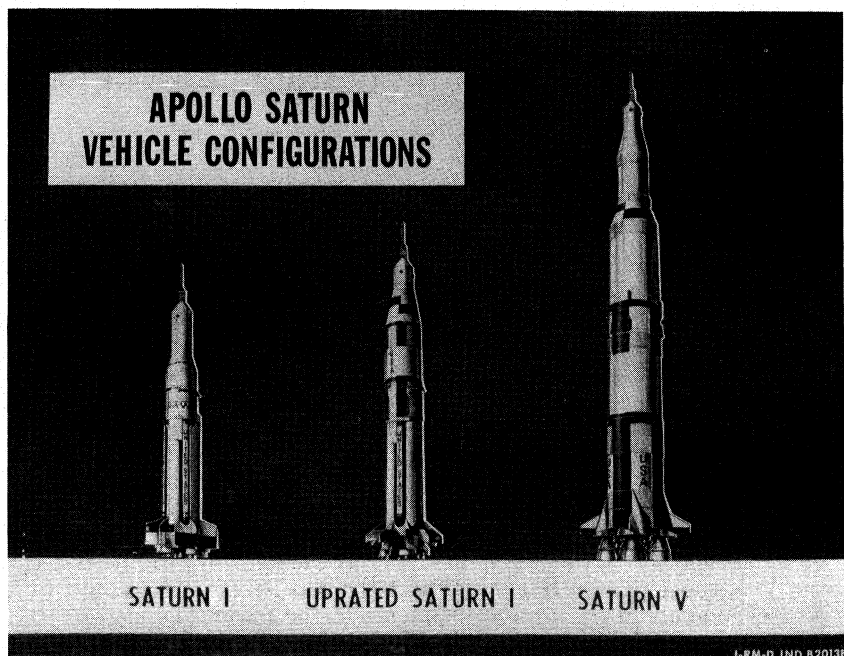


FIGURE 6

On the Saturn I program there were 10 flights programed, scheduled and flown successfully. There were no losses or failures. The program, completed in 1965, went a long way in preparing us and serving us as flight prototype hardware for both the Uprated Saturn I and the Saturn V.

For example, in the Saturn I program we proved that clustering of the engines was a satisfactory and workable method toward accomplishing the objectives being laid out for later Saturn programs. The art of kerosene and liquid oxygen propulsion was developed with the first stage of the Saturn I. The art of liquid hydrogen and liquid oxygen was first successfully applied in large quantities to the Saturn I second stage which was manufactured by Douglas. Later this basic technology was improved upon in development of the second stage of the Uprated Saturn I and the third stage of the Saturn V. In addition, Saturn launch-vehicle basic design and structure were proven and that knowledge was carried across into the remainder of the family. The early prototype Apollo hardware—the escape tower and the command module—was flown on Saturn I vehicles. And the last three Saturns, VIII, IX, and X, flew the Pegasus micrometeoroid detection payloads; put them out into earth orbit where they are still functioning, and registering micrometeoroid data.

On figure 7 is a comparison of the Uprated Saturn I and Saturn V vehicles. Starting from the top of the launch-escape system and going down through the Uprated Saturn I second stage and the Saturn V third stage, we have essentially the same hardware now being flown on the Uprated Saturn I that will be used for the Saturn V lunar mission.

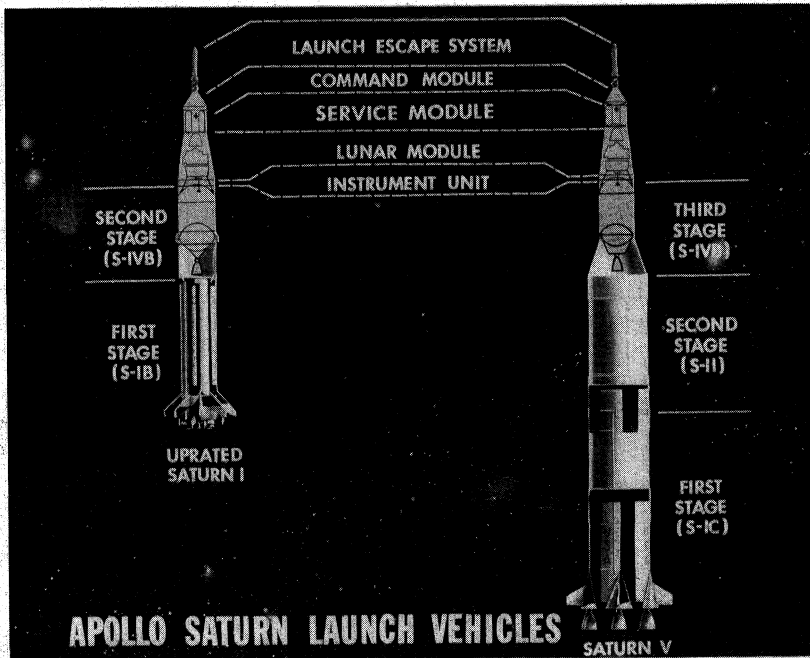


FIGURE 7

The first stage of the Uprated Saturn I is a clustering of nine tanks and eight engines; kerosene and liquid oxygen are used as propellants. The second stage (S-IVB) is the improved second stage which I mentioned we flew on the Saturn I vehicle. This stage is serving a dual role—second stage for the Uprated Saturn I and the third stage of the Saturn V vehicles. So one might say that from the Saturn V second stage down we developed two new propulsive stages to meet our lunar objectives. We acquired the knowledge and experience and technology with the Saturn I, then we went to a larger diameter (33-foot) stage with Saturn V. You saw the second first-stage flight article in the quality laboratory this morning. The basic differences, other than size, are the use of an integral tank rather than a clustering of tanks, and use of an F-1 engine rather than the much smaller H-1. However, the same kerosene and liquid oxygen propellant is employed and one can say this is within the state of the art.

The second stage is manufactured by the space and information division of North American Aviation and is probably the largest liquid hydrogen-liquid oxygen stage in existence. It is a new stage. However, we did apply the Saturn I second-stage liquid hydrogen-liquid oxygen technology to this stage and, to the best of our ability, transferred that knowledge and experience to the prime contractor, North American.

UPRATED SATURN I PROGRAM

In the Uprated Saturn I program (figs. 8 and 9), three successful Apollo missions, designated AS-201, 202, 203, have been completed. These served to prove the design of the Uprated Saturn I vehicle and

to prove the flightworthiness of the J-2 engine and the liquid hydrogen second stage. We gained considerable confidence with these flights with regard to propulsion maturity and developmental status, the guidance and control system and, in fact, all of the subsystems and components associated with the Uprated Saturn I vehicle.

I should inject at this point that the Saturn I program was run in a much smaller, closer manner than we are able to do today with the Saturn vehicles for the lunar program. The organization has grown, contractor participation has grown large and the interfaces have become a very important part of the program. We are able to optimize these to serve the program well.

One of the most important accomplishments thus far in the Uprated Saturn I program is the liquid hydrogen experiment flown on AS-203

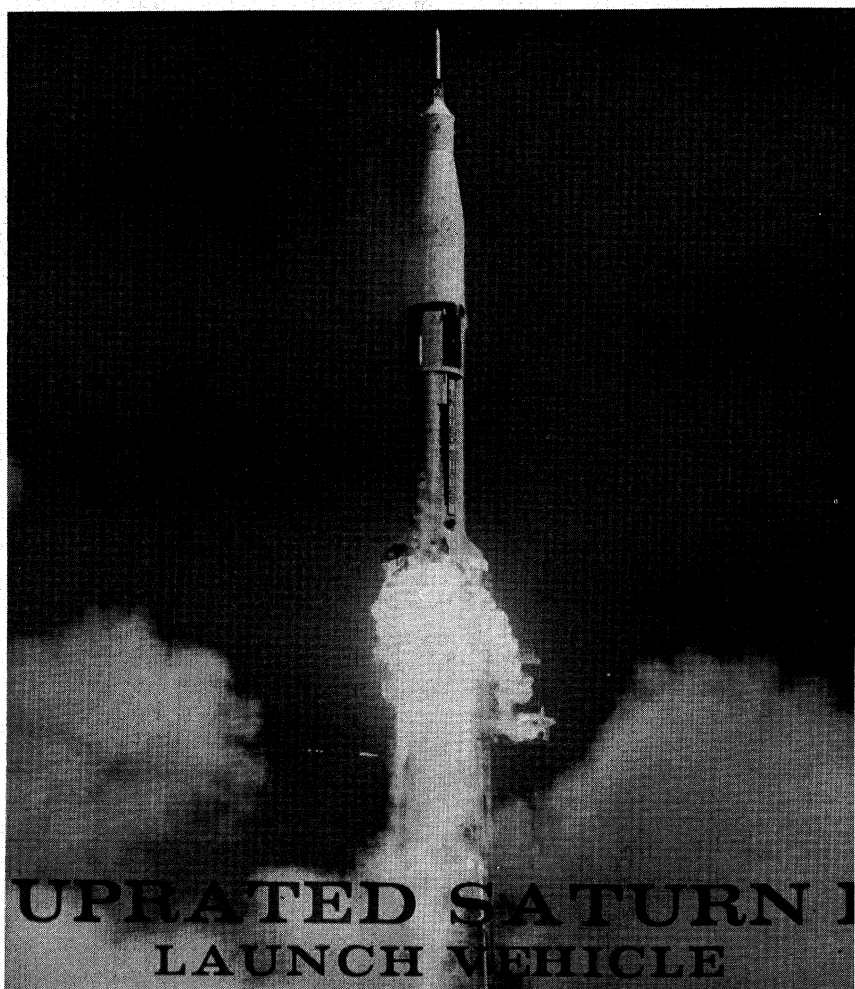


FIGURE 8

(fig. 10). This is a cutaway of the second stage with its single J-2 engine and "payload" which was a nose cone shroud provided by the Marshall Space Flight Center.

To accomplish the lunar mission, the engine will be required to burn for about 100 seconds to place the tremendous lunar payload into earth orbit at a speed of about 17,000 miles per hour. After attaining earth orbit and within a time period of $11\frac{1}{2}$ to $41\frac{1}{2}$ hours; thereafter, the engine will be required to restart to take us out of the parking orbit, into the lunar corridor, and onto the lunar trajectory at a velocity of approximately 25,000 miles per hour. That is quite a trick. However, we have worked out much of the technology associated with restarting this engine. Part of the problem, or one of the unknowns, was the behavior of liquid hydrogen which only weighs six-tenths of a pound per gallon. We had to be sure that the hydrogen would settle into the bottom of the tank and remain settled in earth orbit so that the engine could be properly restarted.

I have a film clip (fig. 11) which shows stage separation and onboard camera coverage of the experiment. The second stage separates from the first stage. The flames you see are from the ullage motors which are fired to settle the hydrogen into the bottom of the tank. Here you see the hydrogen settled. To observe LH_2 behavior, markings were placed on the tank wall as points of reference for viewing from two onboard television cameras. One of the cameras was inoperative; however, we decided to go ahead with the launch anyway. The second stage fires for the first time. The hydrogen bubbles up into the top of the tank and, subsequently, resettles into the bottom of the tank.

ACCOMPLISHMENTS - 1966 UPRATED SATURN I

THREE SUCCESSFUL APOLLO MISSIONS

- PROVED DESIGN
- PROVED FLIGHT WORTHINESS OF J-2 ENGINE AND LIQUID HYDROGEN SECOND STAGE
- DEMONSTRATED MATURITY OF PROPULSION, GUIDANCE AND CONTROL, AND ELECTRICAL SYSTEMS
- MSFC-CONTRACTOR-KSC-MSC INTERFACE EXPERIENCE
- APOLLO MISSION SUPPORT CAPABILITY
- EXPERIMENT TO VERIFY ABILITY TO CONTROL LIQUID HYDROGEN DURING FLIGHT AND LOW-GRAVITY CONDITION

FIGURE 9

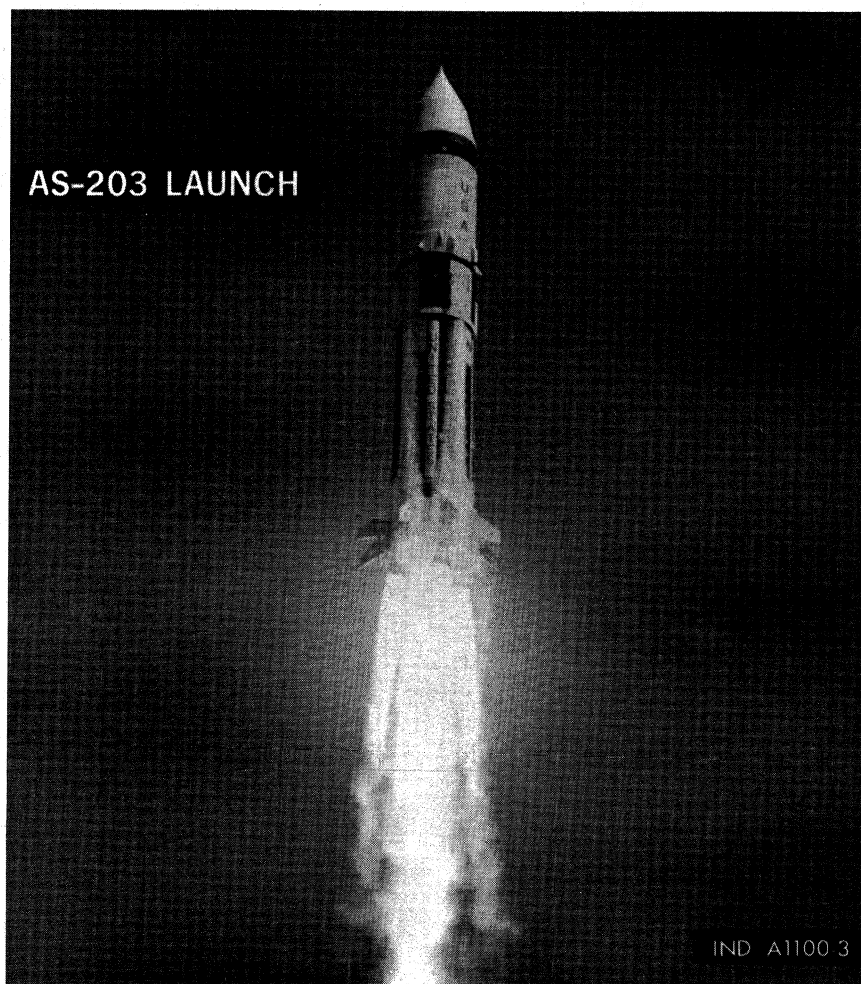


FIGURE 10

The experiment verified that the liquid hydrogen could be controlled and could be kept in a settled condition in a zero gravity environment. The technique employed for settling was through the continuous venting system which provided just enough forward thrust to keep the hydrogen at the bottom of the tank, and subsequently, support the second start of the engine.

