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1978 NASA AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON

SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON

SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

NINETY-FIFTH CONGRESS

FIRST SESSION

ON

H.R. 2221

(Superseded by H.R. 4088)

FEBRUARY 2, 4, 5, 6, 7, 9, 1977

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1978 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 2, 1977

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to call, at 1:40 p.m., in room 2318, Rayburn Office Building, Hon. Don Fuqua (chairman of the subcommittee), presiding.

Mr. FUQUA. The subcommittee will be in order. We welcome today to the Subcommittee on Space Science and Applications—our first meeting of the 95th Congress—Mr. John F. Yardley, the Associate Administrator for Space Flight, NASA.

This is a continuation of the hearings of the subcommittee on the NASA fiscal year 1978 authorizations. Hearings in September of last year provided program reviews.

Since that time substantial progress has been made in NASA's programs and we look forward to Mr. Yardley's assessment of those programs this afternoon.

A number of areas within the Office of Space Flight have been particularly important to the subcommittee during the last year—establishment of a reimbursement policy for the users of the space shuttle; the goal of completion of the hardware for shuttle flights within 2 years, and completion of the space shuttle fleet so that operational capability can be achieved within 3 years.

Of equal importance to the subcommittee is the progress in program planning and development for the future. In this area it is apparent that the already modest funding is being reduced. There is $1 million being reprogrammed from Advance Programs in fiscal year 1977.

The Subcommittee and the Committee specifically increased advanced programs in fiscal year 1977 by $1 million. The ultimate authorization and appropriation bills provided a $500,000 increase.

Our statement last year was that NASA should induce a sense of urgency into advanced program planning. We know that this year OMB reduced substantially your proposed advance program funding. Your comments on this situation will be most welcome.

The progress of the Space Shuttle program, development of Shuttle payload planning, and evolution of an operational Shuttle capability have all undergone major change since our last hearings and we welcome your comment on this subject also.

Before proceeding I would like to invite Mr. Winn, the ranking minority member, to make any comments that he might wish to offer.

Mr. WINN. Thank you very much, Mr. Chairman. I, too, want to welcome John Yardley and his team today for this hearing. I am sure that we will have some questions after he makes his presentation.

Speaking of Space Shuttle, the other night on television I heard the announcer say "tune in, we are going to have pictures" or something to that effect of the rollout of the Space Shuttle craft.

I had been out to what I thought was the rollout of the Shuttle in California but I did not realize we were going to have a rollout where they roll it right down the main street in Lancaster, Calif. I think that is a first for the space program.

I think also it is an indication of the type of PR in an indirect way of rolling that out so that the people of the town could see it and the students were let out of school. It is my understanding the students were let out of school so they could participate in history in the making and I am sorry to say that I had to find out that it was not NASA's idea to do that in the daytime. They wanted to do it at night, but that a Congressman suggested they do it in the daytime.

Anyway John, welcome to the subcommittee.

Mr. FUQUA. Thank you, Mr. Winn and now, Mr. Yardley, if you will proceed. You may introduce for the record your associates at the table with you.

STATEMENT OF JOHN F. YARDLEY, NASA ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT, ACCOMPANIED BY GLYNN S. LUNNEY, DEPUTY ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT; JAMES C. HARRINGTON, DEPUTY DIRECTOR, SPACELAB PROGRAM; DR. MYRON S. MALKIN, DIRECTOR, SPACE SHUTTLE PROGRAM; CAPT. CHESTER M. LEE, DIRECTOR, SPACE TRANSPORTATION SYSTEM OPERATIONS; HAGGAI COHEN, DIRECTOR, RELIABILITY/QUALITY/SAFETY; JAMES L. VANCE, DIRECTOR, RESOURCE MANAGEMENT/ADMINISTRATION; JOHN H. DISHER, DIRECTOR, ADVANCED PROGRAMS; AND JOSEPH B. MAHON, DIRECTOR, EXPENDABLE LAUNCH VEHICLES PROGRAM

Mr. YARDLEY. Thank you, Mr. Chairman.

With me at the table to my far left is Dr. Myron Malkin, our Shuttle Program Director. On my immediate left is Jim Vance, our Office of Space Flight Resources Director and on my right is Glynn Lunney who is my Deputy.

Mr. Chairman, we have submitted a statement for the record and if it meets with your approval we would like to proceed with viewgraphs and an informal discussion of that statement.

Mr. FUQUA. Without objection the statement will be made a part of the record.

[The statement of Mr. Yardley follows:]

Hold For Release
Until Presented by Witness
February 2, 1977

Statement for the Record

by

Mr. John F. Yardley

Associate Administrator for Space Flight

National Aeronautics and Space Administration

to the

Subcommittee on Space Science and Applications

of the

Committee on Science and Technology

U.S. House of Representatives

Mr. Chairman and members of the Committee:

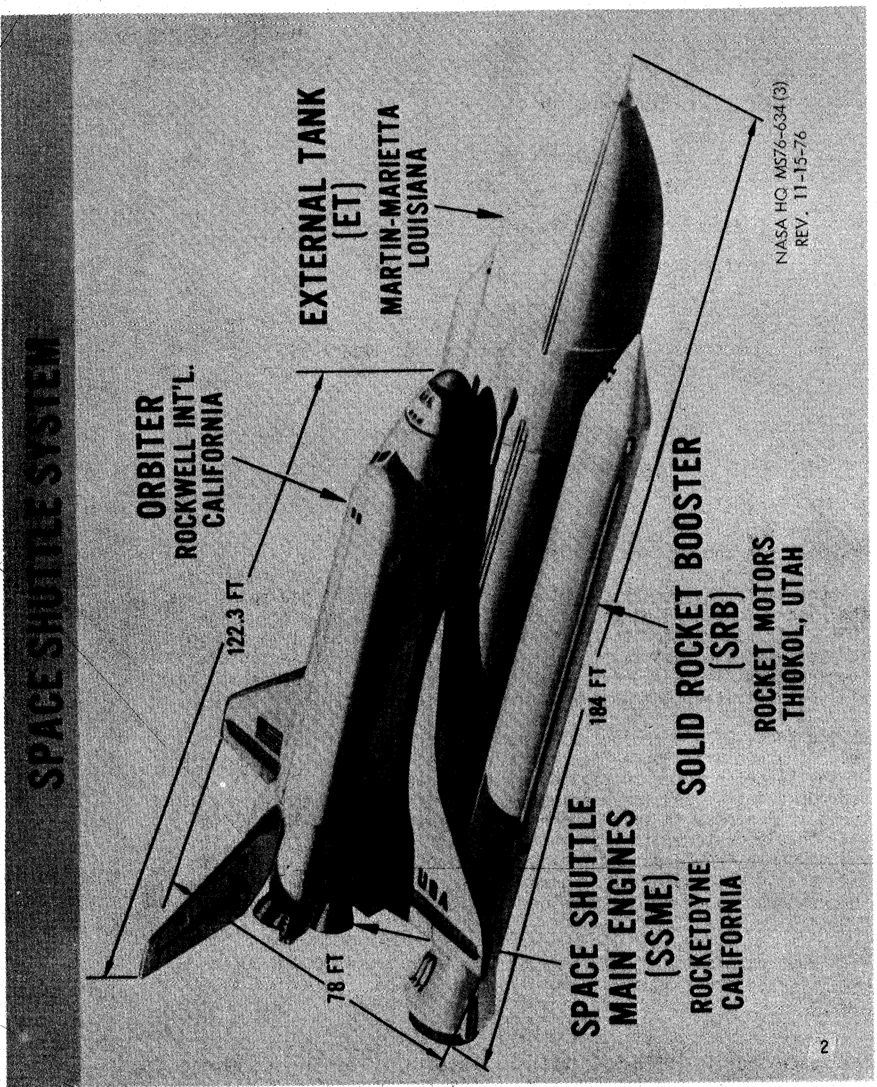
I appreciate having the opportunity to appear before you to discuss the Fiscal Year 1978 budget request for the Office of Space Flight (OSF). In view of the status hearing on September 14, 1976 and in keeping with the desires of this Committee, my discussion today will be generally limited to our FY 1978 requirements, Exceptions to this will be activities which have occurred since last September.

As you know, OSF is charged with management responsibilities to develop the national Space Transportation System (STS) which consists of the Space Shuttle, the Spacelab, and Upper Stages. The STS will provide domestic and international users with regular and economical round trip access to space during the coming decades. The STS era will enable us to capitalize on the unique advantages of space, to expand human knowledge and to increase practical benefits on earth. OSF is also responsible for managing the expendable launch vehicles for unmanned space flight missions and for planning future space programs.

With your permission, I will now discuss each of the OSF programs. First is the Space Shuttle which is the principal element of the STS.

SPACE SHUTTLE

The Space Shuttle (MS76-634) will be reusable, versatile and dependable, and is designed to carry many different types of payloads to and from low earth orbit. It consists of four basic flight hardware elements -- the orbiter, the main engine, an external propellant tank, and twin solid rocket boosters -- and the launch and landing


SPACE SHUTTLE SYSTEM
ORBITER
ROCKWELL INT'L.
CALIFORNIA
EXTERNAL TANK
(ET)
MARTIN-MARIETTA
LOUISIANA
122.3 FT
184 FT
78 FT
SPACE SHUTTLE
MAIN ENGINES
(SSME)
ROCKETDYNE
CALIFORNIA
SOLID ROCKET BOOSTER
(SRB)
ROCKET MOTORS
THIOKOL, UTAH
NASA HQ MS76-634(3)
REV. 11-15-76
2

systems. All these projects are well underway and the Shuttle program is now in the period of peak development leading to the planned approach and landing tests this year and the orbital flight tests starting in 1979. For the Space Shuttle program in FY 1978 we are requesting $1,349.2 million for Design, Development, Test and Evaluation (DDT&E) and for production to establish a national fleet of five orbiters.

Comprehensive studies over the past five years have determined that five orbiters are the minimum cost effective fleet to meet our national requirements. Fewer than five orbiters would require the continued use of the more costly expendable launch vehicles and would result in a substantial cost penalty during the 12 year traffic model now projected for the STS from 1980 through 1991.

To provide added assurance of successfully accomplishing the intensive development ground and flight test efforts, NASA has proposed increasing the funds available for the FY 1977 Space Shuttle program by $30 million. Provision for the increased FY 1977 Shuttle requirements, within the total appropriations available to NASA, will maintain progress toward the critical ground and flight test milestones ahead and will help to assure that the challenging development program is successfully completed on plan and within the cost estimates. The additional FY 1977 Shuttle requirements of $30 million represent a rephasing of the total funding requirements, and the development cost commitment still remains $5.220 million ($ 1971). The $30 million will be used to meet increased FY 1977 requirements in the Shuttle Orbiter, external tank, and solid rocket booster development projects, to deal with unforeseen technical difficulties encountered and to ensure timely delivery of ground and flight test articles.

The Space Shuttle program has stimulated business in virtually every state of the Union and the District of Columbia. Almost 200 contracts, each over one million dollars and many smaller ones have been awarded. Forty-seven of the states have substantial Shuttle contracts; twenty states have contracts totalling over ten million dollars each and in eight of these states we have awarded Shuttle contracts in excess of one-hundred million dollars. The Shuttle program now directly employs about 45,000 industry workers.

Contractor hardware development and testing throughout the program continues to progress on plan. Since February 1976, we have awarded a number of major contracts ranging in value from almost three million dollars to over forty million dollars. One of these is the Solid Rocket Booster (SRB) Assembly and Checkout Contract awarded to United Space Boosters Inc., Alabama/Florida, and another is the contract for ground data and systems software awarded to the Ford Aerospace and Communications Company in Texas.

There are some important contracts still to be awarded, for example, a closed circuit TV system, extravehicular mobility units and an air traffic control communications system.

Space Shuttle Test Program - Success of the Space Shuttle depends on a thorough ground test program (MS 76-1830). Since much of our FY 1978 funding request is to maintain progress in this essential area, we would like to give you an updated description of this comprehensive program.

Extensive activities are necessary to insure that the hardware, as designed, will operate properly when assembled as a system over the full range of conditions which may be encountered during Space Shuttle operations. Testing extends from overall system tests including parts of each program element, down to subsystem and component tests on each project. This will provide the best assurance of achieving overall mission success and the required crew and passenger safety. The test data is used in two ways - to directly verify the expected operations and to verify predictions based on previous analyses. Some of the major tests are described below.

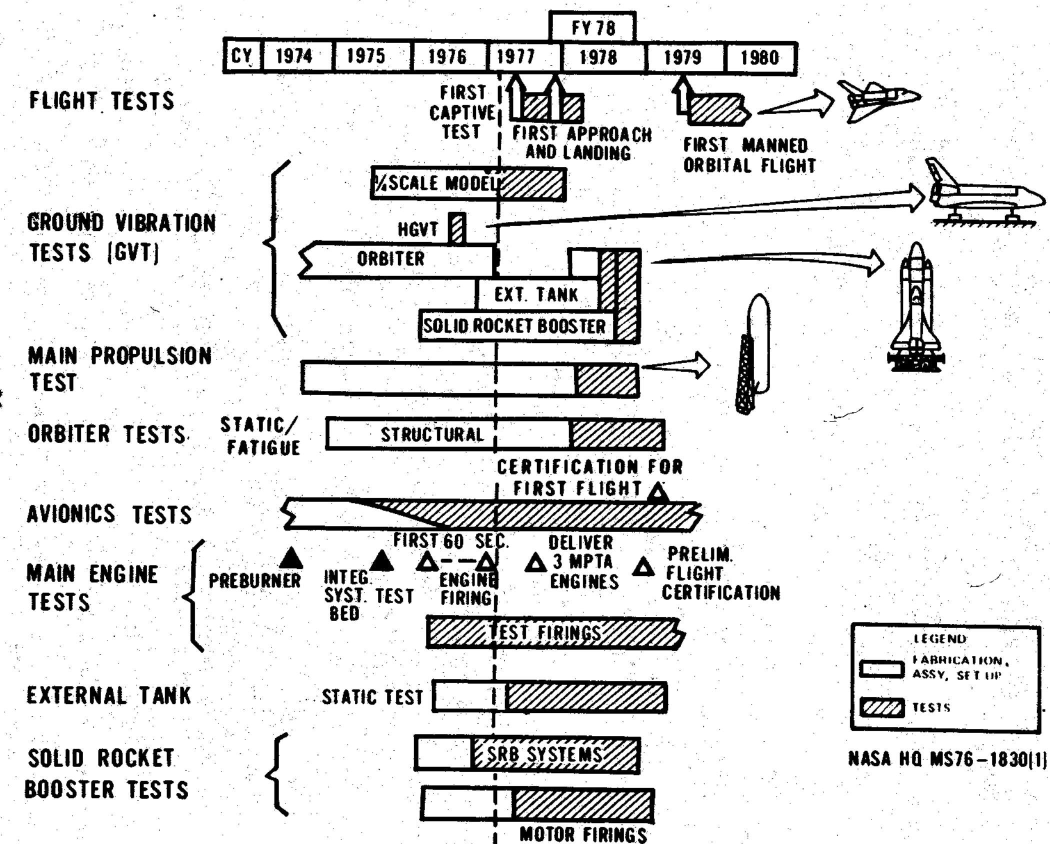
1. Ground Vibration Test (GVT) - The objective of the Shuttle GVT is to verify the analyses used to determine the structural dynamic characteristics of the Shuttle vehicle. Testing will be performed at the Marshall Space Flight Center (MSFC), Huntsville, Alabama, during the last half of 1978. Orbiter No. 1, an external tank, and two sets of solid rocket boosters (one set loaded with inert propellant and one set empty) will be used to assemble the test configurations.

Preparations and planning for this key test are on schedule. Modifications to the MSFC test tower,which were started in September 1975,will be completed in the third quarter of 1977. Design and fabrication of special equipment used to support test operations are underway at both MSFC and the Rockwell International Space Division in Downey, California.