When compared with other decisions we have had to make, the problem with the TV camera on AS-203 is considered minor. For example, the first stage of the first Uprated Saturn I flight vehicle was on the launch pad and undergoing test and checkout when the forward bulkhead of one of the nine clustered tanks collapsed due to an overpressurization in the forward part of the vehicle. We were then faced with

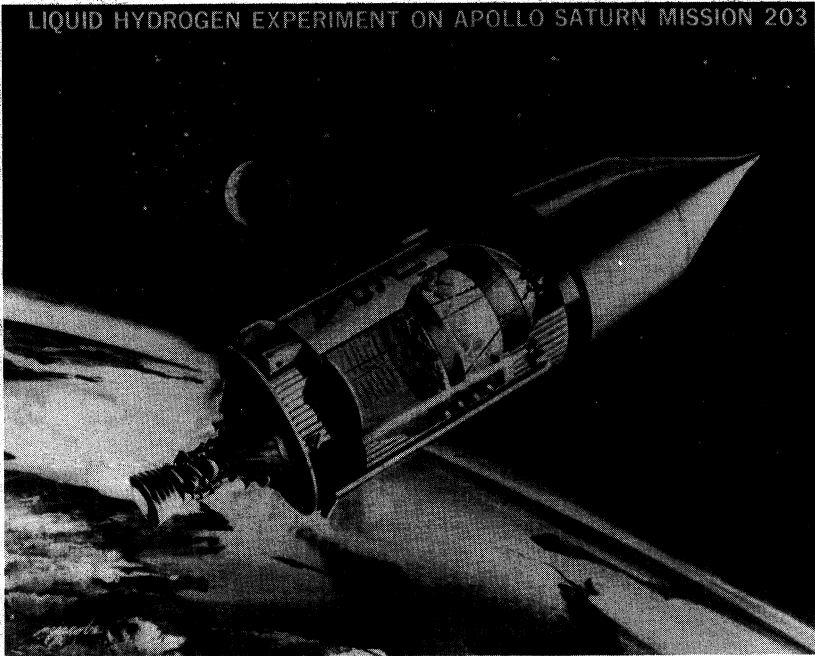


FIGURE 11

the question of what to do. A number of alternatives were considered including removal of the stage from the pad and replacing it with AS-202 first stage which would have caused a program delay; repair of the forward bulkhead at the Cape; return of the stage to Michoud for repair. To illustrate the working relationship and the ability of the team to respond to situations of this sort, we decided to take the one tank up over the top and out of the stack and replace it in the reverse manner with a tank flown down from Chrysler at Michoud (fig. 12). The importance of this is not that we changed the tank in 45 hours, but that we were able to do at the Cape a complex operation normally done in the factory, with the stage in a horizontal position, and with extremely precise tooling.

Prior to the AS-204 accident at the Cape, we were faced with a similar situation. Questionable equipment was found in one of our H-1 engines at the Cape and the engine had to be changed out (fig. 13). Again, this occurred after the launch vehicle had been erected on the launch pad. The importance of this was not just exchanging the engine but being able to acquire an engine from Rocketdyne, check it out with the other engines in the cluster with ground support equipment, particularly electronic support equipment, and maintain the launch schedule as required. This was done successfully.

Figure 14 is intended to convey the launch vehicle program flexibility which we have been trying to acquire to deal with contingencies and unexpected events. Flight AS-202 was scheduled to be launched in April 1966. In early 1966, problems plagued the spacecraft, and

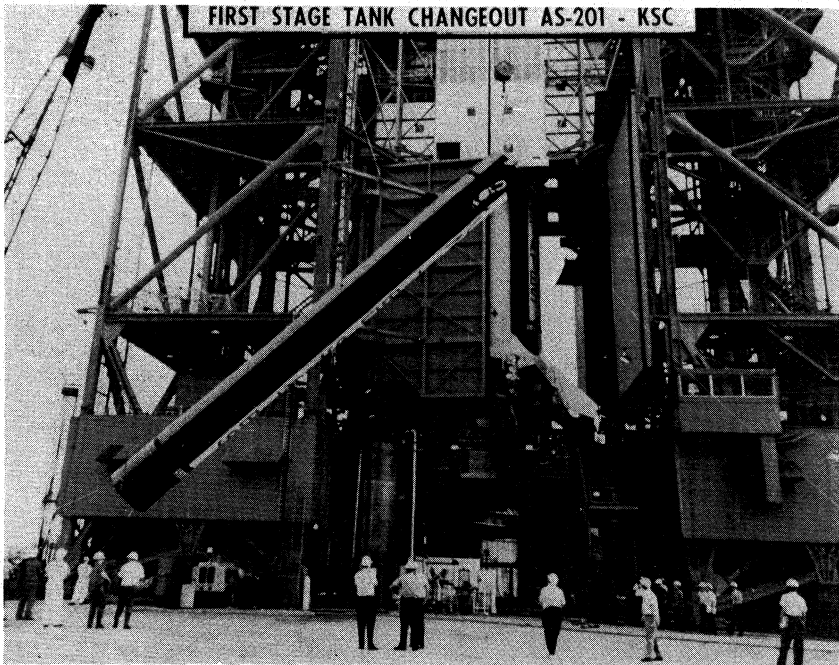


FIGURE 12

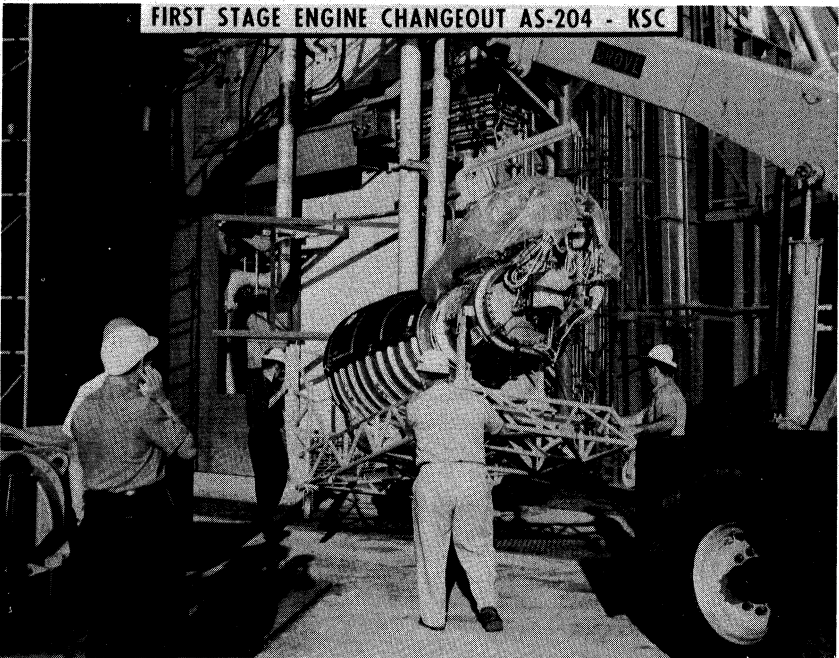


FIGURE 13

UPRATED SATURN I AS-202/203 RESCHEDULING

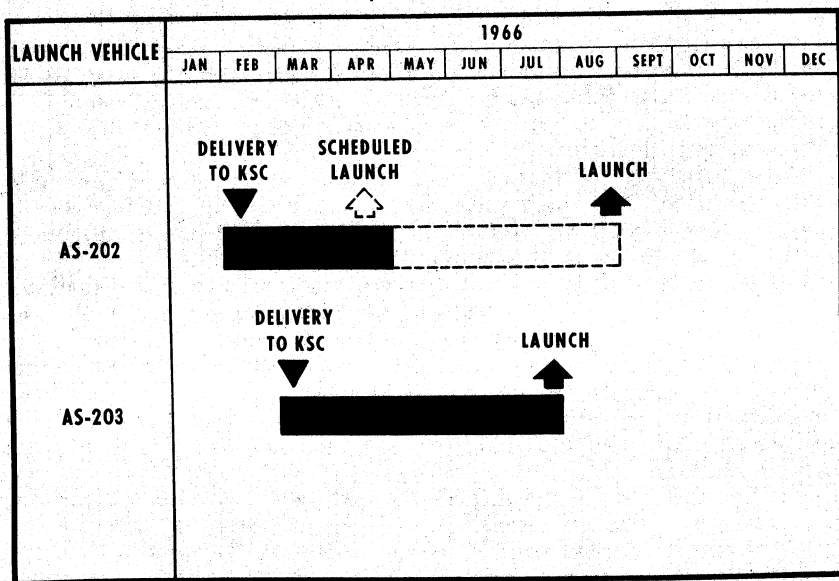


FIGURE 14

it was not delivered to KSC as scheduled. Marshall was asked if AS-203 could be launched ahead of AS-202. After some detailed examination and some reprogramming within our own sphere of influence, we decided that AS-203 could be launched prior to AS-202 with only minimum effect on the program. This was more desirable than sliding the schedule down through the Up-rated Saturn I and even into the Saturn V program. We moved, and AS-203 was launched, as indicated. AS-202 was launched about 1 month later. The importance of this is that we have our hardware qualified and rolling into the manufacturing process, as subsequent illustrations will show.

We do have some flexibility to deal with uncertainties which we may be required to deal with as a result of the AS-204 spacecraft loss and tragedy. In view of the accident 2 weeks ago and the probability of reprogramming following the Accident Investigation Board report, the delivery dates and mission assignments that I refer to today may be changed at some later date.

Despite changes to manned flight schedules, NASA does plan to proceed with the launch of three unmanned flights this year. These are the Up-rated Saturn I AS-206 and the Saturn V AS-501 and AS-502. The first manned orbital flight will be accomplished with a Block II Command and Service Module on an Up-rated Saturn I launch vehicle. When the AS-204 investigation is completed, changes will be determined and flight schedules will be established.

The current outlook for the Up-rated Saturn I program is shown in figure 15. We and our contractors are standing by at Kennedy Space Center to give launch vehicle AS-204 thorough examination and inspection. The vehicle has not been released to us by the Accident Investigation Board, but release is expected soon. Marshall, our contractors, in fact, all of NASA have been charting a course to proceed with the fabrication, delivery, static test, and checkout of hardware so whatever impact results from the AS-204 accident, we will be ready to deal with it.

We feel the AS-206 launch will go on as outlined. The vehicle is stacked on Pad 37 at the Cape. This is an unmanned launch, scheduled for the second quarter of calendar year 1967. Its primary mission is development of an unmanned Lunar Module.

There is a possibility of dual missions for rendezvous and docking maneuvers later. You will recall, in November there was a mishap at North American with the Service Module. At that time the dual AS-207/208 mission was reprogramed to AS-205/208. Basically, this is the flight of a Command and Service Module on AS-205, followed the next day by launch of the AS-208 which will place the Lunar Module into earth orbit for rendezvous maneuvers with the Command and Service Module.

The Up-rated Saturn I launch vehicle, AS-204, is qualified for flight, it has been through numerous tests; it was certified and remains certified through the Design Certification Review process which Dr.

OUTLOOK-UPRATED SATURN I

- AS-204 LAUNCH DATE AND MISSION BEING ASSESSED
- AS-206
 - LAUNCH VEHICLE STACKED ON PAD 37 AT KSC
 - LAUNCH SCHEDULED SECOND QUARTER CY67
 - UNMANNED LUNAR MODULE DEVELOPMENT MISSION
 - MISSION SEQUENCE
- WORK PROCEEDING FOR SUBSEQUENT MANNED LAUNCH
 - BLOCK II COMMAND AND SERVICE MODULE
- POSSIBLE DUAL LAUNCH MISSION FOR RENDEZVOUS,
DOCKING AND PROPULSION EXERCISES
- UPRATED SATURN LAUNCH VEHICLE QUALIFIED FOR MANNED
FLIGHT
- STAGES THRU AS-207 IN STORAGE OR ON SCHEDULE

FIGURE 15

Mueller has established in Washington. AS-204 was scheduled for flight on February 21. The mission may be rescheduled later with some other vehicle; therefore, it might interest you to see the mission sequence (fig. 16). The launch vehicle places the Command and Service Module in an 85 to 130 nautical mile elliptic orbit for the so-called, open-ended mission of up to 13 days. Events 2 through 5 (fig. 16) are Service Module burns or firings in orbit to take the Command and Service Module in and out of the elliptical planes as shown. Some 13 or so days after launch the Service Module is fired for the eighth time to deorbit the payload for return and recovery in the Atlantic Ocean.

Here, in figure 17, is the AS-206 mission sequence. It is an unmanned Lunar Module mission. This is the first Lunar Module, and it will be delivered very shortly from Grumman Aircraft. The sequence of events is to launch the vehicle into an elliptical earth orbit, separate the launch vehicle and the nose cone from the Lunar Module, and then perform exercises with the Lunar Module descent and ascent engines. This is an interesting operation inasmuch as the ascent stage burns through the hole of the descent stage, simulating the departure from the lunar surface.

To summarize the Uprated Saturn I program (fig. 18), three launches were successfully completed in 1966. Vehicles through AS-206, with exception of AS-205, have been delivered to Cape Kennedy. AS-205 is ready but is being held for the potential dual mission with AS-208. In the fiscal year 1968 period, all 12 launch vehicles which constitute the mainstream Uprated Saturn I/Apollo Program, will be delivered. The last Uprated Saturn I (AS-212) of the current buy is midway in manufacture and assembly today.

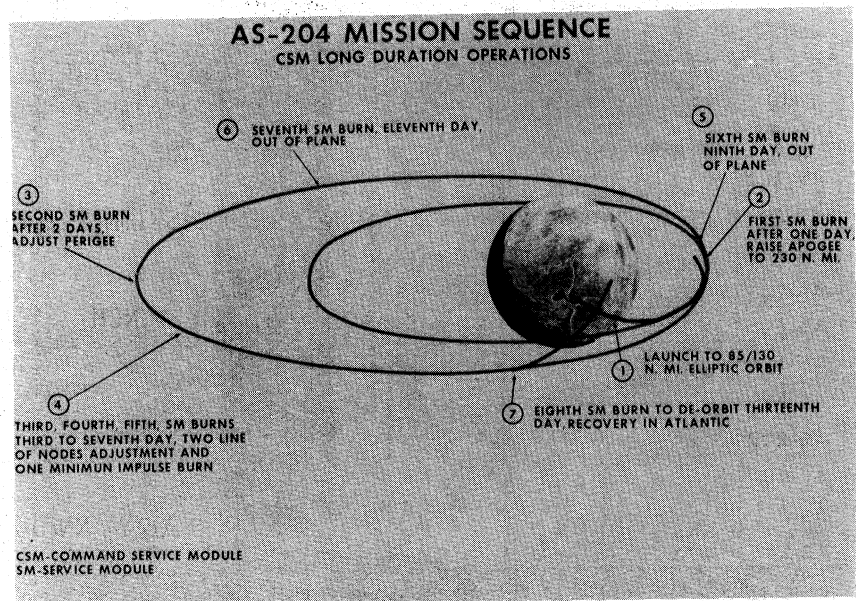


FIGURE 16

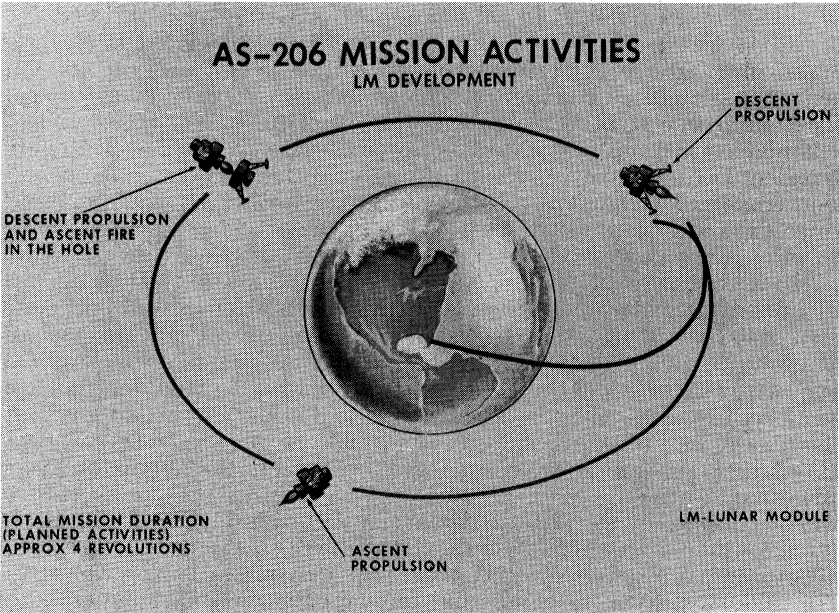


FIGURE 17

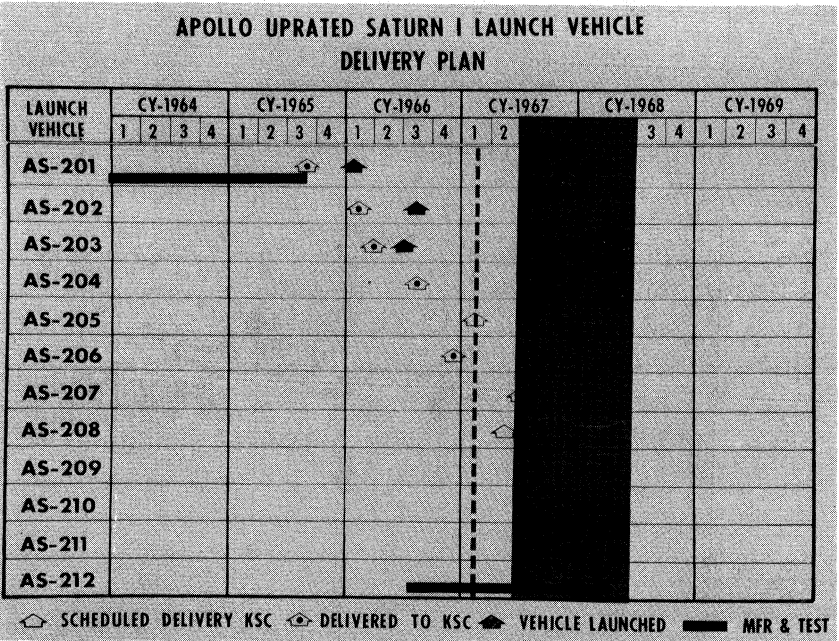


FIGURE 18

SATURN V LAUNCH VEHICLE

Turning now to the Saturn V vehicle (fig. 19), some of the recent accomplishments in the program are shown in figure 20. The Ground Test Program is practically complete. Our facilities are essentially complete and for all intents and purposes, are supporting the entire program. The first stage is considered mature. I will discuss the second stage accomplishments and failures in detail later. We did lose one of our third stages—the stage for AS-503 which I will cover very briefly.

With regard to our Ground Testing Program, I have selected what is probably one of the most important elements, the component and subsystem qualification program (fig. 21) which is comparable to FAA certification of aircraft. On the Saturn V, approximately 3,500 components, valves, pumps, actuators, and so forth were selected to be qualified. Some 2,500 of these were qualified by prior application and use on ballistic missiles, Saturn I, and Uprated Saturn I vehicles. One thousand of these components had to be qualified by strenuous test prior to the flight of AS-501. These components have been subjected to rigorous conditions far in excess of those expected to be encountered during the actual launch and mission operation. These tests vary from vibrations for hour after hour on shake tables to thermal vacuum tests. Of the 1,000, only 11 remain to be qualified. In fact, I was

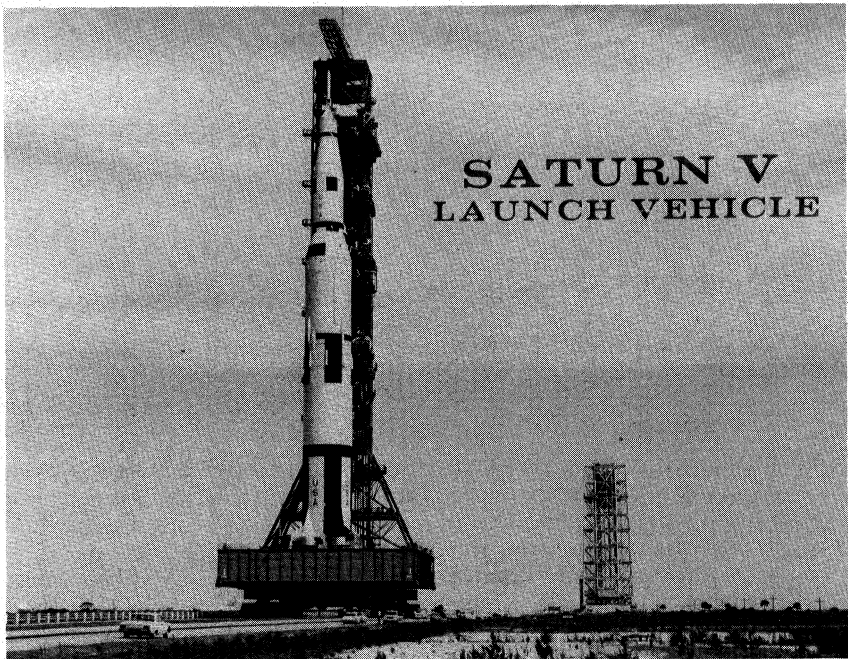


FIGURE 19

SATURN V ACCOMPLISHMENTS AND SIGNIFICANT EVENTS - 1966-67

- GROUND TEST PROGRAM NEARING COMPLETION
- FACILITIES CHECKOUT COMPLETED
- FIRST STAGE AND ENGINE MATURITY
- SECOND STAGE ACCOMPLISHMENTS AND FAILURES
- THIRD STAGE LOSS AT DOUGLAS - SACRAMENTO
- LAUNCH VEHICLE GROUND SUPPORT EQUIPMENT - FOR EARLY FLIGHTS DELIVERED, INSTALLED AND CHECKED OUT
- FIRST FLIGHT VEHICLE DELIVERED TO KSC

FIGURE 20

SATURN V COMPONENT QUALIFICATION

3,500 COMPONENTS IDENTIFIED FOR QUALIFICATION.

2,500 QUALIFIED BY PRIOR USE, SIMILARITY OR ENGINEERING ANALYSIS

1,000 REQUIRED QUALIFICATION BY TESTING.

- ELEVEN REMAIN TO BE QUALIFIED

NINE FLIGHT CRITICAL

TWO NON-FLIGHT CRITICAL

FIGURE 21

told this morning the number is now down to 10. We expect to qualify these remaining components before rollout of the AS-501. There is nothing particularly constraining about this except that when a unit fails, it must be run through the entire qualification process again.

Another facet of the Ground Testing Program is Vehicle Dynamics Testing (figs. 22 and 23) which you saw this morning. These tests are conducted to monitor the dynamic response of the flight vehicle under all simulated flight conditions such as launch and stage separation. The tests are planned to confirm flight control system design; to verify vehicle structure dynamic analysis; and to finalize the vehicle guidance and control systems.

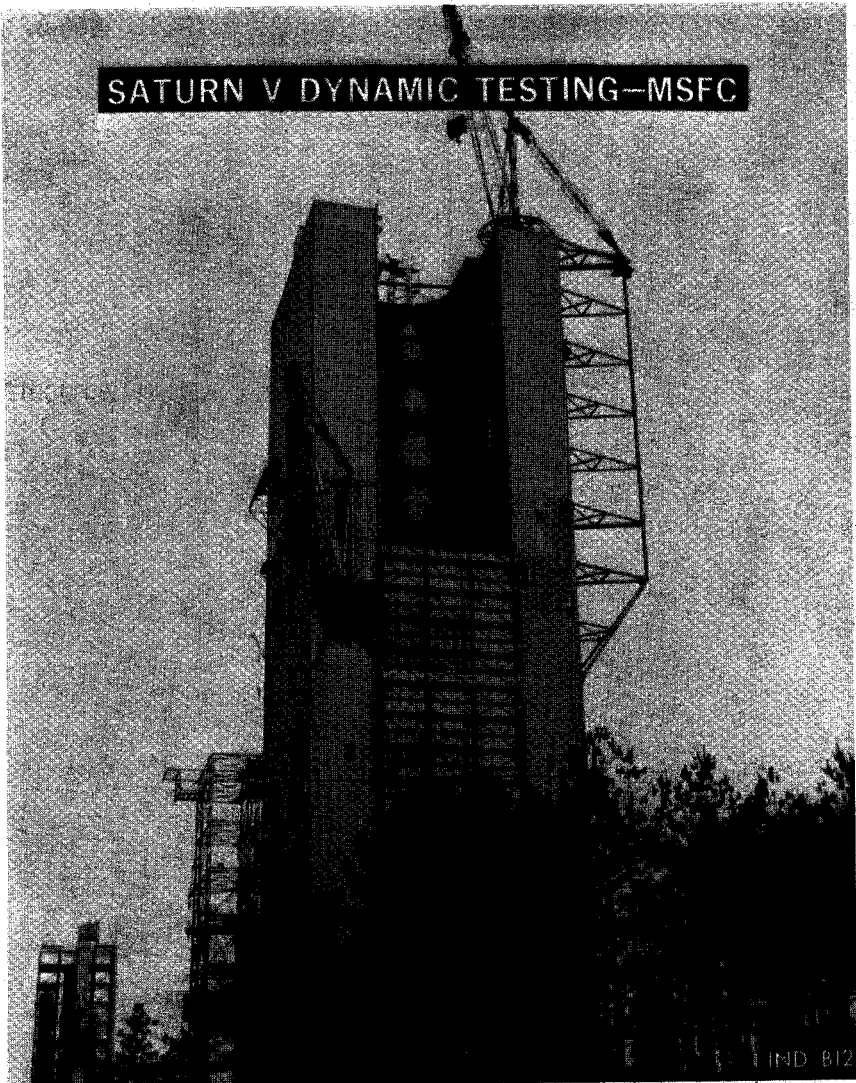


FIGURE 22

One of our most important accomplishments in the recent past was the delivery to Kennedy Space Center and use of the Saturn V Facilities Checkout vehicle (fig. 24). This is a near flight-worthy article from top to bottom with a few exceptions such as engines which were not needed to achieve program objectives.