2. Quarter-Scale Shuttle Vibration Test - The quarter-scale Shuttle vibration testing scheduled for 1977 complements the full-scale Shuttle GVT. The objective of the quarter-scale testing is to obtain vibration data for a wider range of test configurations than allowed by cost and schedule constraints of the full-scale GVT and to obtain these data as much as a year earlier so that maximum benefit is obtained from limited testing of the full-scale GVT. This testing will be performed on replica models of the Shuttle orbiter, external tank (ET), and solid rocket boosters (SRB) in both individual and mated configurations and will be performed at a Rockwell International laboratory located in Downey.

The test stand for supporting the test article has been completed. A system of vibratory shakers and associated computer controller equipment (which will also be used in the full-scale GVT) has also been completed. The ET model and an SRB model have been

SPACE SHUTTLE SYSTEMS TEST PROGRAM



delivered and fabrication of the orbiter model is nearing completion. Vibration testing was started late last year on the SRB model and is now in progress on the ET model.

3. Main Propulsion Test (MPT) - The objective of the MPT is to demonstrate main propulsion system performance and compatibility with interfacing elements and subsystems. The configuration includes an Orbiter aft fuselage structure, the Space Shuttle main engines and an external tank. The testing will be conducted at the National Space Technology Laboratory (NSTL).

The MPT program will include cryogenic tanking tests, short duration and long duration static firings including engine gimballing and throttling, and investigation of off nominal conditions. It is the only test program during which cluster firings of all engines will be conducted prior to the firing of the first flight vehicle at the Kennedy Space Center (KSC). The test program will include 12 static firings, with the initial firing scheduled for early 1978.

An important test objective was added to the MPT program this past year, that is to obtain vibro-acoustic data during engine firings. Previously, response data was to have been obtained on an aft fuselage test article subjected to an acoustic noise environment in a Johnson Space Center (JSC) test facility. This test was deleted in favor of obtaining the data on the MPT article. Instrumentation is being added to the orbiter MPT article to measure the acoustic and vibration levels. The data will be used to verify analytical predictions of the dynamic response characteristics of the structure and the internal equipment vibration levels.

4. Orbiter Static Testing - The structural test article is a full scale replica of the orbiter airframe built to flight specifications. Final assembly is scheduled to be finished in the 3rd quarter 1977 with testing completed in the first half of 1979. The test article will be subjected to loads expected in all the critical flight conditions and testing will be phased to support the first manned orbital flight.

The structural test article will be tested by Lockheed at their Palmdale facility adjacent to the Rockwell orbiter assembly building. Part of the test fixture was completed and activated in early 1976 for proof testing of the MPT article which is a full scale aft fuselage section used in the main propulsion test program. The remaining sections of the reaction frame are in design and fabrication. Engine loads will be simulated by large hydraulic jacks applying forces at the points where the main engines are attached. Air loads are simulated by bonding pads to the surfaces and loading them with computer controlled hydraulic jacks to reproduce loads anticipated in the spectrum of flight conditions.

5. Orbiter Avionics Testing - The majority of Orbiter No. 1 avionics component development testing has been completed. The component qualification tests have started. Integrated avionics testing is now underway at the avionics development laboratory (ADL) at the Rockwell Corporation in California and at the electronics system test laboratory (ESTL) and the Shuttle avionics integration laboratory (SAIL) at JSC.

Testing on Orbiter No. 1 avionics system at Palmdale is proceeding using test procedures demonstrated on the ADL and SAIL facilities. The combined ADL and flight control hydraulics laboratory testing has started in Downey, California and closed loop end-to-end flight control testing is underway.

Combined operation of the SAIL and ESTL at JSC has been demonstrated and preliminary closed loop flight control tests in the SAIL have begun. The ESTL is used to demonstrate the combined ground station and flight hardware radio frequency communications systems. These facilities are being used in the development of the Orbiter No. 1 subsystem and the systems software operating routines. At points in the software development cycle, software packages are checked in SAIL and ADL to determine their ability to support formal avionics certification and verification test procedures. Formal avionics verification runs are scheduled to be completed prior to their need on the approach and landing tests.

Detailed plans for Orbiter No. 2 configuration modifications to the ADL, SAIL, and ESTL have been established. The Orbiter No. 2 configuration component deliveries to these facilities will begin in 1977 and be completed in 1978. The Marshall mated element system (MMES) preliminary design has been completed and delivery to SAIL is scheduled for December 1977. This system,when installed in the SAIL,will provide representation of the orbital flight test mated vehicle configuration. This SAIL facility, in combination with the ESTL, will be used to verify the Shuttle avionics system including hardware/software operation, operation with the mated element avionics system and interfaces with other selected orbiter systems.

6. Space Shuttle Main Engine Tests - Three engines have been delivered and tested on the two engine test stands at NSTL. More than 140 tests with total test time greater than 2500 seconds have been achieved. We expect to complete a 60-second engine firing at rated power level during the first quarter of 1977. The main engine critical design review was held in September 1976, at which time the engine system design drawings analyses, component test data and engine test data were reviewed. No major problems were discovered. Delivery of the three engines for the main propulsion test article is scheduled for mid-1977, with preliminary flight certification scheduled for late 1978. A 35 start, 2 1/2 hour life demonstration will be performed on a preselected development engine as part of the flight certification program.

7. External Tank Structural Tests - The external tank structural test program will be performed at MSFC to confirm the structural analyses and to verify the structural design. The major test elements will consist of the flight configured oxygen tank, intertank and hydrogen tank. The test program is comprised of intertank structural tests, oxygen tank strength and modal survey tests, and hydrogen tank strength and interface hardware tests. The static structural tests will be performed to simulate the loads during the critical periods of prelaunch and flight which establish the external tank design. The oxygen tank modal survey tests will be performed in addition to the static tests to determine the hydro-elastic properties of the fluid/structure combination in order to verify the analytical model. These tests will begin in the third quarter of FY 1977.

8. Solid Rocket Booster(SRB) Systems Test - Preparation for these major tests on the SRB systems began during the latter part of 1976. These tests will include static structural strength tests of the SRB, integrated electrical and instrumentation subsystem verification tests, recovery drop tests for the parachutes and booster separation motor development and qualification tests. Flight type hardware will be utilized and the integrity of the subsystems, both in terms of its structure and performance characteristics,will be demonstrated.

The solid rocket motor (SRM) development tests will begin with the first of four development firings in the third quarter of 1977. Three SRMs will be static fired beginning in late 1978 to complete qualification. The last qualification test will use refurbished hardware from the first qualification test to demonstrate the reusability of motor cases.

9. Approach and Landing Test (ALT) - The ALT program of the orbiter will be conducted at the Hugh L. Dryden Flight Research Center (DFRC) beginning in the first half of 1977. Orbiter No. 1 configuration will be that required for atmospheric flight. The systems required only for space flight will not be installed. This series of ALT will verify the performance of the orbiter for the low altitude, subsonic portion of the return from an orbital flight mission. The tests increase in complexity from (1) taxi tests with the unmanned orbiter on the Boeing 747 carrier aircraft, to (2) mated flights with the orbiter unmanned, to (3) mated flights with a two-man crew in the orbiter, to (4) the last series of tests in which the manned orbiter will be separated in flight from the 747 and flown to landing. After successful completion of these tests the orbiter will be transported to MSFC in mid-1978 for the mated ground vibration tests prior to being modified for orbital flight.

10. Orbital Flight Tests (OFT) - The OFT program, beginning with the first manned orbital flight in mid-1979, will use the second orbiter and will consists of a series of launches from the Kennedy Space Center (KSC) with landings at Edwards AFB in California and

at KSC. These flights will verify the performance of all Space Shuttle systems. The orbiter will have additional instrumentation to verify the system performance. Flight test objectives will increase in complexity as the orbiter's launch, flight, entry and landing characteristics are explored.

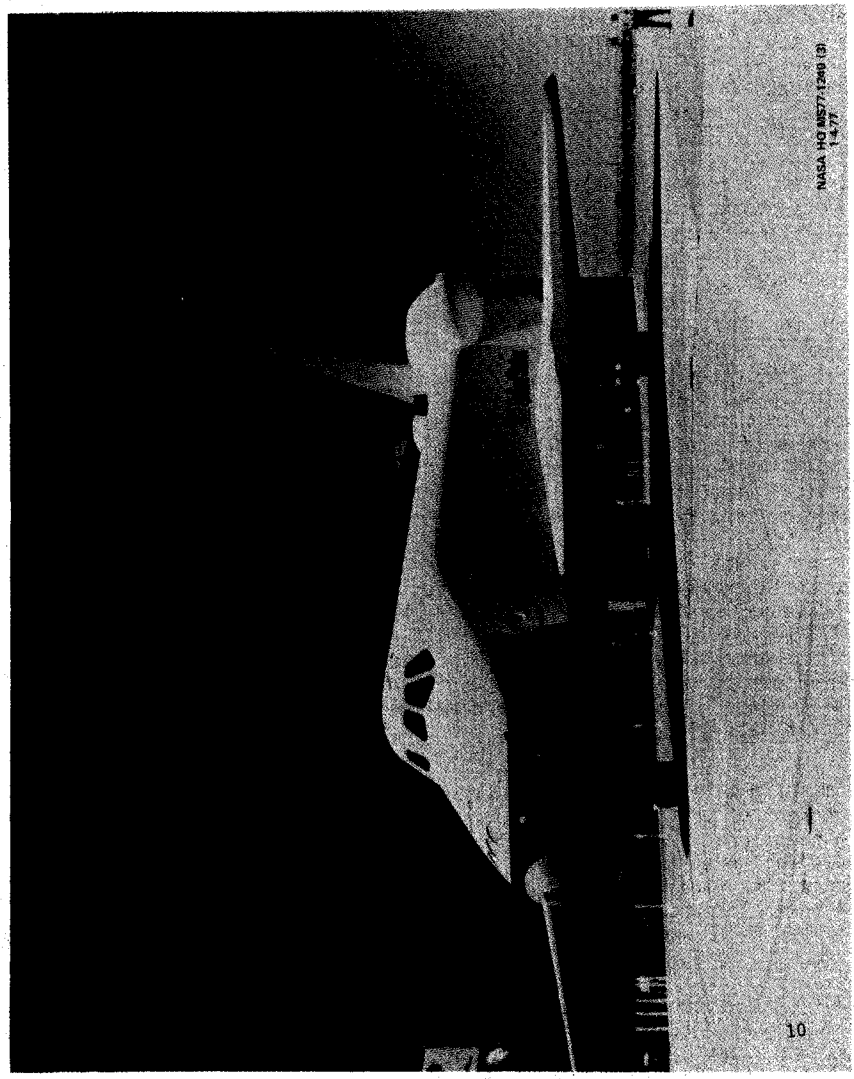
Consistent with the engineering evaluation of the Space Shuttle system, science and engineering payloads will be flown on these development flights. At the completion of these orbital flight tests the Space Shuttle system will transition, along with the Spacelab and the Upper Stages, to an operational space transportation system.

Orbiter (DDT&E) - We are requesting $690.5 million for the orbiter project in FY 1978. The Space Division of Rockwell International has completed the fabrication, assembly and checkout of Orbiter No. 1 (MS 77-1240) which will soon be used for the approach and landing test (ALT) program. Modification of the Boeing 747 carrier aircraft to be used for these tests has been completed and flight testing is proceeding. Captive flight tests of the orbiter mated to the carrier aircraft will begin in the first half of 1977 from the DFRC in California.

Major structural elements for Orbiter No. 2 are being delivered to the Rockwell orbiter assembly plant in Palmdale, California. Individual systems installation and checkout will continue during 1977 and early 1978. FY 1978 activities will include the completion of the approach and landing test program; continuation of development, qualification and verification testing to support the first manned orbital flight; and delivery of Orbiter No. 2 to KSC in late 1978.

A major activity in FY 1978 will be the final assembly and checkout of Orbiter No. 2 at the Palmdale plant of Rockwell International. All of the major structural subassemblies will have been delivered to Palmdale and partially assembled by early 1978. During the first half of 1978, major subsystems of this orbiter will be installed and checked out. In the latter half of 1978, Orbiter No. 2 will be mated to the 747 carrier aircraft and ferried to KSC to prepare for the first manned orbital flight in 1979.

Rockwell has completed manufacture of a sled test article which is being used to qualify the ejection seats and the crew escape system. Static and dynamic testing is now being conducted at the Holloman Air Force Base in New Mexico.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The one-quarter scale model of the Space Shuttle system consisting of the orbiter, external tank, and solid rocket boosters will all be delivered in 1977 to the test location in Downey, California. Ground vibration testing of the individual quarter-scale elements and of the quarter scale mated Space Shuttle configuration will be completed early in 1978 and results used to verify the analytically developed mathematical model.

Development and verification testing of major test articles will continue during FY 1978: the main propulsion test article, the structural test article, and the crew module structural test article which will be assembled during FY 1978 with structural tests scheduled to start in mid-1978.

Characterization and materials testing of the thermal protection system will continue during FY 1978. Manufacture of reusable surface insulation tiles and the reinforced carbon-carbon surfaces for Orbiter No. 2 will proceed through the fiscal year. Also, during FY 1978, qualification testing of the major parts of the life support system will be completed. They include the active thermal control system; food, water, and waste management; and the atmospheric revitalization system.

The emphasis during FY 1978 on avionics subsystems will shift from support of the ALT flights to providing support to the OFT program. Software development, integration and performance analyses, and detailed design of the OFT software packages represent major avionics activities during FY 1978. Coding and checkout of early releases of the entry, ascent, on-orbit and abort packages will be accomplished in early 1978.

Certification of the orbital flight test hardware and software configuration will begin during FY 1978. The Shuttle Avionics Integration Laboratory will be used to develop and demonstrate the launch processing system avionics software and systems interfaces. A simulated flight checkout test will be demonstrated in the SAIL and conducted on Orbiter No. 2 to verify the overall systems operation in the flight configuration using the actual orbital flight hardware.

Simulations will be conducted in the avionics development laboratory at the Rockwell Space Division's plant in Downey, California, to develop and confirm the design of the flight control system with refined data on structural forces (airloads), aerodynamic effects and flight trajectories.

The Space Shuttle Remote Manipulator System (RMS) for handling payloads in the course of space operations is being developed and produced by Canada. Under an agreement between Canada and the United States, the National Research Council of Canada has been designated the Canadian agency responsible for providing the RMS to NASA. During the first quarter FY 1977, the preliminary

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design review was completed on schedule establishing the RMS fundamental design. This event permits the detailed engineering drawings to proceed and subcontracts to be initiated on electrical and mechanical hardware and subassemblies. In FY 1978, the manipulator booms, end effector, joints, hand controllers and operator displays are to be fabricated, tested and qualified. Interface hardware, such as the manipulator control interface unit and stowage fixtures will be completed and integrated with the Space Shuttle systems.

Simulations will be conducted first in Canadian facilities to evaluate the final space qualified designs. Subsequently, integration and verification with the Space Shuttle control systems will be accomplished in the SAIL at JSC.

Many other orbiter project activities being performed by JSC will require funding in FY 1978. These include the White Sands Test Facility reaction control system testing, simulators for crew training and mission procedures development, extravehicular mobility unit design and fabrication, and modification of the JSC mission control center for the orbital flight test program.

Space Shuttle Main Engine (DDT&E) - A total of $219.9 million is being requested for the Space Shuttle main engine (SSME). In FY 1977, the prime contractor, Rocketdyne Division of Rockwell International, is testing and fabricating major subsystems of the Space Shuttle main engines. Components tested at Santa Susana, California, include the ignition system, thrust chambers, fuel and oxidizer turbopumps, and the preburners. Continued testing of these components is scheduled for FY 1978. Engine firings were conducted at the NSTL (MS 77-1249) throughout 1976. Fabrication of the main propulsion test article engines will be completed this year and delivery to support the main propulsion test activity is scheduled for early 1978. Also manufacturing of the initial set of flight engines has started and they will be delivered to KSC in late 1978.