The vehicle was delivered on schedule to the cape. I think, Mr. Chairman, you were there when the rollout took place. The importance of the operation was checkout of the ground crew personnel including contractor personnel, mating of the vehicle stages and the

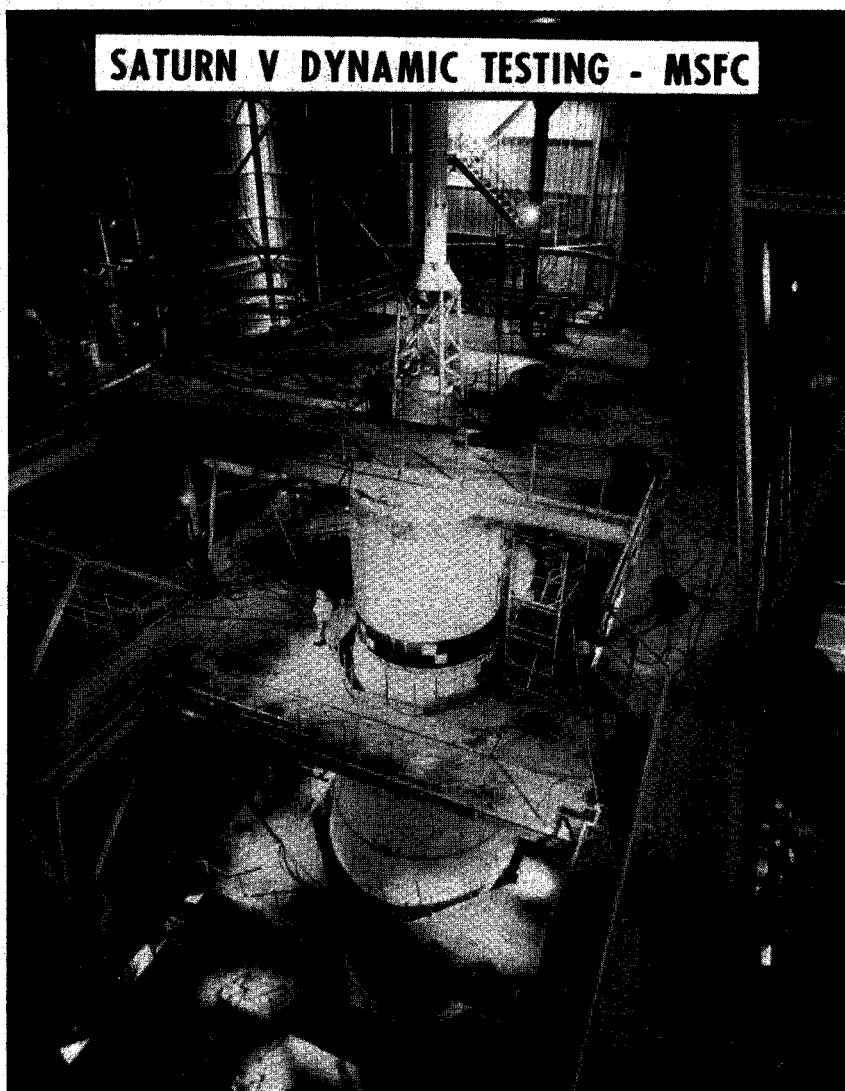


FIGURE 23

total vehicle to the ground support equipment, and checkout of propellant handling and loading procedures. The vehicle was fueled with kerosene, liquid hydrogen, and liquid oxygen. Of equal significance was the automatic checkout of the vehicle by the electronic support equipment contained in the firing room at the cape. This operation went very smoothly and is one that cannot be portrayed in a picture due to the great mass of electronic equipment involved.

After the Facilities Checkout vehicle was destacked, the second stage was returned to Huntsville and is the second stage which you saw in the dynamic test tower.

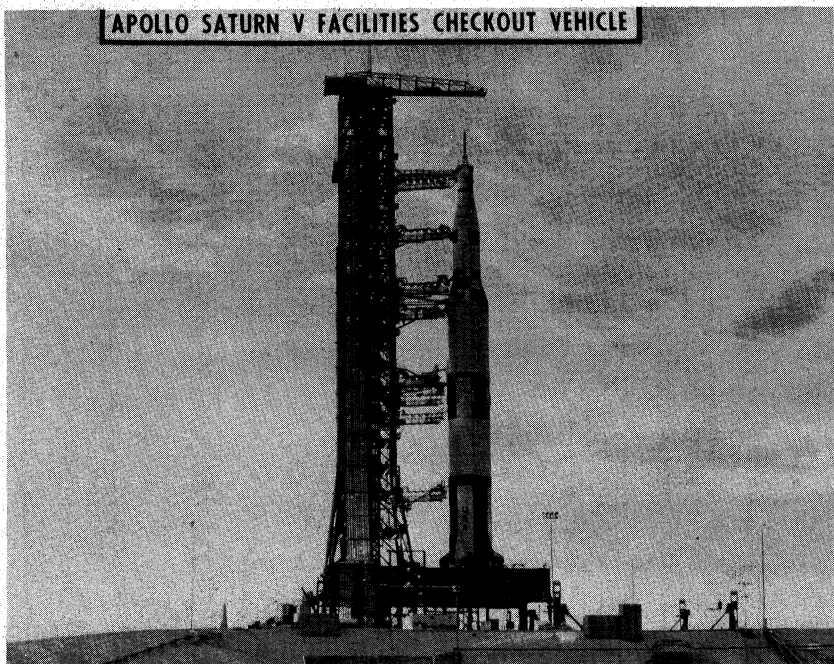


FIGURE 24

In the Saturn V first stage project, we have successfully static fired the first three flight stages at Huntsville (fig. 25). The second flight stage will be shipped to KSC in about a week; the third one is at Michoud undergoing refurbishment and post static checkout. The fourth and subsequent first stage flight articles will be static tested at our Mississippi Test Facility.

There have been failures in the Saturn V program (fig. 26). This was the second stage All-systems test article manufactured not for flight but for developmental ground testing to prove second stage flightworthiness. The stage was delivered late to the Mississippi Test Facility; numerous problems were encountered after it was erected in the stand and prior to static firing. Five short duration firings were accomplished, on the order of 6 seconds and 43 seconds; some were cutoffs due to redline conditions. One full duration test of 360 seconds was achieved; this is the requirement for the second stage in its launch trajectory. The second stage project was progressing quite well when last fall, the All-systems stage failed due to an overpressurization in the hydrogen tank.

Note the spool-like fit-up fixture in the lower part of figure 26. The fixture is being used to great advantage in the program, and I will show you how later.

We underwent some agonizing reappraisal subsequent to the loss of the All-systems. It was quite a blow to the program. We had some plans for that stage which we could no longer achieve; however, we

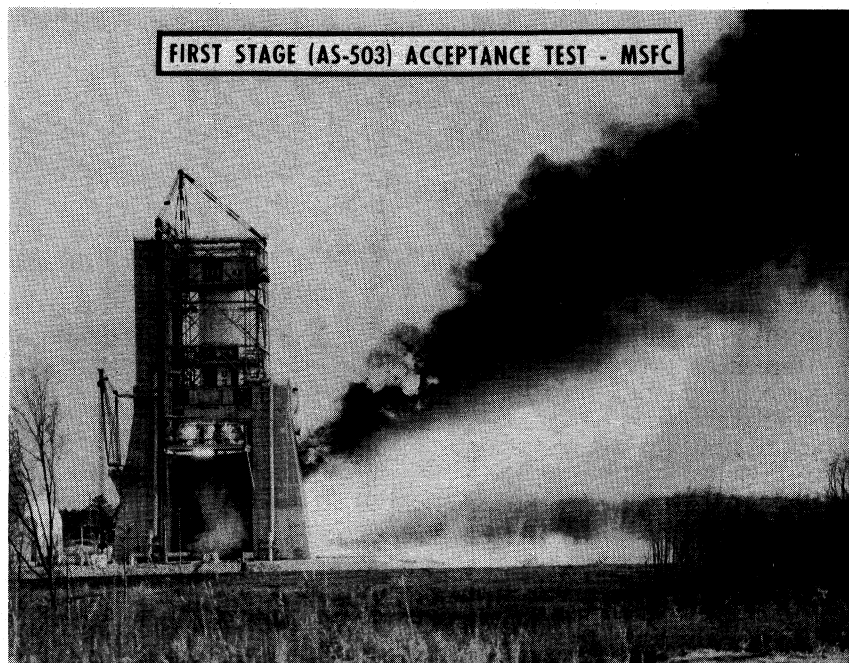


FIGURE 25

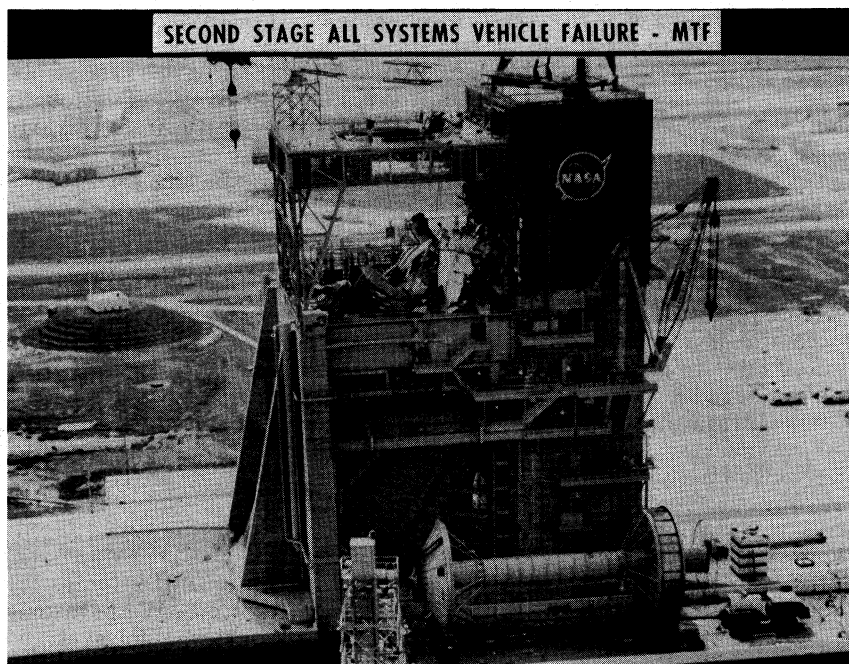


FIGURE 26

have not relaxed the program. The stage was immature and to provide more project assurance the test program for the first flight stage was intensified to require the contractor to perform two consecutive full duration firings.

The first flight second stage was placed in the stand at Mississippi, and the objectives were achieved (fig. 27). The stage has been checked out, refurbished and sent to the Cape, and is now stacked in the low bay of the Vertical Assembly Building.

The first flight stage, like the All-systems, was late and as a result, it was shipped to the Cape with some manhours of work to be completed. However, it is scheduled to replace the fit-up fixture in the AS-501 stack toward the latter part of this month.

Here is a short film clip of the AS-501 erection showing the use of the second stage fit-up fixture (figs. 28 and 29). We determined the fit-up fixture could be used to represent the second stage in the AS-501 stack to preclude the loss of 3 to 3½ months which otherwise would have been lost by late delivery of the second stage.

The point to be made is that very valuable schedule time would have been lost had we not done this. This was not only a mechanical improvisation; we wired around the fit-up fixture so that the ground support equipment, and particularly the all important electrical support equipment, could check out the vehicle stages that were there.

Turning now to the third stage of the Saturn V, two flight stages have been acceptance tested (fig. 30). One is at the Cape and the

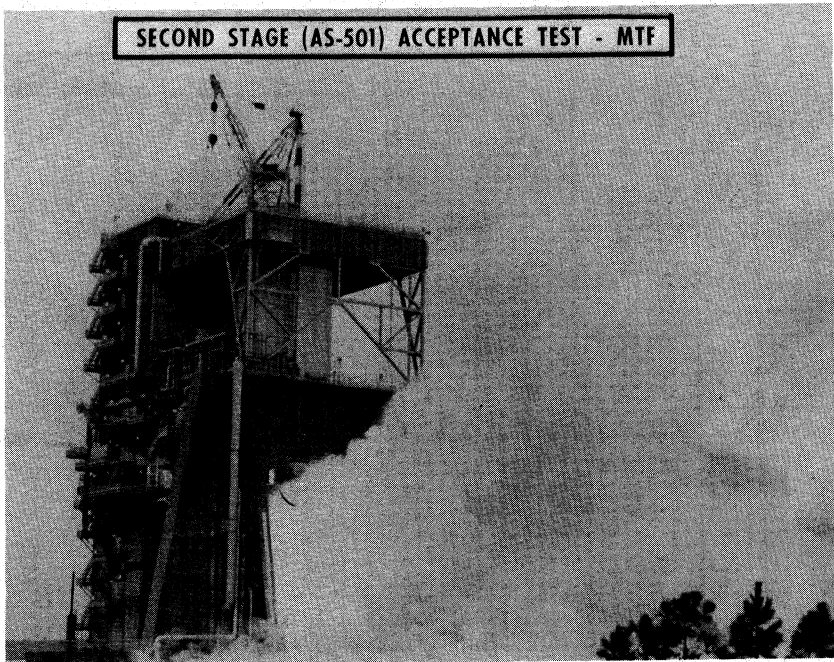


FIGURE 27

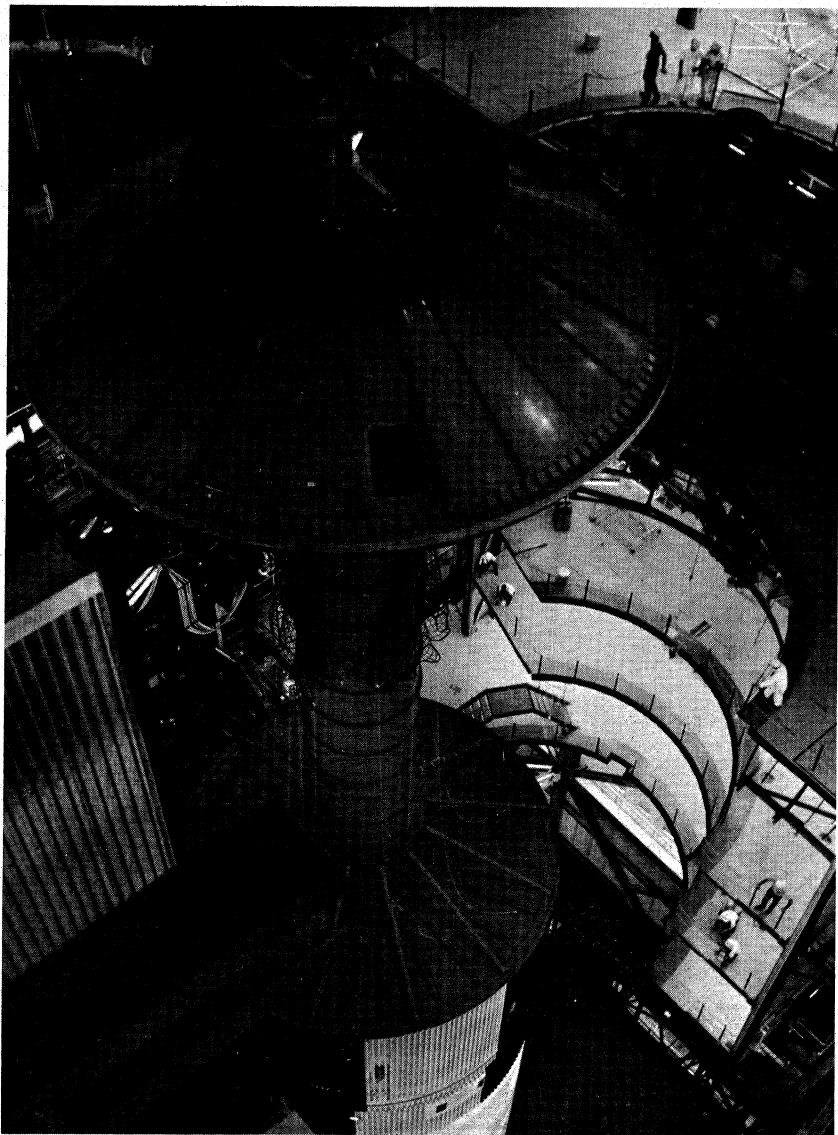


FIGURE 28

second is in post static checkout like so many of our other stages. The third stage project has been progressing rather satisfactorily; however, I am sure that you heard and read and were perhaps briefed on the fact that we lost the third stage for AS-503, as it was being prepared for static firing at Sacramento. Damage to the stage, Beta III test stand, and the surrounding area is shown in figure 31. We

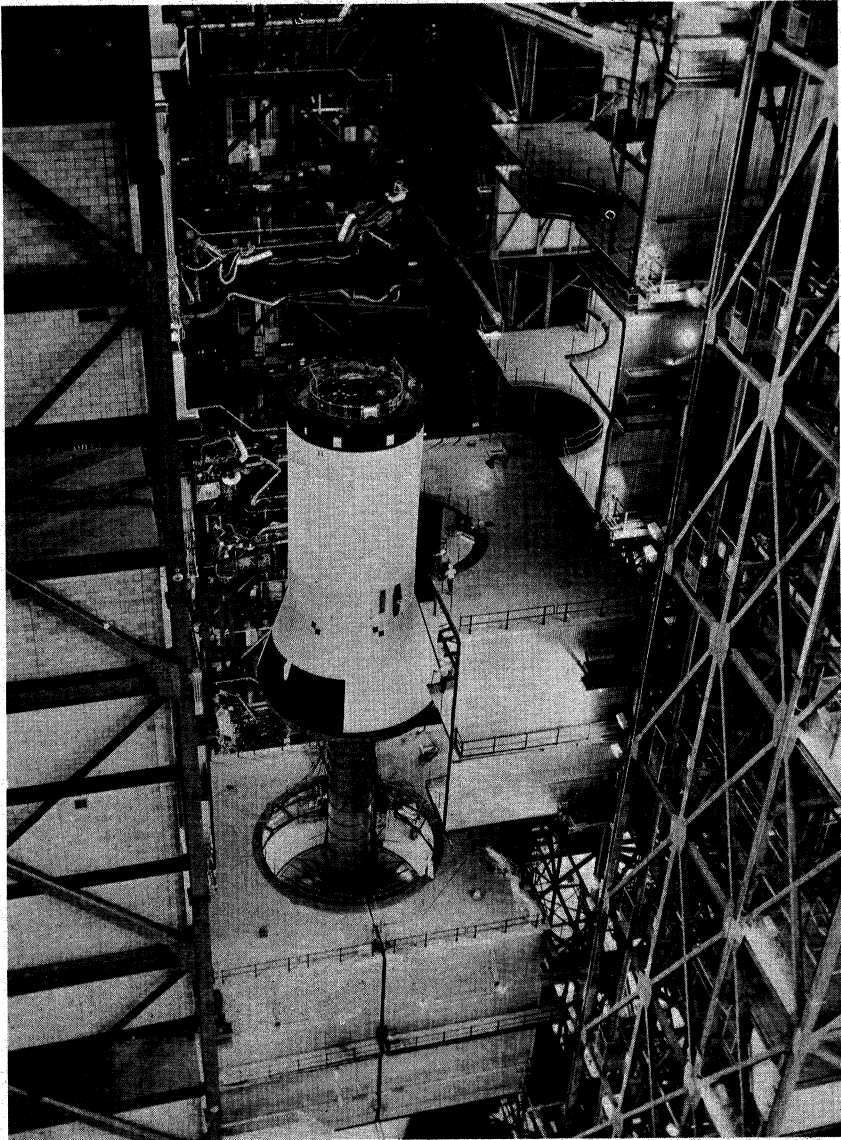


FIGURE 29

do have the Beta I stand which can accommodate the on-coming third stages. As a matter of fact, the fourth flight stage, for AS-504 was shipped to Sacramento for testing about a week and a half after the incident. Again, this is indicative of the schedule flexibility which I tried to illustrate earlier.

In the immediate aft skirt area of the third stage (fig. 32) are eight spheres which are titanium pressure vessels and which are pressurized

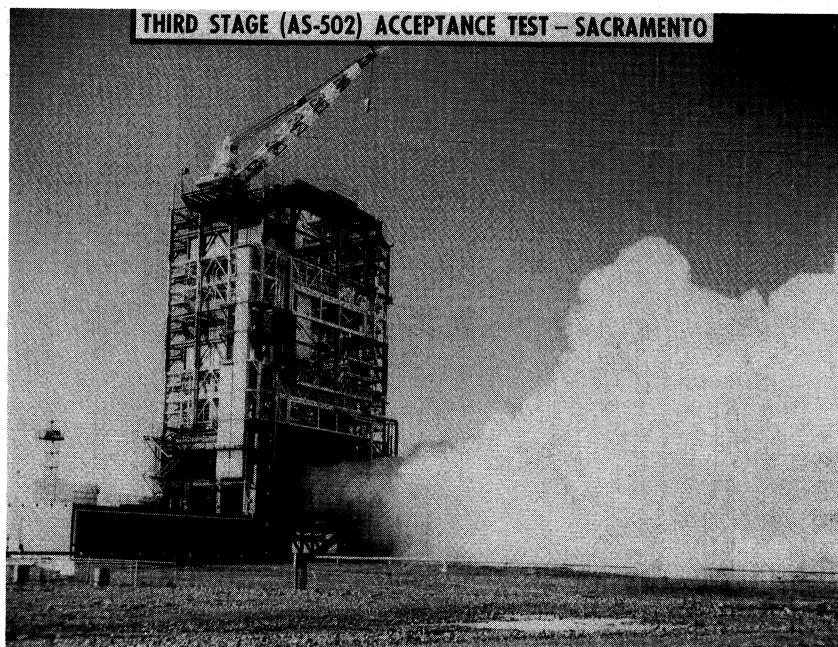


FIGURE 30



FIGURE 31

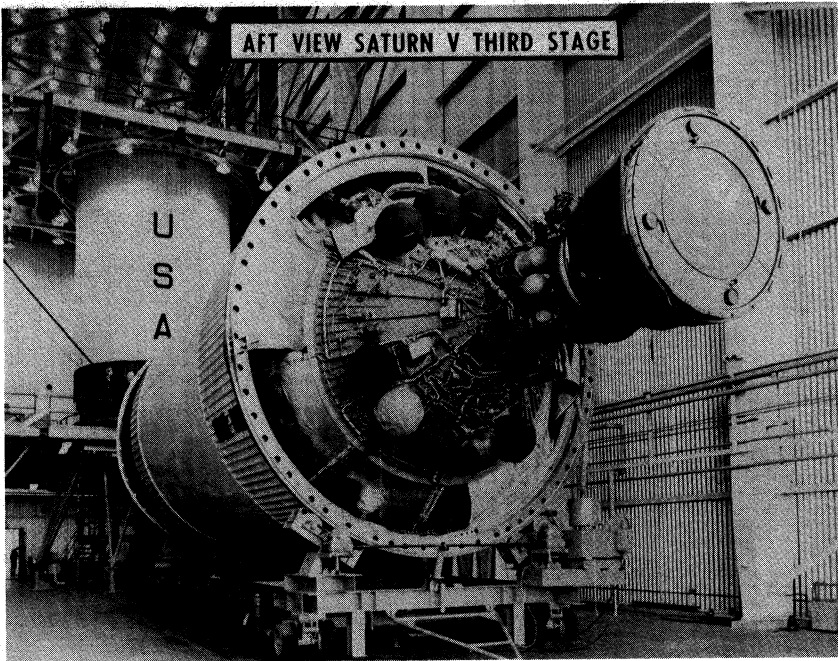


FIGURE 32

to a nominal pressure of 3,000 p.s.i. The purpose of these vessels is to store the pressurants used for propellant tank repressurization for restart. A protective cover is placed over each sphere for shipment and handling. When the stage is static fired, the protective cover is removed.

These spheres are manufactured in hemispheres with an equatorial type weld around the center. These are about $4\frac{1}{2}$ -cubic-foot titanium spheres. The titanium is alloyed with aluminum and vanadium. During the accident investigation, Dr. Debus and his board reported that the failure of one of the spheres on the third-flight stage occurred in a very clean manner at the point of the weld nugget circumferentially around the sphere where there was under some 3,100 p.s.i. pressure (fig. 33). In qualification tests, these spheres have been taking ultimate pressures on the order of some 9,000 p.s.i. and all of the failures have occurred perpendicular and in a jagged manner across the weld (fig. 34). This immediately became a very suspect condition. The weld is supposed to be made with a titanium alloy which is identical to the structure of the tank: namely, a titanium-aluminum-vanadium alloy. The accident board and the people in the laboratories here at Marshall found that some small amount of pure commercial titanium had been shipped to the manufacturer of the sphere; it was used in the weld nugget and as a result, the sphere's structural strength was reduced to 30 to 40 percent. Ten of these spheres had been manufactured with the wrong welding wire; all have been located and taken out of the system.