Throttling of the SSME from rated power level (100% thrust) to minimum power level (50% thrust) has been accomplished recently and soon we expect it to operate at rated power level for 60 seconds. These two major development tests were originally scheduled to be completed in 1976, but two significant problems with the high pressure fuel turbopump were identified; rotor shaft vibration, and turbine end bearing cooling. Extensive effort was required to solve these problems.

As a result, the actual rate of progress compared to the engine test plan shows that while we have achieved the planned number of tests, we have not achieved our planned duration. Our test rate capability has proven better than we had postulated in laying out the engine development schedule so that we should be able to make rapid recovery toward achievement of all test objectives. We expect to


SHUTTLE MAIN ENGINE TESTING AT NSTL
ENGINE NO. 1
ENGINE NO. 2
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recover our planned rate of testing in late 1977, exceed this rate during 1978, and to recover to the total accumulated duration prior to the first manned orbital flight.

Although the overall engine test program is now estimated to be four months behind schedule, none of the future milestones such as delivery of the main propulsion system test engines and engines for the first orbital flight have been revised. It is anticipated that much of the schedule slip will be recovered.

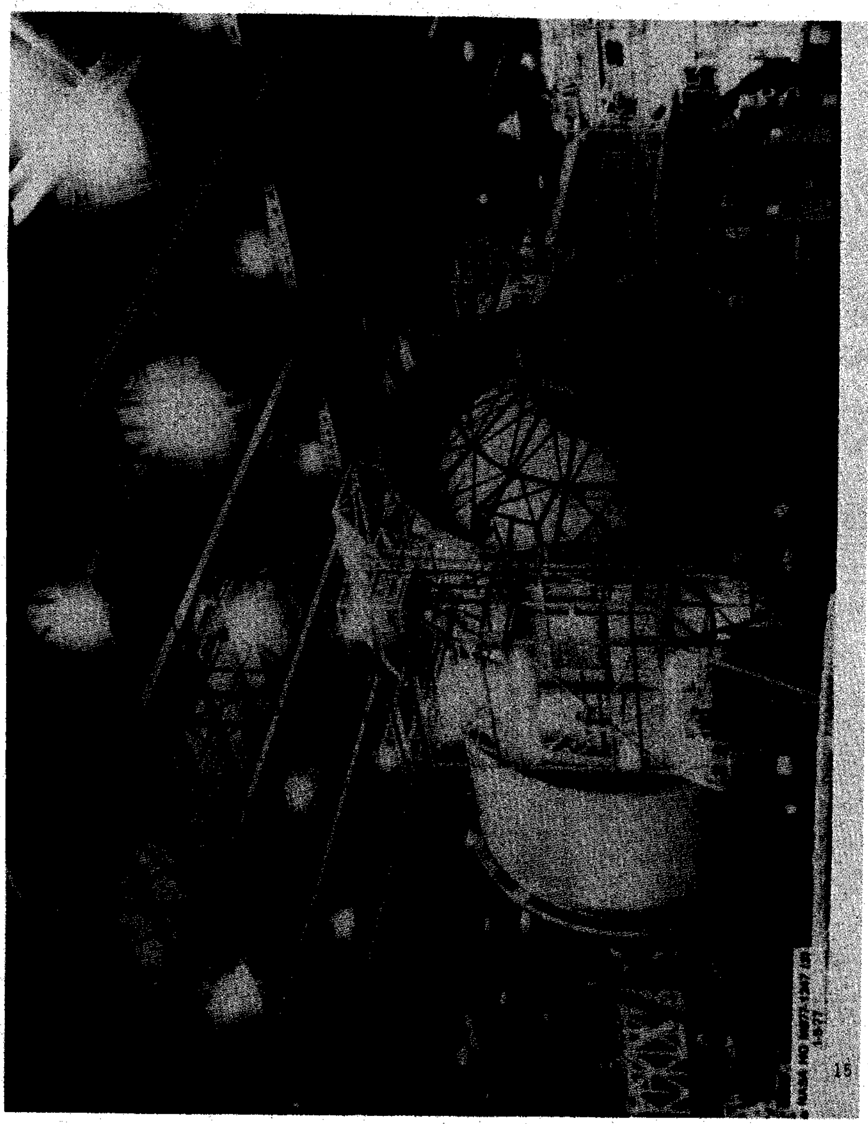
FY 1978 funding requirements for the main engine development provide for intensive test activity. Engine component certification testing will continue at Santa Susana on such components as the fuel and oxidizer preburners, ignition subsystem, main combustion chamber, and the high and low pressure turbopumps. Testing of these components will be conducted at operational power levels to certify their performance and reliability characteristics for flight operations. Concurrent with component testing at Santa Susana, testing of flight-configured engines will be conducted at NSTL to demonstrate engine flight readiness. Main propulsion system verification tests of three engines combined with the orbiter and external tank test articles will also be conducted at NSTL during FY 1978.

The first three flight engines will be completed, acceptance tested at NSTL, and shipped to KSC in late 1978. Prior to this time, the engine ground support equipment necessary to support engine installation, checkout, and operational support of the first manned orbital flight will be available at KSC.

Additional engine project support activities requiring funding during FY 1978 include hardware for the engine systems simulation laboratory testing, engine software integration support, and propellant procurement for the test programs at both NSTL and Santa Susana.

External Tank (DDT&E) - We are requesting $80.0 million for the external tank. Development and fabrication by the prime contractor, Martin Marietta Corporation, is taking place at the government-owned Michoud Assembly Facility near New Orleans, Louisiana.

In FY 1977, major assembly and welding operations will be completed on the liquid hydrogen and liquid oxygen tanks, as well as on the intertank for the main propulsion test article at the Michoud plant (MS 77-1247). These three major portions of the tank will be assembled into a complete tank for delivery to the NSTL test site in late 1977. Assembly of the structural test article intertank and simulators for testing at MSFC are in the final phase to support a delivery to the test site in the middle of FY 1977.



At MSFC, during FY 1978, a complete load test of the first intertank structural test article will be accomplished to verify structural integrity. Later a second intertank test article and liquid hydrogen and liquid oxygen structural test articles will each be completely assembled and delivered to MSFC for structural verification testing. The design of the test support equipment will also be completed during fiscal year 1978.

Assembly of the external tank ground vibration test article will be accomplished by mid-FY 1978. This tank will be shipped to MSFC where it will be assembled with two solid rocket boosters and Orbiter No. 1. The mated ground vibration tests will expose the vehicle to vibration environments, and data will be obtained to verify mathematical models of vehicle dynamics including flutter, flight control, loads, and longitudinal oscillations called POGO.

In the second half of 1978, the first orbital flight external tank will be completely assembled, acceptance tested, and prepared for shipment to KSC. Assembly of the second, third, and fourth flight tanks will continue and component fabrication and initial assembly operations on the fifth and sixth flight tanks will begin.

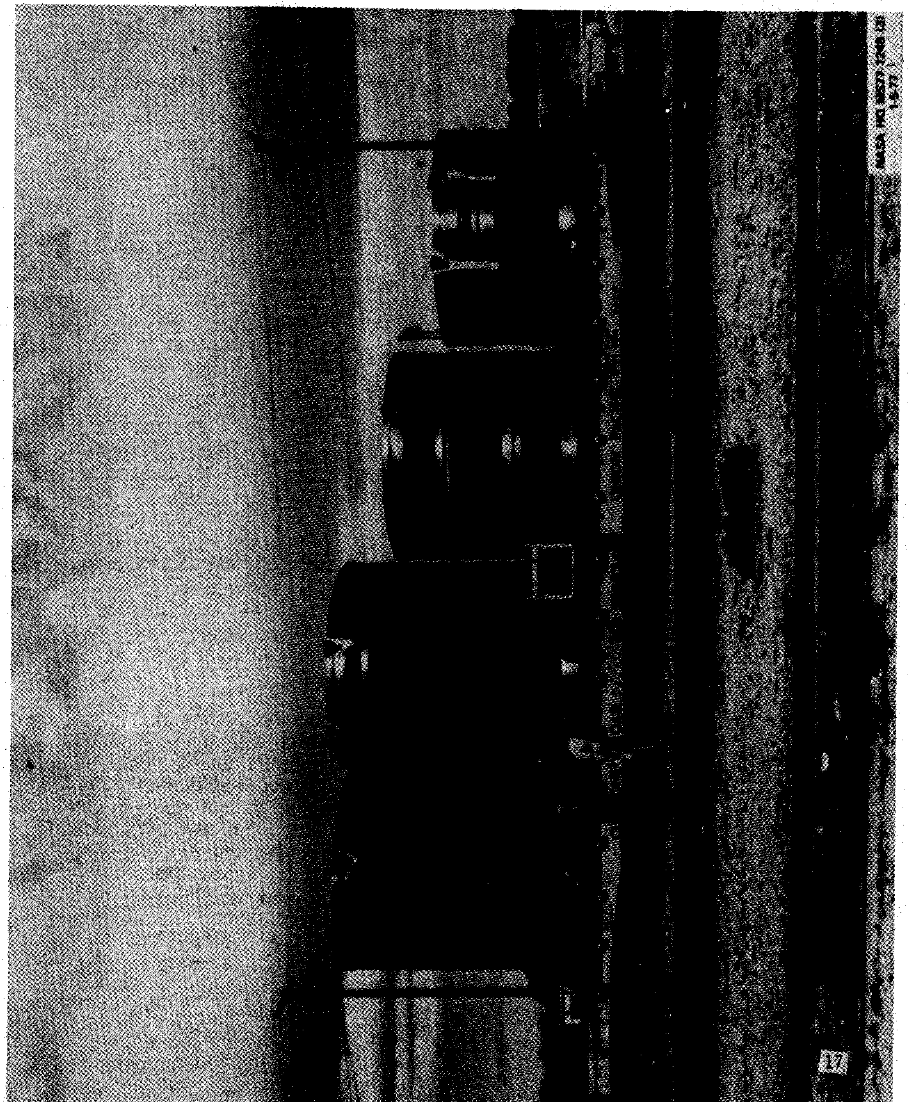
Solid Rocket Booster (DDT&E)

We are requesting $83.6 million for the Solid Rocket Booster (SRB). The main element in the solid rocket booster system is the solid rocket motor (SRM), which is being developed by Thiokol, Wasatch Division, Utah. The other booster system elements such as the recovery system, thrust vector control, attach structures, forward and aft skirt, and separation motors have been or will be procured separately. The MSFC will perform designated systems integration tasks and has the responsibility for total systems integration of the SRB effort.

In FY 1977 the first development motor case was delivered to Thiokol on schedule. A group of these motors segments are shown in (MS77-1248). Development motor no. 1 will be loaded with propellant in mid-FY 1977 and static fired late in the fiscal year. Development motor no. 2 is scheduled for test firing in early FY 1978.

The SRB critical design review and the deceleration subsystem preliminary design review were both completed in December 1976. The full scale development test firings of four booster separation motors were also completed with preparations underway for conducting a second set of four motor firings.

In addition to initiating testing for our major components, the booster assembly contractor,United Space Boosters, Inc. was selected and will start work on preparation for assembly and checkout of the booster at KSC.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In FY 1978 extensive efforts will be devoted to manufacture, propellant loading, and delivery of solid rocket motors. Two development motors will be fired early in this period to complete the development test series of four motors. These will be followed by the first two qualification motor firings near the end of FY 1978. In addition, four dynamic test motors will be manufactured and delivered to MSFC to begin the ground test program. Solid rocket motors for the first orbital flight will also be manufactured and delivered to KSC during the latter half of 1978.

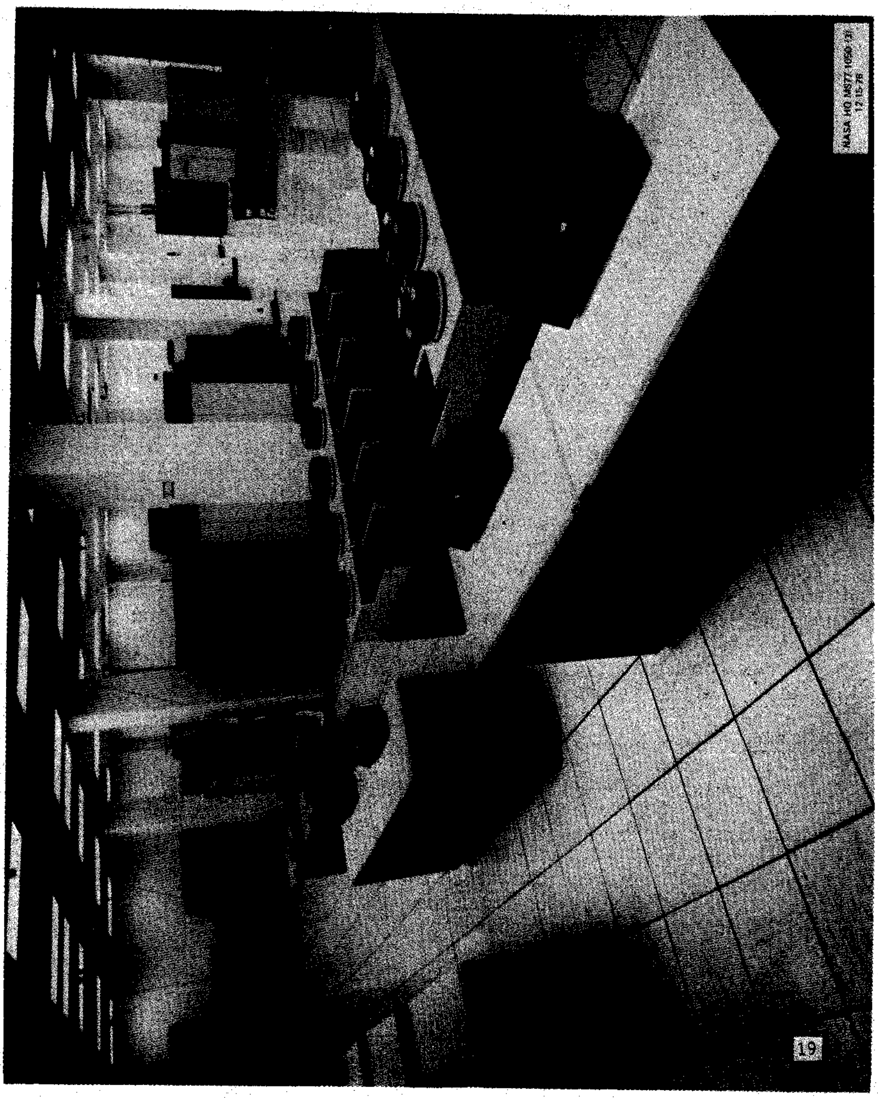
A major activity on the solid rocket booster project during FY 1978 will be the continuation of the qualification and verification test program. This includes the completion of the electrical and instrumentation verification testing, the drop test program to verify the recovery system parachutes, completion of booster separation motor development and qualification static firings, and the verification of the overall thrust vector control system. During FY 1978, the fabrication of flight hardware will continue and the hardware required for the first orbital flight will be delivered to KSC. The booster assembly contractor will complete preparations for checkout and assembly of this hardware and will also continue with planning and activation of an SRB refurbishment facility.

Launch and Landing (DDT&E)

Funding requirements for the launch and landing project total $133.5 million for FY 1978. During FY 1977, design requirements will be established for essentially all of the ground support equipment (GSE). Procurement will proceed during the next two fiscal years and the GSE will be incorporated into the launch and landing station sets at KSC and DFRC.

The schedule and milestones planned for the launch processing system (LPS) have been maintained. The LPS hardware designed by KSC engineers for checkout of the SRB electronics at MSFC was assembled, checked out and accepted by MSFC. The required operating software was successfully developed by the KSC/IBM team and the hardware and software have been installed at MSFC to meet the SRB checkout need date. Minicomputers have been delivered and will be used as part of the checkout, control, and monitoring subsystem (CCMS) being developed by the Martin Marietta Corporation (MMC). The CCMS design is complete and the initial system has been delivered to KSC for software development. Honeywell Information Systems, the central data subsystem (CDS) contractor, delivered and installed the primary and secondary computer systems with peripherals in the launch control center at KSC in 1976 (M77-1050). Software simulation support is now being provided for checkout procedure development.

The development contractors' on-site launch support efforts at KSC have been initiated with Rockwell International and Martin Marietta. The booster assembly contractor, United Space Boosters, Inc., started work in January 1977. These contractors are pre-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paring test documentation for vehicle assembly, test servicing, checkout and launch requirements, process specifications and procedures.

The LPS hardware deliveries required to initiate processing of the first orbiter at KSC will be completed early in FY 1978. The final increment of hardware and system software for the central data subsystem will be delivered to KSC by mid-1978. Installation of the LPS checkout, control, and monitoring subsystem and integration with other ground support equipment will continue through mid-1978. Operating systems software development, verification and validation will reach its highest level of activity during FY 1978.

Some of the major launch support systems to be completed in FY 1978 include the orbiter forward umbilical, tail service mast/umbilical and ET vent umbilical/access systems for providing fluid services and ground monitor and control up to the moment of launch; the SRB support holddown mechanisms to release the vehicle for lift-off; and the crew compartment access/egress arm for boarding the crew.

The development contractors' support at KSC during FY 1978 will become a large portion of the launch and landing R&D budget and contractor manpower buildup will continue. Before the end of 1978 processing of the vehicle for the first orbital flight will begin. The launch team is also the operator of the launch processing station sets, launch support equipment, and the GSE. Detailed procedures for assembly, test, servicing, checkout, and launch of the total Shuttle flight vehicle will be developed.

Production

Production will be initiated during FY 1978 and will require $141.7 million. The production phase will provide for the fabrication of Orbiters 3, 4, and 5, and for the modification of the first two orbiters which are being procured in the development program. Orbiter No. 1, following completion of the ground vibration test program in late 1978, will be upgraded to full manned orbital flight capability. Later, Orbiter No. 2 will be modified to operational status after the initial orbital flight tests. Production also includes the fabrication of the flight engines. In addition, the ground and launch support equipment for the second series of ground processing stations at KSC for simultaneously processing two Shuttle vehicles and the flight equipment spares will also be part of the production activities.

Procurement of components and materials and subcontracting for Orbiters 3, 4, and 5 will be initiated during FY 1978. Purchasing of long lead items for these production orbiters will be combined to obtain the most economical procurement. Also during FY 1978, components and subsystems will be procured and hardware fabrication will be initiated for upgrading Orbiter No. 1.

The prime contractor will begin fabrication of primary structures for Orbiter No. 3, including the aft fuselage, the crew module, and the forward fuselage. Procurement of the payload bay doors and the avionics airborne hardware will be initiated.

In addition to long-lead procurements, activity on Orbiters 4 and 5 will include start of detailed parts manufacturing for a number of subsystems including wings, vertical stabilizer, orbital maneuvering system engine, orbital maneuvering/reaction control system pod, and air revitalization system, and the power reactant storage assembly.

Efforts on the main engines to be installed in the production orbiters will start in FY 1978 with the procurement of critical long-lead components. These include the hot gas manifold forgings, the engine nozzle jacket, and the housings for the high pressure fuel and oxidizer turbopumps.

SPACE FLIGHT OPERATIONS

We are requesting $267.8 million for Space Flight Operations in FY 1978. Included in this budget line item are Space Transportation System (STS) Operations, STS Operations Capability Development, Planning and Program Integration; the common support activities conducted under Development, Test and Mission Operations (DTMO); and, Advanced Programs. STS Operations, which I will discuss first, is a new project under Space Flight Operations.

Space Transportation System (STS) Operations - As the development activities of the STS continue to progress, we are directing an increasing proportion of our efforts towards planning and establishing operational policies and procedures for the STS. These activities include user development, mission planning, launch and flight operations planning, payload integration and development of financial plans including user charge policies. In FY 1978 we are requesting $17.8 million for STS Operations.

Agency user charge policies have been established for commercial, foreign and civil U.S. government users. Negotiations on reimbursement are underway with the Department of Defense (DOD). A guaranteed fixed price will be charged from 1980 through 1983 for standard Shuttle and payload services for both dedicated and shared flights. Operational services are available at additional cost. The policy provides for short term call-ups, postponements, cancellations, standbys, and for substantially reduced prices for exceptional and small, self-contained payloads.

Proposals for five self-contained science payloads have been received from individuals wishing to use the Space Shuttle for scientific experiments. For example, a private citizen has offered one half of a $10,000 payload to Utah State University. It will be offered, in turn, to high school students who will submit proposals to fly their own equipment in small, self-contained payloads. Those selected will be given tuition waivers at Utah State University which is also establishing a follow-on program to be offered to high school students. In addition, a German consultant is contracting for two $10,000 payloads, one for space processing, one for biological experiments and the Battelle Institute has contracted for two $10,000 materials science payloads.

Examination of the long range projection of payload activities for the decade of the 80's and the Shuttle traffic required to support this effort is continuing. Although the 1973 Traffic Model is still representative of the kinds of payload activity being planned for the Shuttle, the level of flight activity has been adjusted and reduced to be more consistent with current agency objectives and budget constraints. A reference payload model has been developed which includes payload programs for 1980-1991 based on current planning of the various users requiring STS support. It was determined that 560 Shuttle flights were needed to carry out the overall payload program over the twelve year period.

In planning our mission activities for Shuttle, particular emphasis has been given to defining near term cargoes during the initial years of Shuttle operations. Cargoes are being developed for flights in the 1980 and 1981 time period. For example, a major effort is underway to formulate missions for Spacelab flights 1 and 2. Several cargoes of mixed payloads, e.g., a combination of pallet elements, high energy spacecraft requiring upper stages and free flyers on a single cargo, are being examined to determine how best to support multiple payload operations on a single flight. Discussions are underway with a number of external users who require launch support in the 1979-1981 time period. Agreement was reached with COMSAT in the summer of 1976 to develop a INTELSAT V spacecraft series that can be launched both on Atlas/Centaur and on Shuttle. COMSAT has contracted with the Ford Aerospace and Communications Company to design and build INTELSAT V with this compatibility, and NASA is currently negotiating an agreement to provide Shuttle launch service for the INTELSAT V program, following the initial four launches on Atlas/Centaur in 1979 and early 1980. The first Shuttle launch would provide a back-up launch to the initial four spacecraft and is planned for November 1980. Subsequent INTELSAT V launches will be scheduled on Shuttle.

Effort is also underway to develop an overall plan to transition launch support from Expendable Launch Vehicles to the Shuttle. Studies have shown that designing the spacecraft for dual compatibility causes minimal cost impact. Discussions are underway with many users requiring transportation service during the transition period and specific plans are being developed to effect this transition with minimum impact on the user. NASA currently expects to complete transition of all civil payloads to the Shuttle at Kennedy Space Center by 1981 and at Vandenberg Air Force Base by 1983.

In compliance with NASA policy to provide assured launch service to users during transition to Shuttle, we are actively studying back-up strategies to provide this assured launch capability while minimizing investment by both NASA and the user in expendable launch vehicle hardware. Transition planning and back-up requirements have been developed separately by the DOD for its programs and coordinated with the overall transition plan for STS.

Planning for payload verification of integration concepts, by using the Convair 990 aircraft is continuing. A mission is scheduled for late May 1977. The lessons learned from this simulation are expected to provide better insight into developing operational concepts for Spacelab.

Flight operations planning and crew training/simulation planning are progressing. The initial Baseline Flight Operations Plan, which contains the basic operations concepts, is being updated.

NASA has recently announced opportunities for additional pilots and mission specialists; actual selection and appointment into NASA will be made in December 1977. Guidelines and plans are also being developed for selection and training of payload specialists. A review of approximately 25% of the applications received, indicates that the candidates appear to be well qualified and we are pleased with the response we have received to date.

Examination of payload support requirements, both engineering and scientific in nature, is continuing. Requirements are currently undergoing close scrutiny since they will have a bearing on the sizing and design of equipment and facilities. Payload users have been informed of our initial results and should respond to the concepts proposed to them by about mid-1977.

With the initial operational flights of the Shuttle scheduled for 1980, funding is required in FY 1978 to initiate vehicle spares procurement, crew training, flight simulations, software development, and flight and mission planning. We will initiate procurements of long lead-time hardware and spares for the external tank and the solid rocket booster. Funds will be used to supply raw materials, castings and forgings to machining vendors to assure availability of finished parts at the start of external tank assembly at the Michoud assembly facility in early FY 1979. Solid rocket booster initial procurement will include motor components, electronic and instrumentation parts, recovery and separation motor parts. FY 1978 funding will also provide for initiation of crew training and procedures, engineering support, console handbooks, training records and flight data checklists.

STS Operations Capability Development - We are requesting $63.0 million for STS Operations Capability Development. This activity includes space transportation system development and support activities to facilitate the planning and orderly transition to STS operations. Principal areas of effort are the Spacelab, the STS Upper Stages, Multi-Mission and Payload Support Equipment (MMPSE), Mission Control Center (MCC) Upgrading (Level II), and, Payload and Operations Support.

Spacelab - Of the $63.0 million requested, $24.5 is for Spacelab, first of the principal areas of effort under STS Operations Capability Development. The Spacelab is an orbital facility which will provide a pressurized module and unpressurized pallets, for use by experimenters to conduct scientific and applications experiments in earth orbit. It is an integral part of the Space Transportation System and is carried into space and returned to earth in the cargo bay of the Space Shuttle.

Under the terms of a Memorandum of Understanding with NASA, the European Space Agency (ESA) is responsible for the design, development and manufacture of the initial Spacelab flight unit. Ten nations of Europe have agreed to carry out the ESA agreement and to commit approximately $575 million to design and deliver one flight unit to the U.S. NASA is responsible for all operations activities after delivery of the Spacelab from Europe and also for the development of selected items such as the tunnel connecting Spacelab to the Shuttle Orbiter and the verification flight instrumentation. The first Spacelab flight is scheduled for 1980.

Since our last report in September 1976, ESA has continued to progress in its development of the Spacelab. The most significant accomplishment was the successful completion of the preliminary design review in December 1976, which essentially established the technical baseline for the program and which will permit manufacturing and testing to proceed. Further, system layout for harnesses and piping, using the development fixture, was completed ahead of schedule. The hard mockup unit (MA 75-0304) was also completed and is now being evaluated.

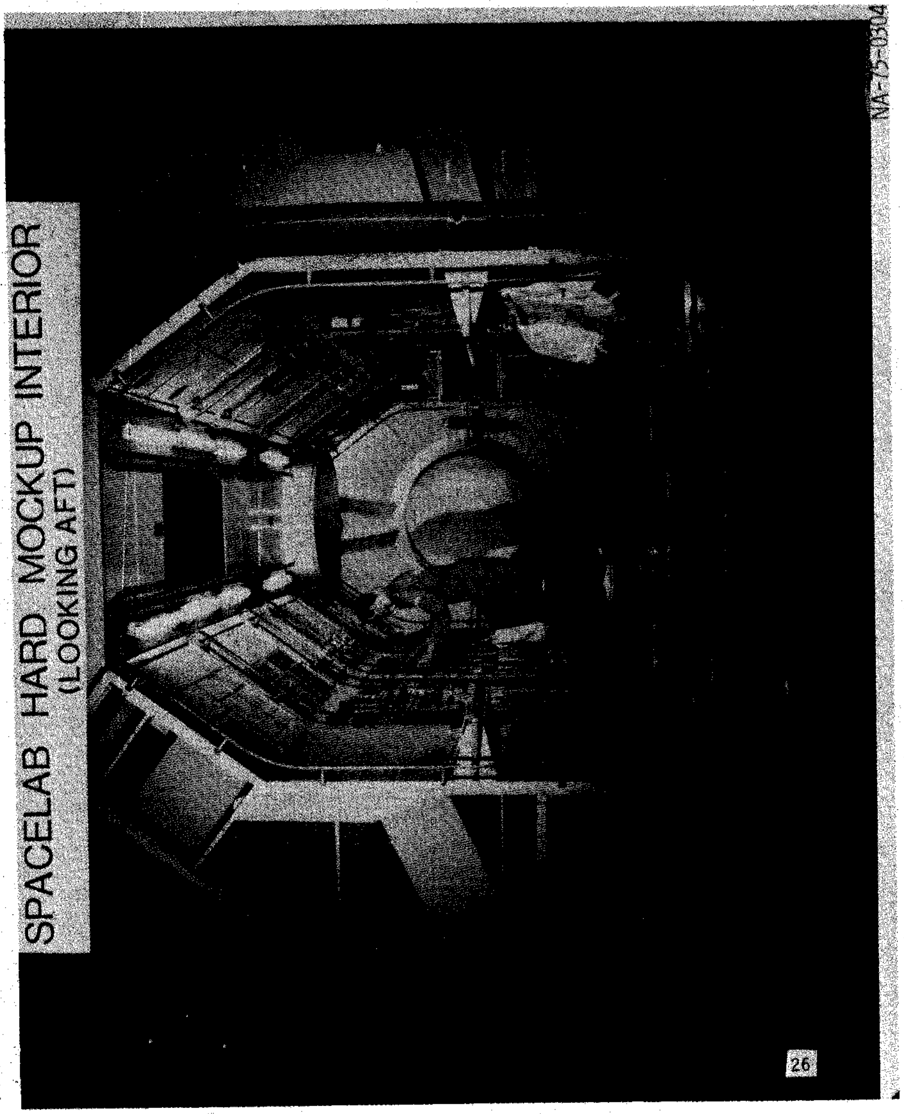
In addition, certain personnel changes occurred. Mr. M. Bignier was appointed ESA Spacelab Program Director in November 1976 and Mr. Burkhard Pfeiffer was appointed ESA Spacelab Project Director in January 1977.

In the United States, NASA has continued to plan and prepare for the integration effort and ground operations support for the Spacelab missions. During the first quarter of 1977, a Spacelab integration contract will be awarded. This contract will include design, development and fabrication of most of the Spacelab hardware for which NASA is responsible.

In FY 1978, NASA will be deeply involved in the design and fabrication of various pieces of hardware and development of systems and procedures for handling and processing the Spacelab. FY 1978 funding will be used to support these activities and will also provide for incremental procurement of a flight hardware inventory from ESA as called for by the NASA/ESA Memorandum of Understanding.

The Spacelab integration contractor will perform much of the hardware design, development and fabrication as well as the planning and analysis which is required for the safe and efficient operation of the Spacelab. The hardware includes the transfer tunnel, verification flight instrumentation, ground support equipment, a neutral buoyancy trainer and the design and outfitting of a software development facility. The transfer tunnel is a passageway connecting the Shuttle orbiter cabin to the Spacelab pressurized module where researchers or scientists can perform experiments in a "shirt-sleeve" environment.

The first two Spacelab flights will be used to check-out all the systems and structures. For this purpose, funding in FY 1978 is required to continue the manufacturing of the verification flight instrumentation. This group of instruments will include measuring and monitoring devices to interface with on-board computers and recorders. They will measure the pressures, strain, vibration, electrical


SPACELAB HARD MOCKUP INTERIOR
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characteristics, noise level to insure the safety, reliability and performance of the Spacelab.

The ground support equipment which NASA will develop in FY 1978 is primarily transportation and facility-related. It includes those items which due to their size or other unique requirements are best provided by the U.S. rather than by ESA. This equipment includes workstands outfitting which will be used to integrate and check-out the various elements of the Spacelab, special handling equipment to rotate the Spacelab Engineering Model to a vertical position for early testing, and equipment to unload and transport the Spacelab when it is delivered to the Kennedy Space Center.

The neutral bouyancy trainer, which is scheduled to be completed in FY 1978 is a full scale, low fidelity mockup of the Spacelab. It will be used in a water tank for simulating extra-vehicular activities and the transfer of crewmen and hardware to the Spacelab in zero gravity.