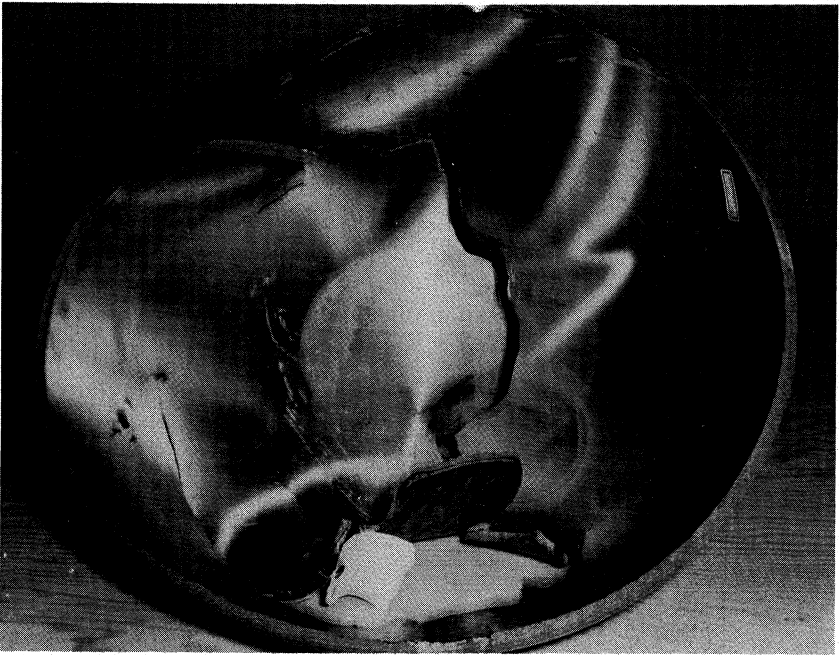


FIGURE 33

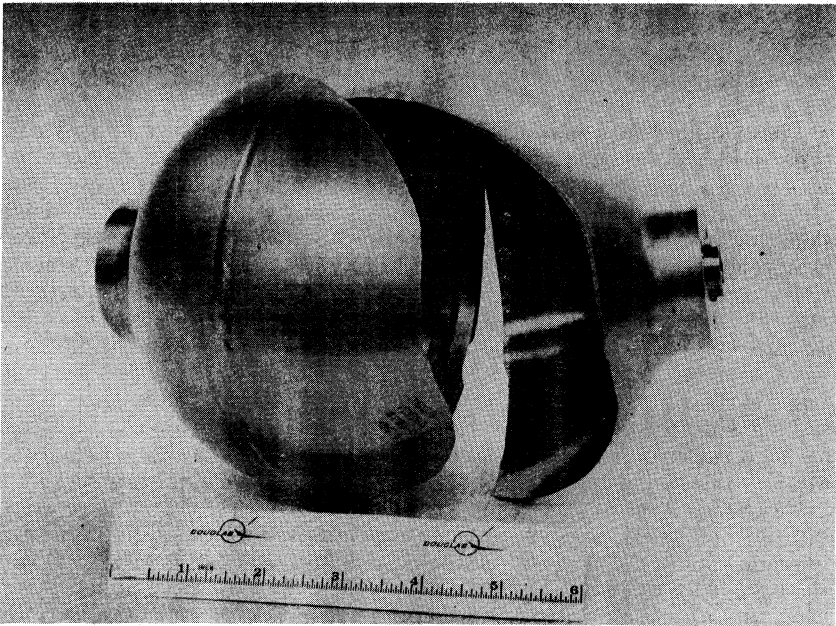


FIGURE 34

Although the first Saturn V flight vehicle is at the Kennedy Space Center and in preparation for launch, several items remain to be accomplished before launch (fig. 35). The third-stage engine restart test is in progress at the Arnold Engineering Development Center; I will discuss that in just a moment. We expect to complete the dynamic testing in time to support the AS-501 flight. I have discussed the qualification program and the status of the first flight second stage. We will have a detailed flight readiness review before AS-501 will be certified for flight.

I might spend a few minutes discussing the missions of the early Saturn V launch vehicles. AS-501 will be an unmanned flight (fig. 36). The mission is to verify launch vehicle design, hardware and performance in the flight environment, and flight development of the command and service module.

Following first and second stage burn and first burn of the third stage, we are in a circular orbit of about 103 nautical miles. Second burn of the third stage will occur at an altitude of 100 nautical miles. The second burn will be less than the full duration second burn required for the lunar mission. The third stage second burn is followed by about a 10-minute coast, after which the stage and spacecraft are separated. The command and service module will reach an ellipse of about 8,000 nautical miles before reentering at a velocity of 36,000 feet per second.

The mission for AS-502 will be very much the same as AS-501.

MAJOR ITEMS TO BE ACCOMPLISHED BEFORE LAUNCH OF FIRST SATURN V

- THIRD STAGE ENGINE RESTART TEST
- DYNAMIC TESTING (CONFIGURATION I)
- COMPLETE COMPONENT QUALIFICATION
- CERTIFY AND MATE SECOND STAGE INTO VEHICLE
- HOLD FLIGHT READINESS REVIEW FOR VEHICLE
CERTIFICATION

FIGURE 35

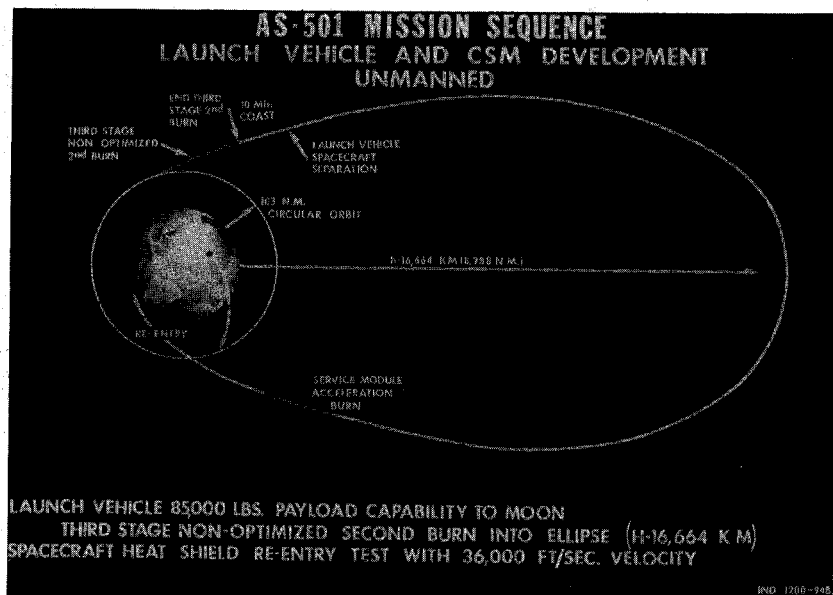


FIGURE 36

AS-503 may or may not be manned; however, the launch vehicle will have a manned capability. This is a lunar mission simulation (fig. 37). After the second burn of the third stage, the command and service module will be transposed and docked with the lunar module. The third stage is separated from the spacecraft. These maneuvers are designed to closely simulate the maneuvers which will be required for the lunar mission and will involve going out into a 4,000-nautical-mile elliptical orbit and returning for reentry.

Similar to the uprated Saturn I, figure 38 is a summary schedule of Saturn V launch vehicle activity in fiscal year 1968. AS-501 is at the Kennedy Space Center. AS-502 will follow very closely. You can see that by the end of fiscal year 1968, we will have delivered to Kennedy Space Center about half of the proposed and authorized Apollo Saturn V hardware. Here again, you can see that during fiscal year 1968, the AS-515 or the last flight article will be well into the manufacturing process for subsequent delivery in late calendar year 1969.

ENGINE PROGRAMS

Let's look at our engine program for a moment (fig. 39). Eight H-1 engines power the first stage of the uprated Saturn I. The J-2 engine is used in a cluster of five on the second stage of the Saturn V. It is used individually on the third stage of Saturn V and the second stage of uprated Saturn I. The F-1 engine is used in a cluster of five which produce 7.5 million pounds of thrust to power the first stage of Saturn V.

I would like to emphasize that our engines have served us extremely well. We have never delayed a launch because of engine fail-

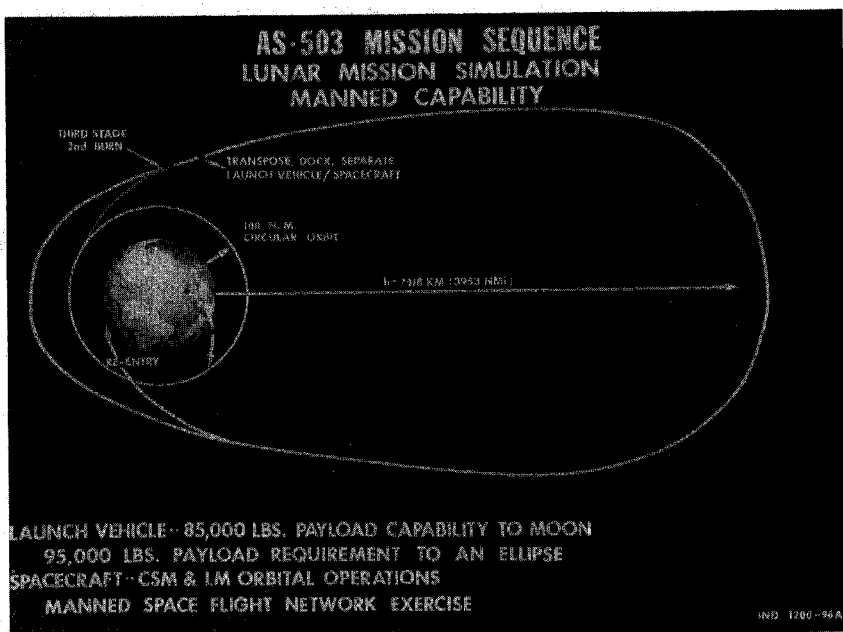


FIGURE 37

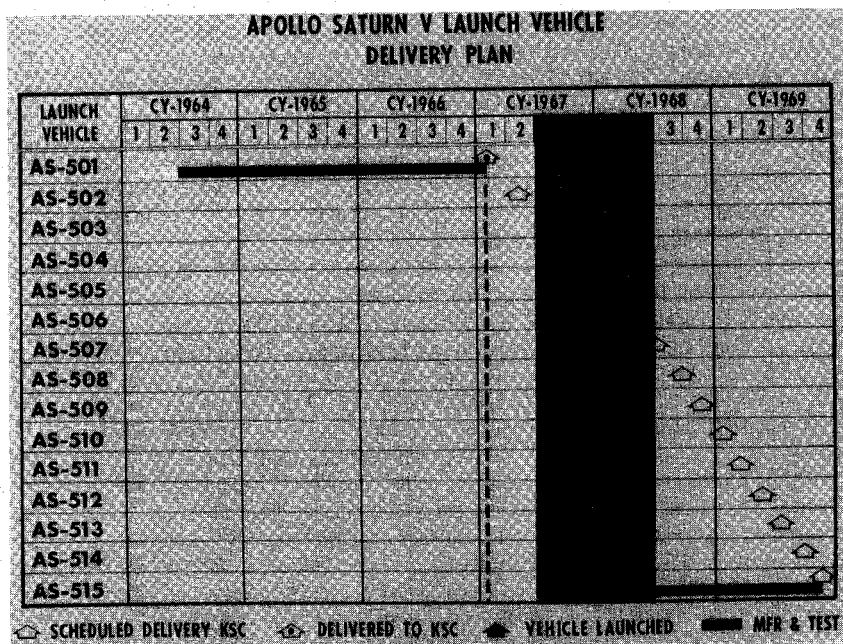


FIGURE 38

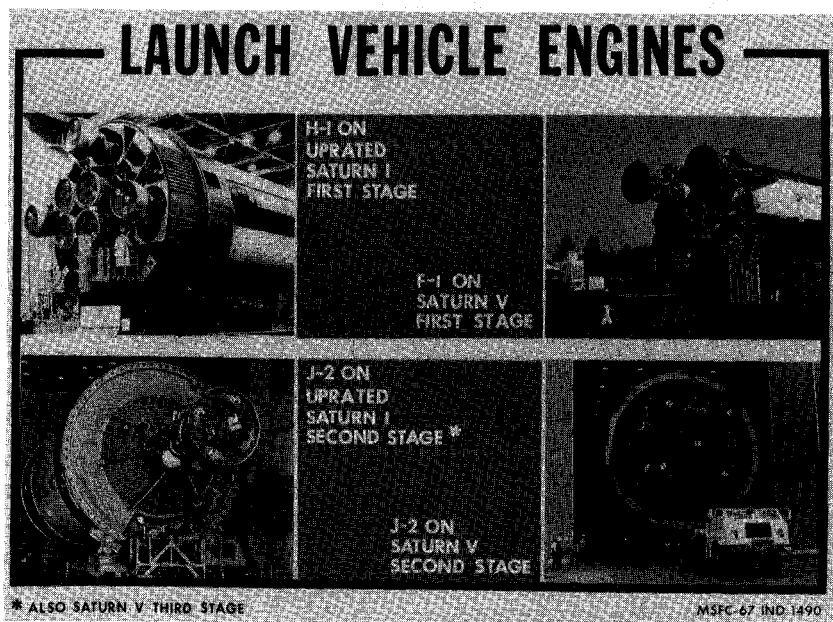


FIGURE 39

ure. We have never lost a mission nor equipment because of engine failure.