The last major item of ground hardware which the integration contractor will be developing in FY 1978 is the equipment for the Software Development Facility. Funding will support system design and procurement of computers and peripheral hardware which will be used for maintenance, integration and verification checkout of the software delivered by ESA.

In FY 1978, in addition to the development of hardware, the integration contractor will continue to develop procedures for the operation of Spacelab. This includes such areas as maintenance, logistics, configuration control, training requirements and integration procedures.

The Spacelab to Orbiter interface is complex and critical. With the Spacelab being developed in Europe and the Shuttle in the United States, it is necessary to make extensive tests to assure the compatibility of these two items. Toward this end, in FY 1978, we will continue to fund a series of studies, analyses and fabrication of test fixtures representing this interface. Mechanical interface verification equipment will be constructed in the U.S. and provided to ESA for testing ESA developed hardware prior to delivery. Also, the Shuttle Avionics Integration Laboratory is being modified to make certain that the avionics of the Spacelab and the Shuttle Orbiter will interplay correctly.

STS Upper Stages - Our funding request for this effort is $13.5 million in FY 1978. The STS Upper Stages are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. Two upper stages are presently envisioned: The Interim Upper Stage (IUS) and the Spinning Solid Upper Stage (SSUS). The IUS will be used primarily for high energy lunar and planetary missions and the SSUS will be used for the delivery of small, lightweight payloads into geosynchronous transfer orbit.

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Interim Upper Stage (IUS) - (MV 77-717), under development by the Department of Defense, will be a multi-stage, solid propellant, expendable vehicle designed to place up to 5000 pounds into geosynchronous orbit and be used primarily for high energy lunar and planetary missions. It will be operational in 1980. During the DDT&E phase, NASA is coordinating the incorporation of NASA-unique and non-DOD requirements with the DOD to insure that the IUS is operationally compatible with the STS.

The validation phase of the IUS program, funded by the USAF, is underway. In September 1976, the DOD awarded the validation phase contract to the Boeing Aerospace company. An IUS Systems Requirements Review is to be conducted early in 1977 followed by the Systems Design Review in April 1977. The full-scale development phase contract is scheduled to begin in FY 1978.

The DOD and NASA continue working closely in technical and management efforts related to IUS development activities. Specifically, the NASA activities include analytical integration of the IUS system and its payloads into the Shuttle; STS/IUS flight operations and mission control planning and support equipment implementation; studies of integrating the IUS into the NASA's launch site systems/facilities and the STS ground processing flow as well as the initial procurement of long lead items for supporting equipment; IUS design support; the establishment of the final non-DOD IUS system specifications; and initial support of the IUS full-scale development phase for all NASA-unique IUS items. In FY 1978 NASA will continue to assist the DOD in assuring that the IUS will satisfy the national upper stage mission needs; to work with the DOD to ensure the effective integration of the IUS into the STS; and to fund the approved non-DOD IUS development items.

Spinning Solid Upper Stages (SSUS) - (MV 76-3142)will provide for certain payloads a low cost stage and an effective transition to the Shuttle from current expendable Delta and Atlas Centaur vehicles. To the maximum extent possible, the interfaces to which the payloads now must design will remain unchanged. The SSUS is to be developed in two weight classes; the "Delta class" (SSUS-D) will be capable of injecting about 1200 pounds into a geosynchronous transfer orbit, while the "Atlas Centaur class" (SSUS-A) will deliver about 2200 pounds into the same orbit.

The SSUS system includes the stage, airborne support equipment (cradle, tilt table, and spin mechanisms), and ground support equipment for both the Delta class missions and the Atlas Centaur class missions to be delivered by the STS. Two Atlas Centaur class SSUS's and four Delta class SSUS's can be flown with their spacecraft on a single Shuttle flight and still maintain separate spacecraft interfaces.


INTERIM UPPER STAGE
US AIR FORCE
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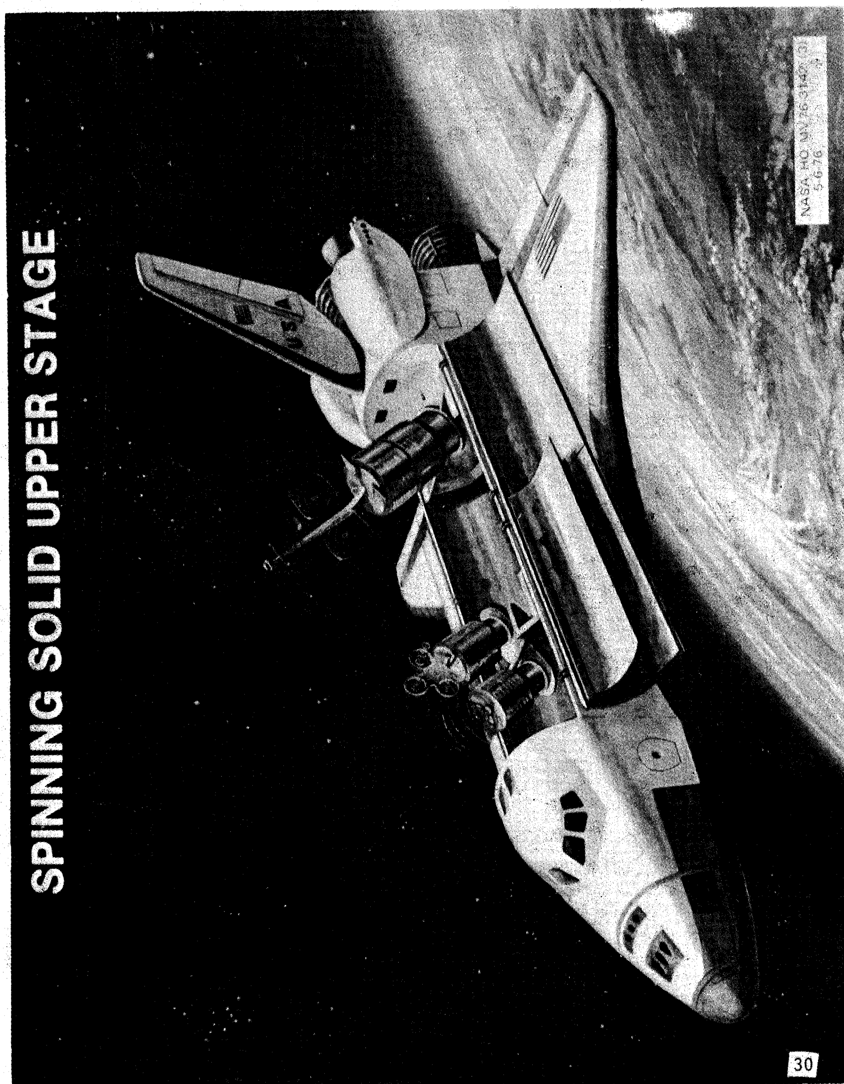

SPINNING SOLID UPPER STAGE
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Currently two approaches are under consideration for acquisition of the two SSUS systems: (1) NASA development and (2) development by industry as a commercial venture. While our discussions with industry are proceeding well, should agreements not materialize, we are prepared for NASA development of the SSUS systems.

NASA development plans for the SSUS system include the necessary flight hardware, associated launch site preparations, STS integration and training. Low level starts of the SSUS-A and SSUS-D will be initiated in FY 1977, to be followed in FY 1978 with full scale development. Additional funding may be required to expand the effort should mission requirements indicate an early need or should the commercial development not progress satisfactorily.

Availability of these funds will provide assurance for the development of the SSUS until commercial development is determined to be well underway. In that event, these funds will then be utilized for the procurement of SSUS vehicles and airborne support equipment for future STS missions. With this program, NASA will be assured of a fully operational SSUS-A and SSUS-D capability in 1980.

Multi-Mission and Payload Support Equipment (MMPSE) - We are requesting $7.0 million in FY 1978 for Multi-Mission and Payload Support Equipment. Emphasis is being placed on developing equipment which can be provided more economically from a standard inventory, rather than by individual payload users. This reusable, long-life equipment will be used to integrate, check-out, transport and accommodate a wide range of payloads. Examples of such equipment are: (1) A Trace Gas Analyzer which, by monitoring the Spacelab cabin atmosphere for toxic ingredients, will allow relaxation of the payload materials requirements and still provide a safe cabin atmosphere for the crew. (2) A Payload Specialist Station to provide command and display capability for a wide variety of the payloads for STS missions from 1980 to 1991. (3) Intersite Payload Transportation Equipment to move individual experiments and payloads from the development sites to the launch site. (4) A flexible Multiplexer/Demultiplexer (MDM), to be located in the Orbiter cargo bay, which can be programmed to accept varying payload data and combine it with operational data for transmittal to ground stations. (5) Cargo Integration and Test Equipment (CITE) to integrate payload elements at the launch site and to verify cargo/orbiter interfaces.

Design requirements for the highway transporters recommended as the primary mode for shipment of payloads from the developer to the launch site have been completed. The requirements will form the basis for procurement action of the transport equipment to be initiated during the first half of this calendar year. The Payload Specialist Station equipment and flexible MDM design concepts are being defined and formally reviewed against user endorsed requirements. The resulting equipment performance specification will allow initiation of hardware procurement during calendar year 1977.

Funding in FY 1978 will provide for continued design and development of hardware for these equipments. FY 1978 funds also will be used for design and development of Cargo Integration and Test Equipment (CITE) and the Trace Gas Analyzer to support early operational flights beginning in 1980.

Mission Control Center (MCC) Upgrading (Level II) - We are requesting $5.0 million for this activity. The Johnson Space Center Mission Control Center will be reconfigured to support STS flight schedules. It is being accomplished in two phases or levels. The first level of activity supports the orbital flight test program and is funded from the Shuttle development budget.

The second level reconfiguration or upgrading, for which FY 1978 funds are requested, will provide additional hardware, equipment and software to configure the MCC with the capability to support two simultaneous orbiter missions, a ground simulation network, and MCC/launch site interface requirements. Initial funding is required in FY 1978 to meet the operational flight requirements in FY 1980.

Payload and Operations Support - In FY 1978 we are requesting $13.0 million for Payload and Operations Support. Funds will be used to develop a Payload Operations Control Center (POCC) at the Johnson Space Center (JSC). The POCC will operate in conjunction with the Mission Control Center and will provide for command and control of attached payloads. Computers, displays and communications links will be provided in time to support the first Spacelab mission.

Effort is now underway to support payloads to be flown in the 1979/1980 time period. This effort is focused primarily on feasibility analysis and integration planning of candidate payloads for Orbital Flight Test (OFT) and early operational flights. Alternate payload arrangements are being evaluated consistent with mission constraints and flight test objectives established by the Shuttle Program.

NASA has released an Announcement of Opportunity (AO) soliciting payload proposals for Orbital Flight Test flights. Responses are currently being evaluated for scientific merit and technical feasibility. In addition to those proposals, a number of other major payload elements are being considered as possible candidates for Orbital Flight Test. These include a Space Technology Payload and an Interim Upper Stage verification mission suggested by the DOD. Also included are a number of NASA proposed activities such as a Skylab revisit, a Solid Spinning Upper Stage qualification flight, and development of a Long Duration Exposure Facility. Interface and mission support requirements are being developed for these candidate payloads. Several commercially sponsored experiments are also being examined.

Similar analyses are underway for several candidate payloads on early operational flights. These include three Spacelab flights, an

INTELSAT V in late 1980, another Long Duration Exposure Facility in 1981, retrieval of the Solar Maximum Satellite, and transition of several commercial payloads from Delta expendable launch vehicles to the SSUS-D with the Shuttle. Mission managers have been identified for the first three Spacelab flights to consolidate candidate experiments and Spacelab verification test objectives into an integrated plan for these missions.

The Kennedy Space Center has been assigned the role of integrating all logistics for the STS operational phase. The Center is developing an integrated logistics plan which will incorporate all logistics efforts being conducted for the operations phase by the development program offices (Shuttle, Spacelab, Upper Stages). Each program office also maintains its responsibility for logistics support of the development flight phase.

In addition to funds being required to develop POCC hardware and software, FY 1978 funds will be used to study operational concepts and requirements for the STS, to define OFT payload/Shuttle interface equipment, to design the hardware modifications necessary to adapt Spacelab engineering model pallets to OFT payloads and to initiate fabrication of this hardware.

Planning and Program Integration - We are requesting $4.0 million for Planning and Program Integration. This effort concentrates on ensuring that NASA user requirements are being met in the design and development of the STS and on consolidating NASA's plans for using the STS. Carrying out this effort requires the involvement of both NASA staff and selected contractor organizations in a diverse range of activities which focus on two specific areas.

In the first of these areas, payload analysis and mission planning, the primary effort in FY 1978 will continue to be the identification of missions to be flown by the STS. This work involves revision of the NASA payload model, updating of engineering and technical descriptions of proposed STS payloads, development of an early STS mission plan and making recommendations for mission approval. The payload model will continue to be updated on a regular basis to reflect current payload plans. Particular attention is being focused on the 1980-1982 period in order to identify candidate payloads for the early STS missions. This documentation will be expanded to include new payloads recommended by science and applications users.

In addition, all payloads of the NASA payload model will continue to be analyzed in order to group them into the most efficient cargoes for flight on the STS. Near-term groupings will be subjected to detailed mission analyses in order to ensure compatibility of candidate payloads. These near-term groupings are generally comprised of those payloads currently under development and those being considered as new starts in the next fiscal year's budget. Recommendations for STS missions are being formulated based on a thorough evaluation of technical, programmatic and fiscal considerations.

To support this work, specific studies will be concerned with developing techniques for planning missions to minimize costs and complexities, with standardizing mission planning tools, and with defining mechanisms for accommodating carry-on and piggy back payloads.

In the second area, payload requirements and STS accommodation, the primary objective continues to be that of representing the payload desires to the designers and operators of the STS by ensuring that the requirements of payloads that are planned for flights on the STS are considered in the STS design and operations plans. The scope of the effort covers all NASA payloads and the European Spacelab payloads.

To carry out this objective, the following activities will be continued in FY 1978: analysis of NASA and European payloads for their operational concepts and requirements as they relate to the STS design, operations and cargo integration; development of a single set of integrated requriements, documented and represented to the responsible elements of the STS; resolution of incompatibilities among payloads and the STS; analyses of proposed changes to the design and operations of the STS for their impact on payloads; analyses of the STS for its overall mission capability for payload support to understand the potential impact of new payload requirements on the STS; and development of the most cost effective ways for payloads to utilize the STS.

Development, Test and Mission Operations - We are requesting $173.0 million in FY 1978 for Development, Test and Mission Operations (DTMO). DTMO efforts are organized into four categories: (1) Research and Test Operations which support a broad spectrum of technical, engineering, scientific, reliability and quality assurance, and safety operations; (2) Data Systems and Flight Operations which supports definition, design, implementation, and checkout of hardware and software modifications to the Johnson Space Center's Mission Control Center and the real time computer complex, as well as operation and maintenance of the facilities during preparation for mission support; (3) Operations Support which provides contractor effort and maintain technical services at our Centers and their off-site operations; and (4) Launch Systems Operations which provides for the operation of the checkout and launch facilities, complexes and associated ground support equipment as well as the highly technical services required to support the test, checkout and launch of space vehicles and payloads at the Kennedy Space Center. DTMO funds will be used to provide for equipment, supplies, and support contractor personnel at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC) and the National Space Technology Laboratory (NSTL) to maintain the necessary capabilities to conduct space flight research and development. These capabilities are necessary to provide early project definition, including conceptual design, project specifications, and research and technology; to assure engineering support for in-depth technical examination of work performed by prime and major subcontractors on major programs such as the Space Shuttle; and to perform backup design, testing and analysis in high technology areas of design and development.

While relying heavily on private industry, particularly in the development and manufacture of major hardware systems as the Space Shuttle, NASA has developed a specialized in-house capability in research laboratories, test facilities, flight data management, crew training and launch facilities which supports development and flight programs.

The core of our in-house capability is Civil Service manpower, augmented as required by DTMO funded contractors. This management approach provides flexibility, utilizes industry expertise in selected areas, and maintains industrial involvement in NASA technologies. It is an economical and efficient method of operation.

In Fiscal Year 1978, approximately forty (40) R&D contractors will expend about 5,000 man-years of support contractor effort to maintain progress in all Office of Space Flight programs. These range from Lockheed Electronics Corporation doing scientific engineering and technical services at the Johnson Space Center, to the Bendix Corporation/Ground Systems Operations Contractor (GSOC) doing operations and maintenance, engineering and related management functions associated with launch support systems at the Kennedy Space Center to the Bendix Corporation doing work in connection with Space Shuttle structural and dynamic ground testing at the Marshall Space Flight Center.

The request includes support for the Slidell Computer Complex at Slidell, Louisiana, the Michoud Assembly Facility at New Orleans, Louisiana and the White Sands Test Facility at Las Cruces, New Mexico.

FY 1978 is planned to be the peak budget year for DTMO. Future DTMO funding requirements will gradually decrease as the transition is made to STS operations.

Advanced Programs - The request for Advanced Programs in FY 1978 is $10.0 million. Focus of Advanced Programs activities has been on studies of future space programs and systems and supporting investigations of long lead time subsystems. These efforts have continuously provided a sound basis for new programs and systems such as Apollo, Skylab and the Space Shuttle. Specific areas which will continue to be under study in FY 1978 include the space platform and advanced orbital operations.

The space station conceptual studies are proceeding on schedule. Parallel preliminary (Phase A) studies for a space station, capable of supporting continued occupancy by a four to six man crew, awarded in April 1976 to McDonnell Douglas and to Grumman Aircraft Company, are scheduled to be completed July 1977. During FY 1978, pre-Phase B studies will be funded to further explore the most promising of the Phase A-defined concepts. In addition, the extended duration orbiter, the shuttle external tank option, and the use of Spacelab extensions, all based on eventual growth to a permanently manned space platform will be studied. Costs and schedules associated with each option as well as conceptual layouts will be developed.

Various advanced subsystems and software areas supportive of a permanently manned space platform are also under active study. These include advanced systems planning and monitoring techniques to manage on-board consumables such as propellants, water and oxygen with substantially less manpower and energy consumption on a per mission basis than is required with current systems. Long duration, reliable thermal control will be accomplished because of our work on integrated heat pipe systems. These systems allow the elimination of pumps, valves, and leakage sources which in the past have had limited operating life. A deployable radiator to handle peak thermal loads without requiring oversized radiator systems as a part of the basic control system design will also be under study in 1978.

Other advanced subsystems under study or development in FY 1978 include a regenerative life support subsystem which will significantly reduce the logistics requirements for resupply of thousands of pounds of water and oxygen during extended missions. In addition, a lightweight iodination system has been designed and tested which will chemically sterilize large quantities of electrical water automatically, with very low quantities of electrical power required.

Concomitant with a space platform, a number of advanced orbital operations concepts are also being studied. These include techniques for erecting large structures required to accomplish a number of future missions involving space power generation, advanced communications and large aperture telescopes. Studies of using automated machinery to manufacture structural truss sections in orbit from material on reels, to join these trusses to form shapes, and how best to use the Shuttle to transport material and support this type of space operations are in progress and will continue in FY 1978.

Three studies are in progress to define experiments and operational missions achievable in early Shuttle flights. The first is a revisit to Skylab by the Shuttle with the objective of reboosting it to a higher orbit. A second potential mission being studied is a means for inspecting orbiting satellites using available equipment (manned maneuvering units, television). The third study underway is that of a tethered satellite, a unique concept for extending Shuttle operational capabilities. It consists of a subsatellite suspended by a cable from the Orbiter's cargo bay which could be "trolled" through a low-altitude, atmospheric earth orbit by the Orbiter to conduct extensive scientific exploration of the upper atmospheric region extending 80 to 120 kilometers from the Earth's surface.

Subsystem developments are underway which support advanced uses of the Shuttle and future Shuttle cost and performance improvements. These developments will continue in FY 1978. An example is an electromechanical flight control actuator concept which would provide lightweight, more reliable actuators. Laboratory breadboard models have been completed and feasibility tests are now underway. We have developed a prototype regenerative carbon dioxide and humidity control system that could permit Shuttle missions of 30 days and longer without adversely affecting its payload capability. Selected flight prototype components have been fabricated and a design has been completed for long duration future spacecraft application.

EXPENDABLE LAUNCH VEHICLES

Our request for FY 1978 in Expendable Launch Vehicles (ELV) is $136.5 million to cover the procrement and launch of vehicles used by NASA for automated satellite missions. This expendable vehicle transportation system consists of the all solid motor Scout vehicle, the Delta, the Atlas Centaur, the Titan Centaur and the Atlas-F. Except for the Scout, all of these expendable launch vehicles will be replaced, beginning in 1980, by the Space Transportation System.

The ELV Program supports all NASA automated launches and, on both a cooperative and on a reimbursable basis, supports other U.S. Government, international and commercial agencies and organizations. In support of these users in 1976, NASA successfully launched 16 missions. This is the second time in our ELV history that we accomplished a 100% success record. The first was in 1972 when we also launched 16 successful missions.

During CY 1977, 23 launches are scheduled, of which six are NASA missions. They are the High Energy Astronomy Observatory (HEAO-A), the International Sun Earth Explorer (ISEE-A/B), the International Ultra Violet Explorer (IUE), the Applications Earth Resources Satellite, Landsat-C, and two planetary Mariner Jupiter Saturn Missions. In addition, 17 missions primarily communication satellites, are planned to be launched. NASA will be reimbursed for launch services performed in support of these missions.

In 1978, a total of 22 launches is planned; 8 are NASA missions. The 8 NASA missions include the Heat Capacity Mapping Mission (HCMM), the International Sun Earth Explorer (ISEE-C), the Nimbus-G, two Pioneer/Venus Planetary Missions, a High Energy Astronomy Observatory (HEAO-B), a new Weather Satellite, TIROS-N and an Ocean Dynamics Satellite, SEASAT-A. Further, the remaining 14 missions planned during CY 1978 consist of NASA's continued launch support of various communications and scientific satellites for other U.S. Government and non-Government agencies on a reimbursable basis.

An average of three years is required to procure, deliver and launch our expendable launch vehicles. Our request of $136.5M for FY 1978 is based on lead times to properly support scheduled NASA missions. This request is $14.9M less than our FY 1977 request. It reflects the phase down of our ELV Program in transitioning to the Space Transportation System.

The funds requested in FY 1978 will be used for procurement of hardware consisting of solid motors, liquid engines, tanks, shrouds, interstage adaptors, guidance and computer hardware, spares, some long lead time hardware, and other related equipment to support two San Marco missions; the Stratospheric Aerosol and Gas Experiment, the Magnetic Field Satellite; the International Sun Earth Explorer, ISEE-C; the Nimbus-G; the Solar Maximum Mission; the Infra Astronomy Explorer; two Dynamic Explorers; the HEAO-B and C missions; Pioneer A and B missions; and the Tiros-N and the Seasat-A mission. The procurements for the vehicle hardware has, in some instances, been initiated in prior fiscal years and continued funding will be required to complete these actions along with initiation of new procurement actions.

In addition to the vehicle hardware, funds for launch operations and support are being requested to prepare and launch the vehicles being procured. NASA operates from launch sites located at the Eastern Test Range in Florida, the Western Test Range in California, the Wallops Flight Center in Virginia, and the San Marco Range off the East Coast of Africa near Kenya.

The funds requested, along with the reimbursable funds received from the many non-NASA vehicle users, will provide for the continuing operation of our launch vehicle capabilities during the STS transition period.

Mr. Chairman, that concludes my discussion of FY 1978 funding for the Office of Space Flight. Let me summarize from this chart (MS 77-1591). We are requesting a total of $1,753.5 million of which $1,349.2 million is for the Space Shuttle. $267.8 million is for Space Flight Operations, with the chart showing funds for each element. Finally, we are requesting $136.5 million for Expendable Launch Vehicles.

We are well into the development of the Space Transportation System which will begin an era in space flight history that will be characterized by economical, routine space transportation. The roll-out of the first space Shuttle Orbiter last September symbolized our progress and anticipation. We are on schedule and with the requested funding we will be able to continue our progress. Thank you, Mr. Chairman, this concludes my statement.

OFFICE OF SPACE FLIGHT

RESEARCH AND DEVELOPMENT

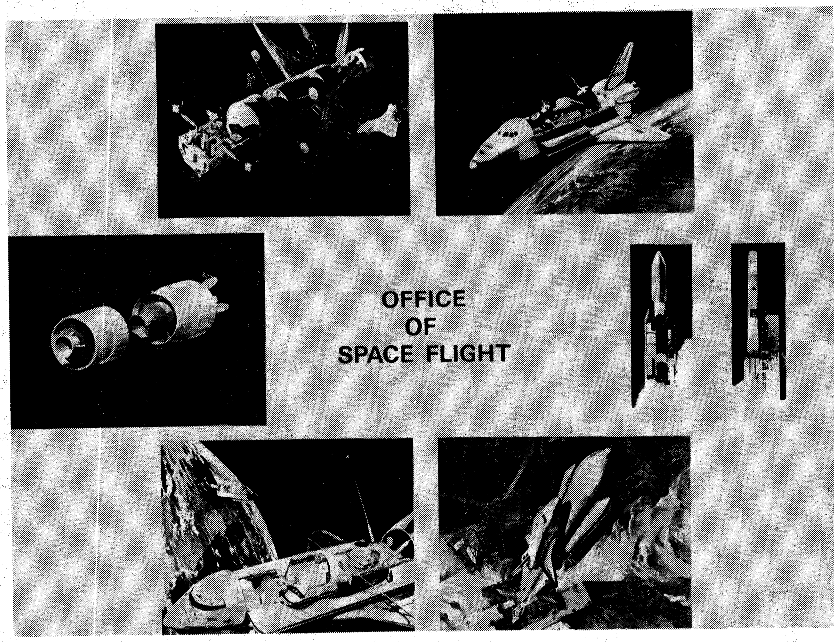
SUMMARY OF FY 1978 BUDGET ESTIMATE

(Millions of $)

PROGRAM/PROJECT	FY 1978
TOTAL	$1,753.5
• SHUTTLE	$1,349.2
• SPACE FLIGHT OPERATIONS	267.8
• SPACE TRANSPORTATION SYSTEM OPERATIONS	17.8
• SPACE TRANSPORTATION SYSTEM OPERATIONS CAPABILITY DEVELOPMENT	63.0
SPACELAB	(24.5)
STS UPPER STAGES	(13.5)
MULTI-MISSION AND PAYLOAD SUPPORT EQUIPMENT	(7.0)
MISSION CONTROL CENTER LEVEL II	(5.0)
PAYLOAD AND OPERATIONS SUPPORT	(13.0)
• PLANNING AND PROGRAM INTEGRATION	4.0
• DEVELOPMENT, TEST AND MISSION OPERATIONS	173.0
• ADVANCED PROGRAMS	10.0
• EXPENDABLE LAUNCH VEHICLES	136.5

NASA HQ MS77-1591 (1)
1-27-77

Mr. YARDLEY. This slide (MS 76–2034) shows some of the major projects that the Office of Space Flight is involved in and, for the new members, I would like to mention what they are.



Starting at the upper right hand corner is the Space Shuttle, in this particular picture the orbiter is in orbit with some of the upper stages which will be used with the Shuttle for launching communication satellites and other payloads.

Coming down the right, while we are designing, building, and testing the Shuttle we are responsible for maintaining a launch capability for NASA. This illustrates our expendable launch vehicle program and there is a lot of activity in phasing from the expendable vehicles to the Shuttle.

The next photo, coming around clockwise, shows the Shuttle liftoff. The next shows the Spacelab, and the next shows a two-stage interim upper stage. The top left picture shows an artist's concept of the potential space industrialization base.

Let us have the next slide, please.

This chart (MS 77–1459) summarizes our overall budget request for fiscal year 1978 of $1.753 billion, just slightly over the $1.67 billion for fiscal year 1977.

OFFICE OF SPACE FLIGHT

RESEARCH AND DEVELOPMENT FY 1978 BUDGET ESTIMATE

(MILLIONS OF $)

PROGRAM/PROJECT	FY 1977	FY 1978
● SPACE SHUTTLE	$ 1,318.1	$ 1,349.2
● SPACE FLIGHT OPERATIONS	199.2	267.8
● EXPENDABLE LAUNCH VEHICLES	151.4	136.5
TOTAL	$ 1,668.7	$ 1,753.5

NASA HQ MS77-1459 (1)
1-19-77

The primary reason for this relatively modest increase is that we are requesting the initial production funding to provide for a national fleet of five orbiters, including the procurement of orbiters 3, 4, and 5 and the refurbishment of orbiters 1 and 2. Also, we are increasing space flight operations activities, which we will discuss later.

Next slide, please (MS 77–1456).

OFFICE OF SPACE FLIGHT

RESEARCH AND DEVELOPMENT FY 1978 BUDGET ESTIMATE

(MILLIONS OF $)

PROGRAM/PROJECT	FY 1977	FY 1978
SPACE SHUTTLE		
• DDT&E	$1,318.1	$1,207.5
• PRODUCTION	----	141.7
TOTAL	$1,318.1	$1,349.2

NASA HQ MS77-1456 (1)
1-19-77

I would like to begin discussing the individual programs with the Space Shuttle for which this chart summarizes the funding request. As you can see, the Shuttle development funding for fiscal year 1978 is considerably lower than in fiscal year 1977. However, with the inclusion of production money in fiscal year 1978 the total program funding is slightly higher.

Now, just a real brief review of some of the activities that we have accomplished since our September hearing with the subcommittee. (MS 77–1294).

SPACE SHUTTLE PROGRAM
PROGRESS SINCE SEPTEMBER 1976

- **ORBITER PROJECT**
  - ORBITER NO. 1 ROLLOUT
  - DESIGN CERTIFICATION REVIEW FOR THE APPROACH AND LANDING PROGRAM COMPLETED
  - CARRIER AIRCRAFT COMPLETED-DELIVERED TO DFRC
- **MAIN ENGINE PROJECT**
  - CRITICAL DESIGN REVIEW (CDR) COMPLETED
  - FIRST THROTTLING TEST FROM MINIMUM TO RATED POWER LEVEL (RPL) ACCOMPLISHED
- **FINAL ASSEMBLY OF EXTERNAL TANK MAIN PROPULSION TEST ARTICLE STARTED**
- **SOLID ROCKET BOOSTER PROJECT**
  - CRITICAL DESIGN REVIEW (CDR) COMPLETED
  - CASE SEGMENTS FOR FIRST DEVELOPMENT MOTOR DELIVERED TO THIOKOL
  - BOOSTER ASSEMBLY CONTRACTOR SELECTED
- **LAUNCH PROCESSING SYSTEM CDR ACCOMPLISHED**

NASA HQ MS77-1294
1-24-77

As Congressman Winn pointed out, we had the first "rollout" of orbiter 101 in September, and its second rollout last Monday when this orbiter was transported overland all the way from Palmdale to the Dryden Flight Research Center at Edwards Air Force Base, about 40 miles away.

In addition, we held our design certification review for the approach and landing test (ALT) Program. We delivered the Shuttle carrier aircraft—a modified Boeing 747—and when this chart was made we had not yet delivered the orbiter, but that is complete now, too.