All H-1 engines for the current Apollo uprated Saturn I buy have been delivered. You can imagine that engines are long-lead-time items. All of our engines are manufactured by Rocketdyne, a division of North American, and must be manufactured, individually static tested, and then shipped to the stage manufacturer to be available at the right time for the stage fabrication sequence. We feel quite confident that we can retain the high standard of quality and performance on the J-2 and F-1 engines that we have enjoyed on the H-1.

We have a wealth of experience in engine test time; over 13,000 seconds have been logged in actual flight time on the Saturn I and uprated Saturn I programs (fig. 40). There are 155 J-2 engines on order to support the entire Apollo Saturn program, and 100 of these have been delivered. These 100 engines represent, for example, the last J-2 engine to equip Saturn V vehicles through AS-507. We are already half way through delivering the J-2 engines for the entire Saturn V program. We have 273,903 seconds of test time on the J-2 engine, and some good experience, in excess of 1,000 seconds, in actual flight. One hundred and six F-1 engines are on order to support the Apollo Saturn program. Again, half of these have already been delivered to Boeing at Michoud. We are approaching 200,000 seconds of developmental test time on the engine and, of course, we cannot acquire any flight time until the first Saturn V is launched.

I mentioned earlier some of the disappointing things that can happen when a program of this magnitude is spread out over the United

SATURN LAUNCH VEHICLE ENGINE MATURITY FACTORS*

ENGINE	TOTAL DELIVERED	TOTAL TEST TIME	TOTAL FLIGHT TIME
H-1	262	483,233 SEC	13,323 SEC
J-2	100	273,903 SEC	1,185 SEC
F-1	54	167,035 SEC	0

*AS OF FEB. 1, 1967

IND B1488B

FIGURE 40

States. Another typical example is the problem experienced on the up-rated Saturn I AS-208 first stage. During static test at Marshall a few months ago, an H-1 engine turbine wheel failed. The blades actually left the turbine wheel (fig. 41). Subsequent investigation showed that we had human error in the manufacturing process. Figure 42 represents the turbine wheel blade production procedure and illustrates from point 1 to 14 turbine wheel manufacturing and assembly. The majority of the turbine wheel blades for rocket engines, including DOD rocket engines and jet engines, are manufactured in Kokomo, Ind., by Haynes Stellite Division of Union Carbide.

The basic manufacturing process is to take bar stock and form it into BB-size pellets which are weighed, placed in storage cans and delivered to multi-bin storage for use in blade manufacture. Unfortunately, employees seeking pellets for casting turbine wheel blades drew material from the wrong storage bin. These blades were ultimately delivered to Rocketdyne where they were assembled into turbine wheels.

Approximately 260 turbine wheel blades were manufactured from the wrong material, stainless steel. However, it is important to note that all of the blades and the wheels to which they were attached have been located, except for those which were scrapped. The system has been purged of this particular malady.

The importance is not that we lost the turbine wheel of course, but with the thousands of people in the United States who are working on the program, this is the kind of thing that can happen. The challenge is the prevention of problems of this sort.

I mentioned earlier the J-2 engine restart requirement and the reason for this requirement (fig. 43). We found on Up-rated Saturn I

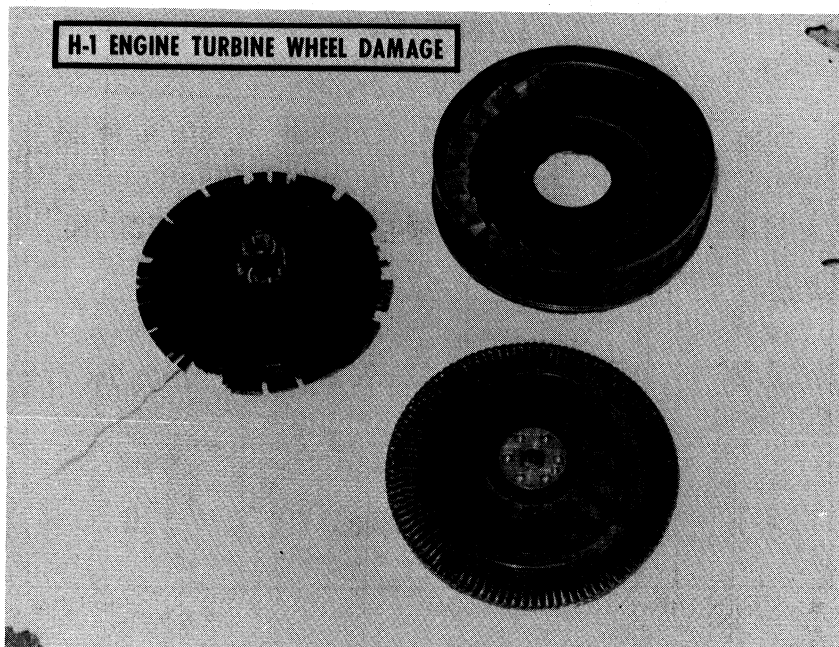


FIGURE 41

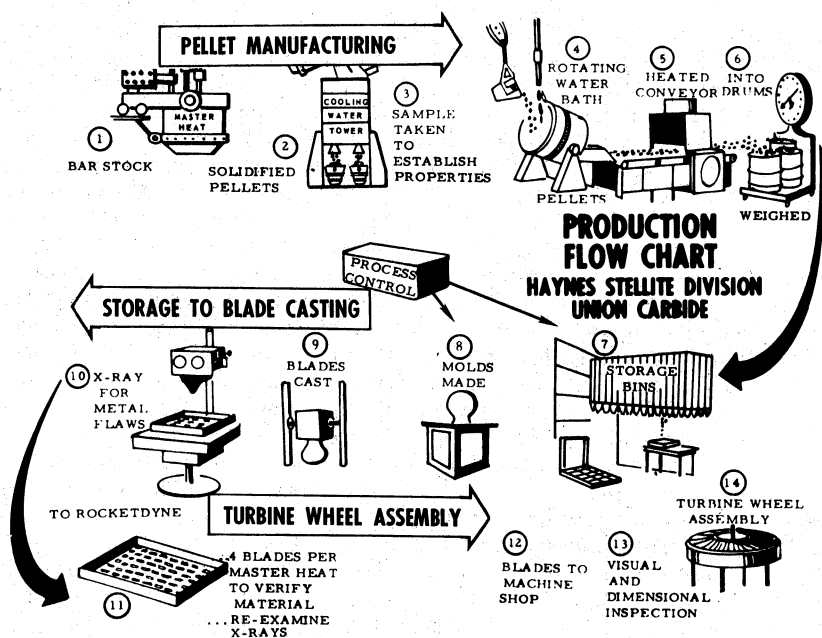


FIGURE 42

J-2 ENGINE RESTART**DEFINITION:**

- HOT CROSSOVER DUCT NECESSITATES MODIFICATIONS TO THE ENGINE START SEQUENCE FOR SECOND BURN.

IMPACT:

- POSSIBLE DELAY OF AS-501 SCHEDULE

RECOMMENDED SOLUTION:

- SATURN V AS-501*

PROPELLANT UTILIZATION VALVE FULL OPEN FOR RESTART**
 REDUCED START BOTTLE ENERGY BY SELECTIVE USE OF VENT VALVES
 RETIMED MAIN OXIDIZER VALVE TO REDUCE RAMP TIME

- FOR RESTART ORBITAL TIME LESS THAN FOR SATURN V AS-501

PAINT CROSSOVER DUCT
 POSSIBLY PURGE DUCT*

* VERIFICATION TESTING TO BE COMPLETED BY APRIL 1967

** REQUIRED STAGE CHANGES ARE IN PROCESS OF BEING ACCOMPLISHED

FIGURE 43

AS-203, which was heavily instrumented, that in earth orbit the J-2 engine crossover duct did not dissipate the heat resulting from the first firing as rapidly as expected.

The way this engine works, in a simplified manner, is the gas generator provides the gaseous driving energy to the LH₂ fuel turbine and those same gases then pass through the crossover duct and drive the LOX turbine (fig. 44). The sequencing and timing between the speed and operation of the fuel turbine and the LOX turbine is an extremely delicate balance. Gases on mission AS-203 were found by measurement to be hotter than predicted; consequently, we would be driving the LOX turbine faster and sooner than required. On AS-203 we programed the engine through restart sequencing to just short of actually firing, and the onboard instrumentation gave us the insight as to this potential problem. This is a normal developmental problem; however, it must be resolved in support of the Saturn V, AS-501 launch.

In figure 45 a J-2 engine is shown installed with third stage tankage in the J-4 test cell at the Arnold Engineering Development Center, Tullahoma, Tenn. The engine is undergoing weekly firings; the test cell is equipped with the proper heating elements and equipment to duplicate the environment found on the AS-203 mission. We are actually going to simulate the third stage restart for the Saturn V, AS-501 mission.

Now to move to incentive contracting (fig. 46). The basic objective of our incentive contracting is to motivate and to reimburse the

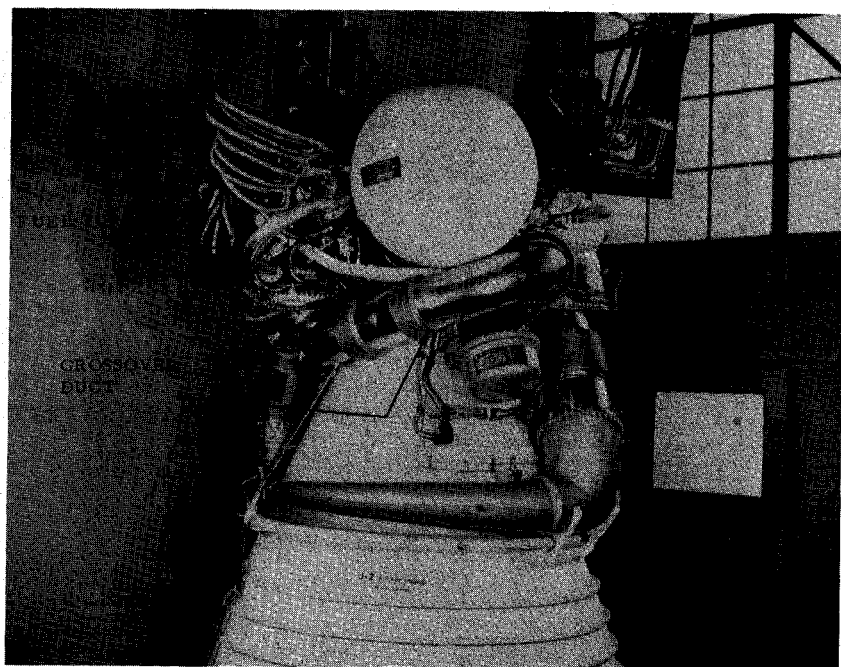


FIGURE 44

J-2 ENGINE ENVIRONMENTAL TESTS



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FIGURE 45

contractors for more efficient or better performance (fig. 47). They are motivated in their performance in the critical areas of schedule, cost, and reliability or in a combination of these. We committed ourselves a year and a half ago to convert—or award—all of our major systems and component contracts from cost-plus-fixed-fee to incentive-fee contracts (fig. 48). We have now fulfilled that commitment with the exception of the Saturn V second stage contract. We have had longstanding difficulties with this stage, so with good and sufficient reasons of a sound business nature, we prevailed on NASA Headquarters that this contract not be converted. Our principal consideration here was that the status of the project did not warrant or sustain conversion at this time.

The overall value of the other 22 major contracts was \$3.7 billion. Those contracts converted were in the middle of the procurement stream, so we actually converted these contracts from a particular date

INCENTIVE CONTRACTING

FIGURE 46

INCENTIVE CONTRACTING OVERALL OBJECTIVES

Place greater responsibility on the contractors for accomplishment of Saturn program schedule, cost and performance objectives by providing rewards and penalties in calculable monetary terms for management efficiency.

FIGURE 47

INCENTIVE CONTRACTING OVERALL STATUS

- 22 OF 23 MAJOR CONTRACTS BEAR SOME TYPE OF CONTRACTUAL INCENTIVE
- NAA CONTRACT FOR SATURN V SECOND STAGE REMAINS CPFF AT THE PRESENT TIME
- TOTAL CONTRACT INCENTIVE VALUE OF \$1, 921, 000, 000
- OVERALL CONTRACT VALUE OF \$3, 768, 000, 000

FIGURE 48

to contract completion. Figure 49 illustrates a cross section of the experiences we have had and listed is only a few of the measurements which we have made with regard to current performance, as opposed to what was happening before incentive contract conversion. It should be remembered that when I say we incentivized costs, schedules, and performance, there are literally hundreds of minor elements of cost, scheduling, and performance which required incentivization.