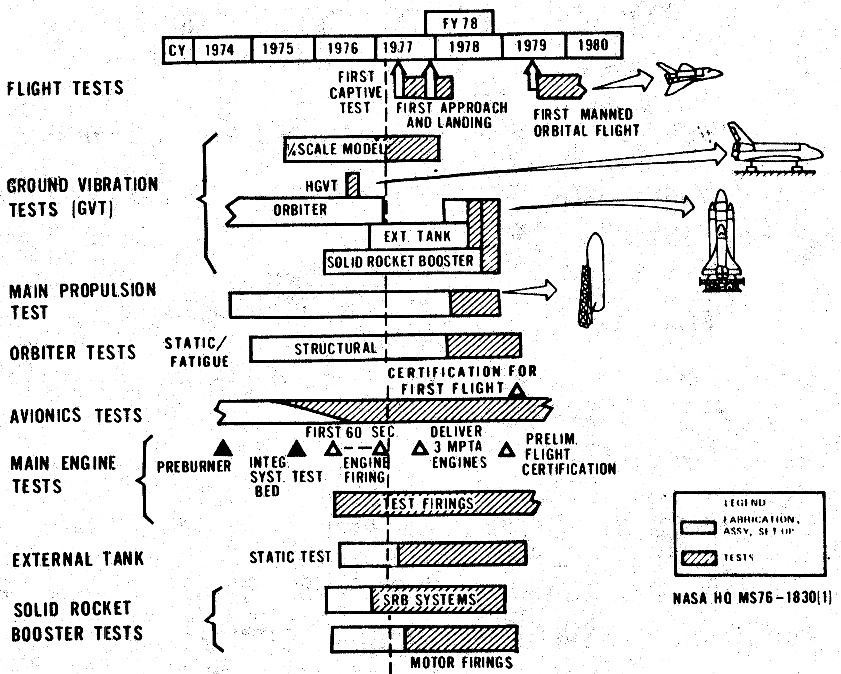
The main engine project has made considerable progress this year. As you know, we have had some technical problems with our main engine. We had two major problems with the high pressure fuel turbopump, which I will discuss in more detail later; but we believe we have those problems solved now and are in a position to continue testing and have the engine program catch up with the rest of the Shuttle development.

We have also started assembly of the first external tank. All the tools are in place. That effort is going quite well.

In the solid rocket booster we completed the critical design review (CDR) and selected a booster assembly contractor. We will be assembling and firing one of these solid rocket motors in the next 6 months.

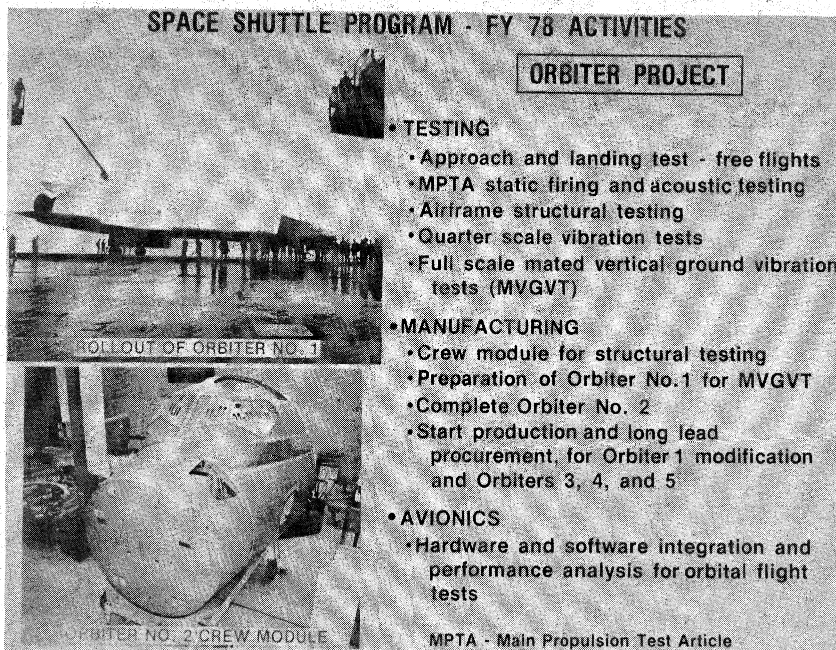
92-082 O - 77 - 4

SPACE SHUTTLE SYSTEMS TEST PROGRAM



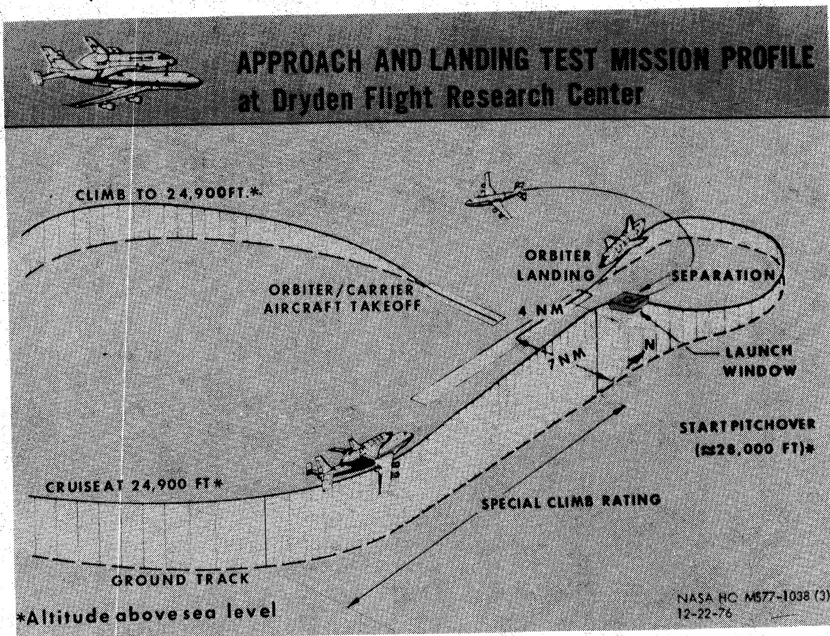
Now, fiscal year 1978 is a very heavy development test year. As you can see from this chart (MS76–1830) it cuts through all of the major tests we will be doing—flight tests, ground vibration, main propulsion, and so on. Most of the hardware for these tests are either complete or in the final stages of preparation, and our major emphasis will be on these important ground and flight test activities in 1978.

Here, we have some of the activities that the orbiter will be undergoing in 1978 (MS77–1109). The ALT program is planned for completion in fiscal year 1978.



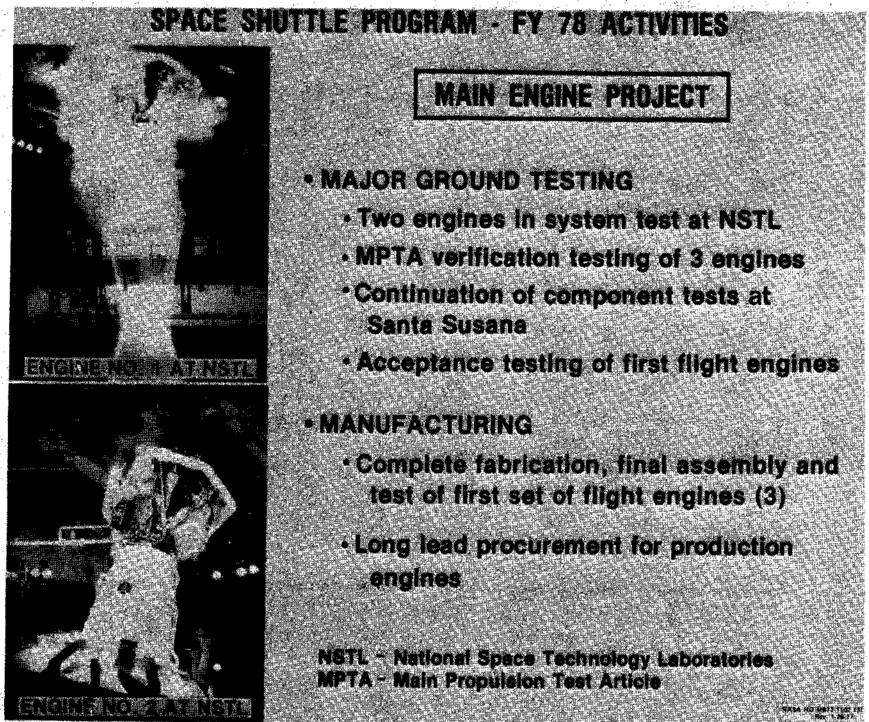
We are scheduled to make the first captive flight with the Boeing 747 in late February. We will fly a progressive series of captive inert flights and then we will go into what we call the captive active mode where we actually power up the orbiter to check out the systems and functions.

The final series of the ALT flights will be the manned free flight tests, where we release the orbiter and the crew flies it to land on the dry lake bed. Of course, while that is going on, all those other tests listed there are being done.

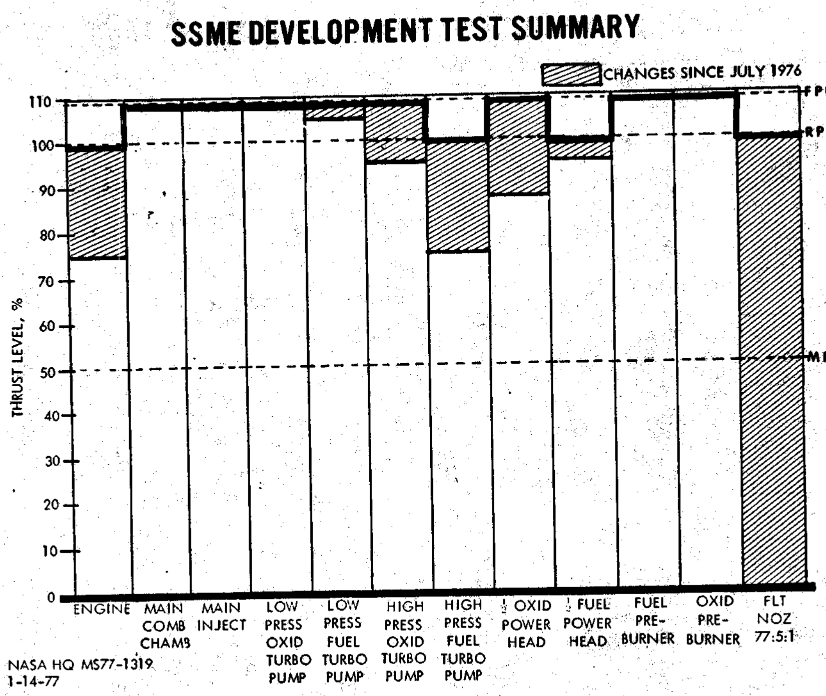


This chart (MS77–1038) shows a profile of the ALT flights. You can see the takeoff and climb to about 25,000 feet. Then it makes about a 270 degree turn and then they separate. The orbiter makes a 180 degree turn and comes in to land on the dry lake bed. The flight time with the tail cone off is approximately 2 to 2½ minutes and with the tail cone on is about 5 to 6 minutes.

In manufacturing during fiscal year 1978 we will complete the second orbiter (No. 102). We will initiate the long lead procurement for the orbiter production phase and initiate fabrication on orbiters 103 and 104 and components for the modification of orbiter No. 101 for operations.



The main engine (MS77–1107) was our major concern in 1976. Our work now is in the ground testing. We have two test stands at NSTL. We now have four engines for test there and although periodically they go back to the contractor for modification and refurbishing, they are almost continuously tested in those stands. In addition, toward the end of 1977, we will have delivered the main propulsion test article, which combines an external tank, the main propulsion system, plumbing, and all the components with three engines, to NSTL in Mississippi and will actually begin that testing in fiscal year 1978. We will continue to manufacture engines at a more or less constant rate to meet our development and production needs.



This chart (MS 77–1319) shows a summary of where we stand on the major components of the engine and the testing that we have done. The components are listed across the bottom. We are trying to achieve 109 percent of thrust on all these components. Everything has been to 100 percent of thrust and most components have been to 109 percent. The main component that has not yet achieved that 109 percent level is the high pressure fuel turbopump. The 77-to-1 nozzle has also not been tested to 109 percent. This flight nozzle has only been to 100 percent. We are down somewhat because of the problems we have had during the main engine tests. We are actually on schedule at this time in terms of the number of tests. However, the tests have been shorter in duration because of some of the problems (MS 77–1728). We have determined, though, that we can test at a considerably faster rate than originally thought. The performance of the engine in terms of turn around time and the ability to reprogram our computer as well as our ability to interchange components has been far better than our past experience would indicate.

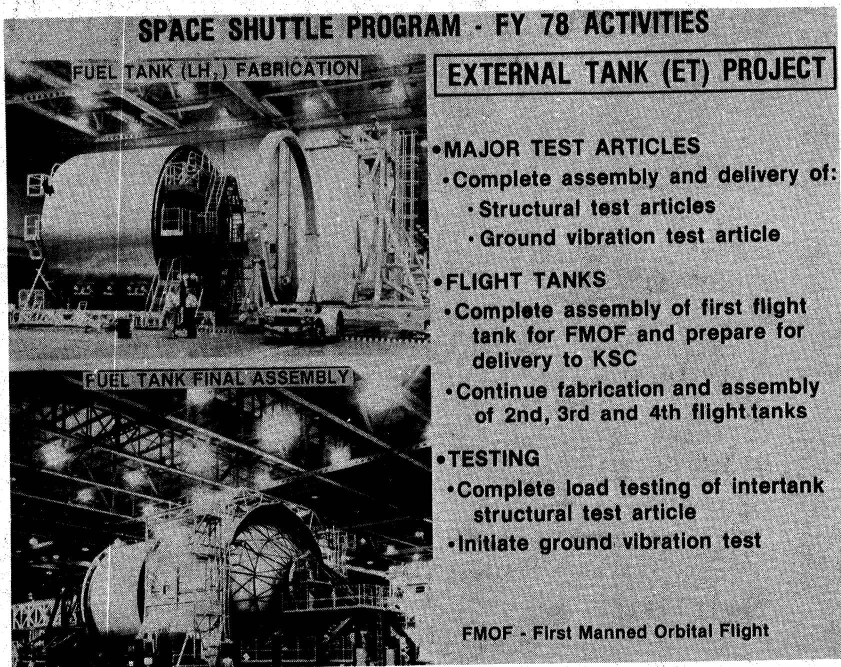
MAIN ENGINE TEST RECOVERY PLAN
(Accumulated Engine Test Time)

AS OF:	ORIGINAL PLAN (est 1973) seconds	RECOVERY PLAN seconds
DEC 1976	8,000	2,373 (actual)
JUNE 1977	20,000	10,000
DEC 1977	38,000	28,000
DEC 1978 (Preliminary Flight Certification)	92,000	92,000

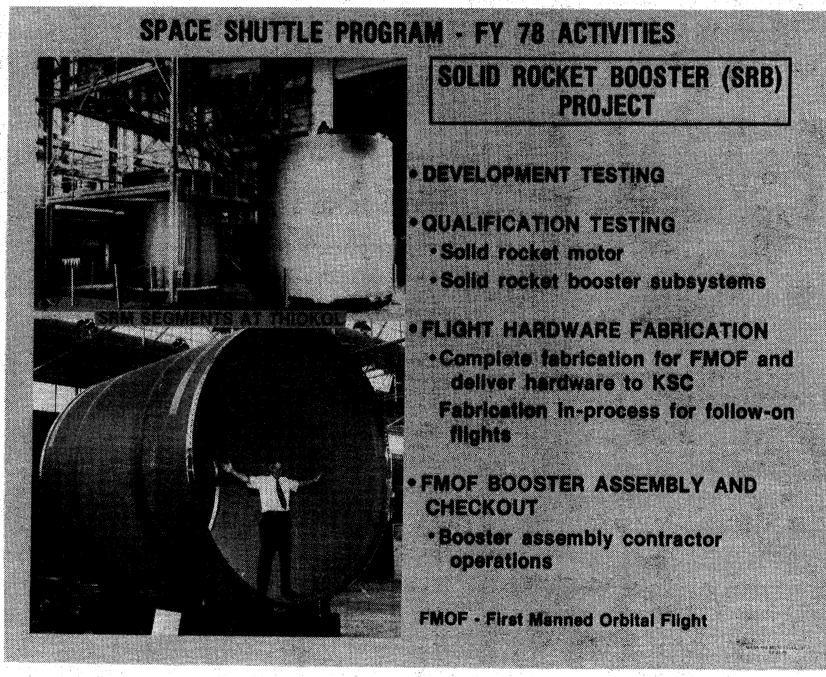
- **CURRENT STATUS**
  - Planned number of tests on schedule
  - Test duration less than planned
- **FUTURE PLAN**
  - Test rate capability better than originally planned
  - Rapid recovery expected

MS77-1728

At this time we have about 2,400 seconds total running time and we had hoped to be at about 8,000. We hope to recover perhaps by mid 1978 but we feel sure to do so by December of 1978 which is our preliminary flight certification date. I want to repeat we have not reduced the testing plan for certification of this engine. Just by way of putting this in perspective, we were talking to some ESA people today about their ARIANE launch vehicle. I asked them how many seconds they qualified their engines for and they said between 10,000 and 15,000 seconds which is considerably less than our planned 92,000 seconds.