As an example of our incentive contracting experience, in post-manufacturing checkout the contractors were told that at a certain point you have the incentive in delivering a complete, checked-out stage. Prior to this incentive feature, and for example, Up-rated Saturn I AS-202 second stage was delivered by Douglas from manufacturing with some 180 shortages which would not be incorporated until the stage was delivered to Sacramento. Here these shortages would catch up and be installed prior to testing. Since incentivization, the shortages have been reduced by a factor of 18 on the AS-209 second stage.

With regard to delivery of the AS-202 second stage prior to incentivizing, the contractor was running some 8 to 10 weeks potentially behind schedule. After incentivization, the contractor delivered the AS-207 stage 2½ months ahead of the required delivery schedule contained in the contract.

One of the things we do not want to do is send open work down to Kennedy Space Center. It is our responsibility to deliver as complete a stage as possible. Up-rated Saturn I AS-202 second stage was shipped to Kennedy Space Center with over 1,000 man-hours

PROJECT STATUS — INCENTIVE CONTRACTING

SATURN V THIRD STAGE - DOUGLAS AIRCRAFT CO

ASPECT	STATUS PRIOR TO CONVERSION	SINCE INCENTIVE CONVERSION
Parts Shortages	AS-202 Entered Checkout With 180 Shortages	AS-209 Entered Checkout With 10 Minor Shortages
Stage Deliveries	PERT Data Showed 8.8 Week Potential Delay AS-202	AS-207 Delivered 75 Days Early
Open Work To KSC	AS-202 Shipped With 1056 Open Hours	AS-206 Shipped With 331 Open Hours
Costs	Potential 50M - 70M Overrun at Program Completion	- FY67 Cost \$3M Under Estimate of June 1966 - Manpower Under Previous Forecast
Contract Administration	- Effort Expected to Increase - Technical Communication Expected to Become More Difficult	- Effort Not Materially Affected - Technical Communications Have Remained Open

FIGURE 49

of open work; whereas, the second stage for AS-206 was delivered with only a third as many man-hours.

Another example, Douglas was showing a potential cost overrun on the cost-plus-fixed-fee contract by some \$50 to \$70 million. After contract incentivization, Douglas incorporated more effective cost monitoring, and their costs are now under good control. I might add that Douglas also brought their schedule and quality under control and are coming down and under their target cost.

We anticipated some problems in the administration of these incentivized contracts we were particularly concerned with our ability to work with the contractor, "direct" him if you will, in an informal way. Experience has shown us, however, that we can communicate with the contractor in the flexible manner that we did before contract incentivization.

Prior to incentivizing the J-2 engine contract, we were faced with a \$28 million cost overrun (fig. 50). After incentivizing the contractor is now reporting about an \$8 to \$10 million underrun. He was behind schedule prior to the incentive time period with some 24 J-2 engines delivered versus a requirement of 42. Since incentivizing, he has delivered 74 engines, either on schedule or ahead of schedule.

In terms of a development activity, the qualification test on any engine is an extremely important milestone in the development of that engine. After incentivizing the qualification schedule for the J-2 engine, the contractor completed the test some 3 months ahead of schedule.

PROJECT STATUS-INCENTIVE CONTRACTING J-2 ENGINE, ROCKETDYNE

ASPECT	STATUS PRIOR TO INCENTIVE	TODAY
PRODUCTION COST	\$28M OVERRUN	UNDERRUN OF \$8-10M IS INDICATED
ENGINE DELIVERIES	BEHIND SCHEDULE - 24 DELIVERED VERSUS 42 SCHEDULED - NONE OF 24 DELIVERED ON SCHEDULE	ON SCHEDULE - 74 DELIVERED SINCE CONVERSION ALL ON SCHEDULE
DEVELOPMENT MILESTONES	CONSISTENTLY MISSED BY CONTRACTOR - FLIGHT READINESS TEST COMPLETED 6 MONTHS BEHIND ORIGINAL SCHEDULE	ACCOMPLISHED ON OR AHEAD OF SCHEDULE - ENGINE QUALIFICATION COMPLETED 3 MONTHS AHEAD OF SCHEDULE

FIGURE 50

We planned to convert the Saturn V second stage contract along with the other 22 conversions which I have mentioned earlier (fig. 51). But considering the status of hardware at the Space and Information Division of North American; their schedule position, their manpower and cost trends which were going upward, and the inadequate overall program control—it was decided that the Saturn V second stage was not in a position where either the Government or the contractor could benefit from incentivizing. Contract incentivization was deferred, and the contractor was given a list of criteria, based generally on improved performance, that he must meet before the contract will be converted.

Regarding the incentive contracting overall assessment (fig. 52), I do not believe that incentive contracting is completely responsible for the program improvements I have mentioned; however, it does deserve a good part of the credit.

This chart (fig. 54) includes all obligations of the Saturn Apollo programs: the Up-rated Saturn I, Saturn V, Engines, and a small amount of money for supporting development for fiscal years 1967 and 1968. The fiscal year 1966 total was \$1.5 billion. A sharp decline is noted for fiscal year 1967. The reduction is mostly attributable to a decline in up-rated Saturn I funding. Approximately \$1.2 billion are planned for fiscal year 1968. This is in line with the President's budget. This sharp drop exists even though only 3 of the 12 up-rated Saturn I vehicles have been launched. For obvious reasons Saturn V is holding rather steady.

STATUS OF INCENTIVIZATION SATURN V SECOND STAGE CONTRACT

- I. PRELIMINARY PLANNING BEGAN IN 1965
- II. PRIMARY CONCERTED EFFORT TO CONVERT IN FALL 1966
- III. CONVERSION POSTPONED BECAUSE OF:
 - SCHEDULE POSITION
 - COST AND MANPOWER TRENDS
 - STATUS OF HARDWARE
 - OVERALL PROGRAM CONTROL
- IV. INCENTIVES TO BE APPLIED:
 - AFTER SETTLEMENT OF COST VARIANCE AND OUTSTANDING CHANGE ORDERS
 - BASED ON CONTRACTOR PERFORMANCE

FIGURE 51

INCENTIVE CONTRACTING OVERALL ASSESSMENT

Saturn/Apollo Incentive Contracts at MSFC Are Achieving Objectives:

- Contractors Have Responded to Motivation.
- Cost Stature Shows Improvement.
- Schedule Being Maintained or Exceeded.
- Technical Integrity Maintained.
- Technical Performance Goals Being Attained.

FIGURE 51

APOLLO FUNDING

FIGURE 52

The engine program funding is decreasing quite rapidly although not as rapidly as the engine figures might indicate. This is because funding for engine production is carried in the launch vehicle account, both in fiscal year 1967 and 1968.

A breakout of the uprated Saturn I major stages (fig. 55) shows a drastic decline of almost 50 percent between fiscal year 1966 and fiscal year 1968. For example, vehicle ground support equipment is now approximately \$6 million; it had been \$26.5 million.

Saturn V funding for the same 3-year period (fig. 56) is holding somewhat steady.

Since fiscal year 1966, our costs, as Dr. von Braun indicated last night, have averaged \$136.1 million per month (fig. 57). It is interesting to note however, that the peak amount was actually \$145 million per month in fiscal year 1966, and since that time we have been declining, as indicated to an average of 116 in fiscal year 1967 and \$102 million, the forecast for fiscal year 1968. These are sizable

**MSFC
SATURN APOLLO
FUNDING PLAN
(OBLIGATIONS)**

	<u>FY66</u>	<u>FY 67</u>	<u>FY68</u>
APOLLO			
UPRATED SATURN I	249.0	199.8	129.9
SATURN V	1,106.5	1,051.8	1,019.7
ENGINES	133.2	49.8	24.5
SUPPORTING DEVELOPMENT	18.2	12.7	14.0
<u>TOTAL</u>	<u>1,506.9</u>	<u>1,314.1</u>	<u>1,188.1</u>

FIGURE 53

**MSFC
UPRATED SATURN I
FUNDING PLAN
(OBLIGATIONS)**

	<u>FY 66</u>	<u>FY 67</u>	<u>FY 68</u>
<u>UPRATED SATURN I</u>			
S-IB	51.6	43.1	30.5
S-IVB	64.0	56.9	37.1
I U	47.7	40.6	22.6
VEHICLE GSE	26.5	11.5	6.5
ENGINES	23.7	14.8	6.1
VEHICLE SUPPORT	35.5	32.9	27.1
<u>TOTAL</u>	<u>249.0</u>	<u>199.8</u>	<u>129.9</u>

DOLLARS IN MILLIONS

FIGURE 55

**MSFC
SATURN V
FUNDING PLAN
(OBLIGATIONS)**

	FY 66	FY 67	FY 68
SATURN V			
S-IC	191.9	184.9	174.7
S-II	256.1	248.6	245.9
S-IVB	162.0	154.0	151.2
I U	67.8	72.9	75.1
VEHICLE GSE	107.6	60.9	35.8
ENGINES	133.4	175.8	183.8
VEHICLE SUPPORT	187.7	154.7	153.2
TOTAL	1106.5	1051.8	1019.7

DOLLARS IN MILLIONS

FIGURE 56

**MSFC
SATURN APOLLO
PROGRAM COST RATE**

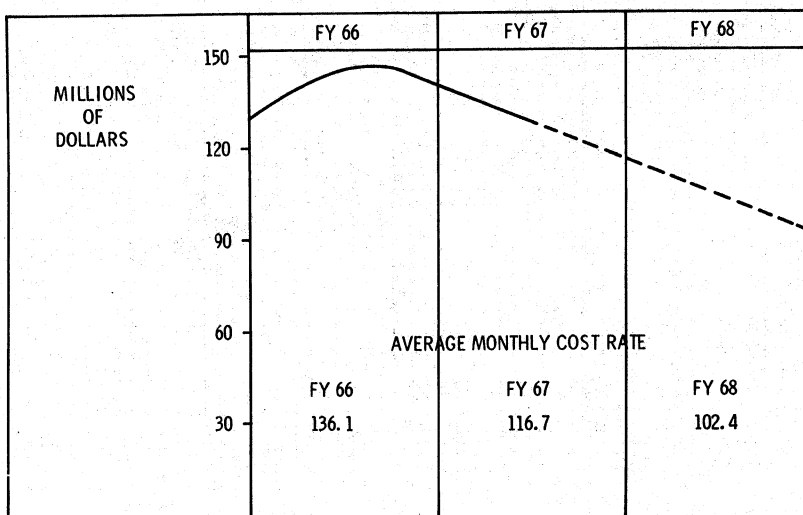


FIGURE 57

reductions, particularly for a program that has so much critical work ahead and which has so much yet to accomplish.

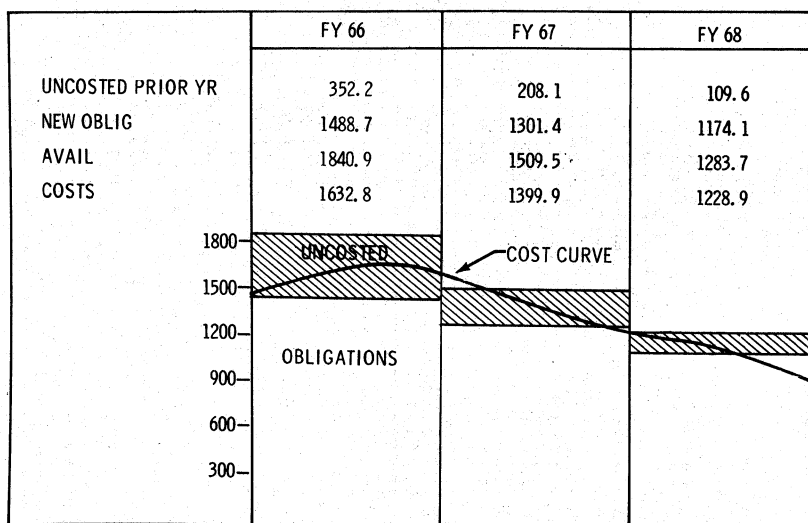
Dr. von Braun stated last night that I would discuss uncosted amounts. In June of fiscal year 1965, we had a 1965 funding carry-over of \$352 million (fig. 58). This carryover plus new obligations totaled \$1.840 billion in available funds. The cost curve reflected here is consistent with the curve on earlier charts except that a small amount of supporting development money is excluded. We plan to spend in fiscal year 1968 an average of \$102 million per month. This is actually about 1 month's value of dollars carried over. The flexibility afforded by the funding carryover is rapidly diminishing, and we feel that the equivalent 1-month carryover is a minimum to cover unfilled orders and termination liabilities.

Our manpower trend is following parallel to the cost trend; this is for major contractors only and not necessarily the manpower total (fig. 59), although the total decline would be even more rapid. The decline in manpower from fiscal year 1966 to fiscal year 1968 is quite drastic.

To summarize the funding for the Apollo Applications program, there has been very little funding in fiscal years 1966 and 1967 (figure 60). For example, the \$24 million received in fiscal year 1967 was applied to the procurement of long-lead-time items for the uprated Saturn I AS-213 and subsequent vehicles.

The Marshall Space Flight Center portion of the President's 1968 budget is \$199.6 million.

MSFC SATURN APOLLO FUNDING RELATION



DOLLARS IN MILLIONS

EXCLUDES SUPPORTING DEVELOPMENT

FIGURE 58