The external tank project has been going on quite well as I said before (MS 77-1110). All the tools are in place and we are building tanks. The major activity in 1978 is to complete major test articles for both the static test and the ground vibration test. The tank for the MPTA testing will be completed in 1977. We will also begin assembly of the flight test tanks and we will be doing the static and vibration tests also.



In the solid rocket booster (MS 77-1111A) you see some pictures of the size of the booster. That tiny person standing in that lower picture is Dr. Malkin. We will be doing a lot of SRB development testing between now and the end of 1978. We are planning to do our first development firings late this summer. We are also planning to conduct four development tests and to begin the three qualification tests in 1978. In addition, we will be fabricating a lot of flight hardware and beginning the booster assembly checkout operations.

In the launch and landing project (MS77–1112), the efforts are going along quite well. As you can see in the pictures, some of the hardware is in place; the central data subsystem which is part of the launch processing system. The orbiter processing facility, which is a new building, is in the lower part of the picture. You can see the towaway leading off the runway. Our biggest task in 1978 will be to complete the procurement of all the launch systems, check out the launch processing systems and the installation and checkout of all this equipment in preparation for launch operations.

SPACE SHUTTLE PROGRAM - FY 78 ACTIVITIES

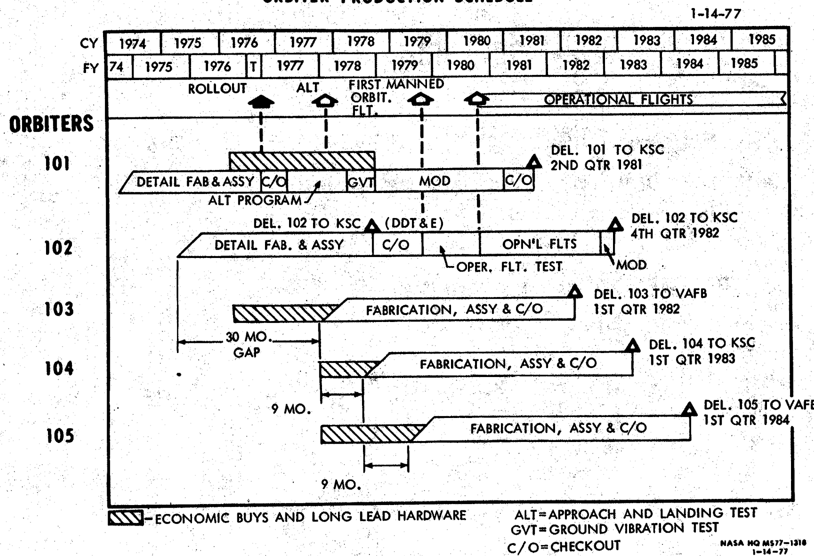
PRODUCTION

- **LONG LEAD PROCUREMENT FOR ORBITERS 3, 4, AND 5**
  - **Components, materials, subcontracting**
- **MODIFICATION OF ORBITER NO. 1**
  - **Procure components and subsystems**
  - **Initiate hardware fabrication**
- **FABRICATE PRIMARY STRUCTURES FOR ORBITER NO. 3**
- **SUBSYSTEMS FOR ORBITERS 4 AND 5**
- **LONG LEAD PROCUREMENT FOR PRODUCTION ENGINES**

NASA HQ MS77-1108 (3)
12-22-76

Now, as I mentioned earlier the Shuttle production phase (MS77-1108) will be initiated in our fiscal year 1978 budget. The fiscal year 1978 production request includes long-lead procurement for Orbiters 103, 104, and 105; initial fabrication efforts on Orbiter 103 and long-lead procurement and initial fabrication of components and subsystems to modify Orbiter 101 to an orbital configuration. Orbiter 101 has been configured for the approach and landing tests. The main engines and a number of subsystems will have to be added for orbital flight. We plan to begin fabrication of the primary structure for Orbiter 103 and the procurement of subsystems for Orbiters 104 and 105 in fiscal year 1978. In addition, the fiscal year 1978 production efforts include funding for ground support items, and long-lead procurement for main engine fabrication.

SPACE SHUTTLE PROGRAM
ORBITER PRODUCTION SCHEDULE



This chart (MS77-1318) shows the orbiter production schedule. The delivery of Orbiter 102 is planned in late 1978 leading to the first manned orbital flight in mid-1979.

After Orbiter 101 finishes ground vibration testing in late 1978, it will be modified for orbital flight and will be the second operational Orbiter delivered to KSC. Our present delivery date is the second quarter of 1981 and we do not like that. We are looking right now to see if there is some way that we can pull that forward by about 6 months because we do not like to have only one Orbiter at KSC when we begin operations in 1980. Preliminary indications are that we might be able to move the delivery date forward into 1980 but we are not yet sure. Orbiter 103 will be the first Orbiter to be delivered to Vandenberg and is scheduled for delivery in 1982. Orbiters 104 and 105 will be delivered at 1-year intervals thereafter.

OFFICE OF SPACE FLIGHT

RESEARCH AND DEVELOPMENT
FY 1978 BUDGET ESTIMATE

(MILLIONS OF $)

PROGRAM/PROJECT	FY 1977	FY 1978
SPACE FLIGHT OPERATIONS		
• SPACE TRANSPORTATION SYSTEM OPERATIONS	$ ---	$ 17.8
• SPACE TRANSPORTATION SYSTEM OPERATIONS CAPABILITY DEVELOPMENT	16.8	63.0
SPACELAB	(8.0)	(24.5)
STS UPPER STAGES	(1.8)	(13.5)
MULTI-MISSION AND PAYLOAD SUPPORT EQUIPMENT	(1.5)	(7.0)
MISSION CONTROL CENTER LEVEL II	(----)	(5.0)
PAYLOAD AND OPERATIONS SUPPORT	(5.5)	(13.0)
• PLANNING AND PROGRAM INTEGRATION	3.5	4.0
• DEVELOPMENT, TEST AND MISSION OPERATIONS	166.9	173.0
• ADVANCED PROGRAMS	12.0	10.0
TOTAL	$ 199.2	$ 267.8

NASA HQ MS77-1458 (1)
1-19-77

Now, I would like to switch from the Shuttle to the line item we call space flight operations (MS77–1458) which includes a number of items.

The first, space transportation system operations, is a new item for which we are asking $17.8 million in fiscal year 1978. This includes initiation of long-lead-time hardware for the external tanks and solid rocket booster procurement for the operational phase, which will begin in 1980.

Then we have a number of projects under operations capability development—Spacelab, upper stages, multimission and payload support equipment, mission control center upgrading—level II— and payload and operations support which I will talk about individually as we go along.

SPACE FLIGHT OPERATIONS

MAJOR PROGRESS SINCE SEPTEMBER, 1976

- SPACELAB PRELIMINARY DESIGN REVIEW "B" COMPLETED
- TECHNICAL PORTION OF SPACE STATION STUDIES COMPLETED
- CHARGE POLICY FOR NON-U. S. GOVERNMENT USERS PUBLISHED
- SMALL USERS' PAYMENTS FOR "SPACE AVAILABLE" FLIGHTS RECEIVED
- SSUS-D AGREEMENT NEGOTIATED
- NASA/DOD MEMORANDUM OF UNDERSTANDING SIGNED

NASA HQ MS77-1455 (1)
1-19-77

I would like to mention some of the highlights that have taken place in the last 6 months in Space Flight Operations (MS77–1455). First, the spacelab preliminary design review has been completed. You may recall that when we talked to you last fall we were somewhat concerned about not having completed the preliminary design review earlier. The Europeans put together a massive effort and did an outstanding job. Everybody was very pleased with the way the design review went and we think we are very close to having an appropriate configuration.

We have done most of the technical work on the space station phase A studies that have been under contract since last summer.

Another accomplishment we are very happy about is that we have been able to coordinate a Shuttle user charge policy for non-U.S. Government users. This policy has now been published in the Federal Register. We are now almost to the same point on the policy for U.S. Government users which should be signed within 2 weeks. We are also negotiating with the Department of Defense on a pricing agreement, Mr. Chairman.

We have come up with a way to encourage users with self-contained, small payloads to utilize the Shuttle on a "space available" basis for a very reasonable price, and we have had excellent response to that part of the policy.

In the upper stage area, we have been negotiating with several industrial firms to build, with their own financing, upper stages for the Shuttle, which we would then buy on a fixed price basis, as necessary. We have two upper stages planned and we have an agreement negotiated on one of these. We are close to agreement on the other.

One of the very important milestones that we have been working on for at least 4 years is a memorandum of understanding with the DOD on Management and Operation of the Space Transportation System. We now have a memorandum signed by Secretary Clements and Dr. Fletcher. I think we are now on a solid footing.

SHUTTLE

- KEY ELEMENTS OF THE PRICING POLICY
    - CONTRACTED ON A FIXED-PRICE BASIS
        - NO POST-FLIGHT CHARGES UNLESS SPECIFIED IN CONTRACT
    - AFTER FY 83 PRICE ADJUSTED ANNUALLY TO RECOVER TWELVE YEAR OPERATING COSTS
    - ALL REIMBURSEMENT PAYMENTS ESCALATED ACCORDING TO U.S. BUREAU OF LABOR STATISTICS, WAGES AND PRICES, PRIVATE SECTOR
    - LISTS STANDARD AND OPTIONAL SERVICES
    - COVERS DEDICATED AND SHARED FLIGHTS
    - COVERS EXCEPTIONAL AND SMALL SELF-CONTAINED PAYLOADS
    - COVERS SHORT TERM CALL-UPS, POSTPONEMENTS, CANCELLATIONS
    - COVERS REFLIGHT GUARANTEES
    - COVERS STANDBY PAYLOAD DISCOUNTS
    - COVERS FIXED PRICE, FLOATING LAUNCH DATE AND SCHEDULE GUARANTEE OPTIONS
    - COVERS ASSIGNING OF SPACE IN SHUTTLE BAY

NASA HQ MO 77-1610
1/27/77

Just a couple of highlights on our pricing policy (MO77-1610). It does involve fixed prices. Once a person signs a contract, we do not change his price. This is one of the most important areas to the user as we found in all of our studies. They had been concerned that after a flight it would take 2 years to collect all the costs and to present the bill to the user. The users are all happy about the policy now, Mr. Chairman.

The user charge policy is designed to recover all costs so that there is no subsidy invloved. We have worked out a way that we can have shared flights and make maximum use of the Shuttle. In order to utilize potential empty space in the orbiter cargo bay, we charge a lower price to people who will let us fly their payloads on a standby basis.

STS OPERATIONS

- USER CHARGE POLICY PUBLISHED FOR NON-U.S. GOVERNMENT USERS – DOD REIMBURSEMENT BEING NEGOTIATED
- POTENTIAL USERS BEING BRIEFED – COMSAT AND SMALL USER (SPACE AVAILABLE) CONTRACTS BEING NEGOTIATED
- OFT AND LONG-RANGE MISSION PLANS BEING FORMULATED – TRANSITION FROM EXPENDABLE LAUNCH VEHICLES UNDER STUDY
- OFT PAYLOADS BEING INTEGRATED – CARGO MANIFESTS FOR EARLY MISSIONS BEING DEVELOPED
- FLIGHT CREW SELECTION IN PROGRESS – FLIGHT PLANNING, INCLUDING CREW TRAINING, SIMULATION AND OTHER GROUND SUPPORT ACTIVITIES WILL BE INITIATED IN FY 78
- LONG-LEAD PROCUREMENT FOR FLIGHT HARDWARE ITEMS AND COMPONENTS WILL BE INITIATED IN FY 78

NASA HQ MO 77-1611
1/27/77

Some of the things we have been doing in the STS operations are shown here (MO77–1611). I mentioned the user charges policy and the briefing of potential users. We have been working quite a bit on our long-range plans and on transition policies.

I might digress just a moment to tell you where we stand on the transition planning. It is a fairly complex subject and I will not go into too much detail but, in the DOD study we asked how we could consolidate launch vehicles and cost savings. The only thing that looked promising in that area was for DOD to try to consolidate some of their configurations, so they are thinking of doing that. Their transition policy basically is to have backup vehicles for their critical flights, not all their flights, for 2 years after Shuttle operations begin. They will use these backup vehicles as required.

The DOD is still developing the plan but there will be somewhere between 12 and 18 vehicles involved.

With respect to NASA, our two major launch vehicles, the Delta and Atlas Centaur, present slightly different problems. In the case of the Atlas, the number of users is small. It turns out NASA does not use the Atlas Centaur in the transition period; the lats NASA Atlas Centaur launch is in 1979.

We have worked with COMSAT on Intelsat V launches, and they have agreed to use the Atlas Centaur for the first four and the Shuttle for the last three of their launches and design a spacecraft to work with either. The fifth Intelsat V flight, which will be the first one on the Shuttle, is scheduled for November 1980, 6 months after the STS becomes operational. Since it is a backup flight, they are willing to take the risk. It does not look like we have a problem to buy hardware for the Atlas Centaur.

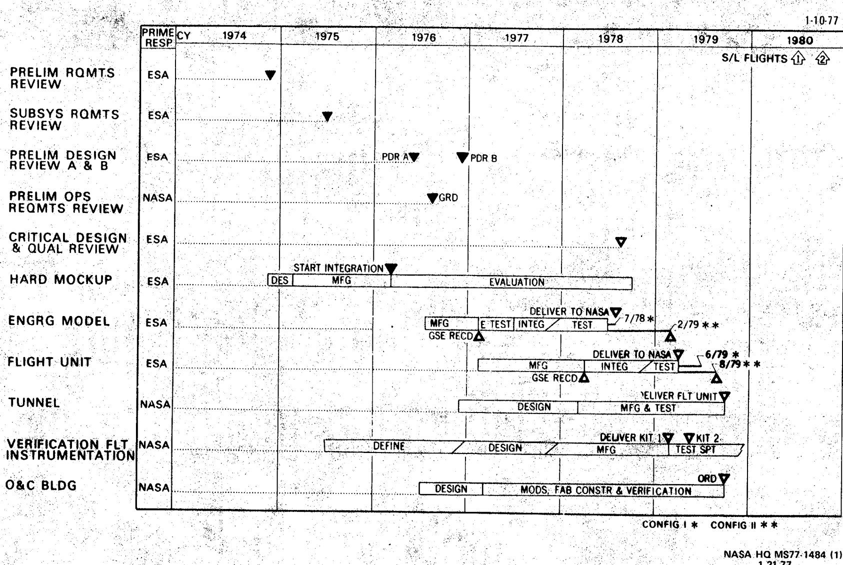
In the case of the Delta we have many more users, a steady stream of them, and we have worked out a way to cover all Delta users that are scheduled after January 1981, by investing a modest amount of long-lead money. Now, if the Shuttle goes on schedule and works in its first flight test, then we feel they should be comfortable with it. If it does not, we can convert them to Delta if there are any schedule slips.

To handle the period between May of 1980 and January of 1981, we have decided to build two Delta vehicles which will ultimately be launched from Vandenberg in 1982, but will be available in early 1980, if we need them as backup for scheduled Shuttle launches. We would still have time to replace them before 1982, Mr. Chairman.

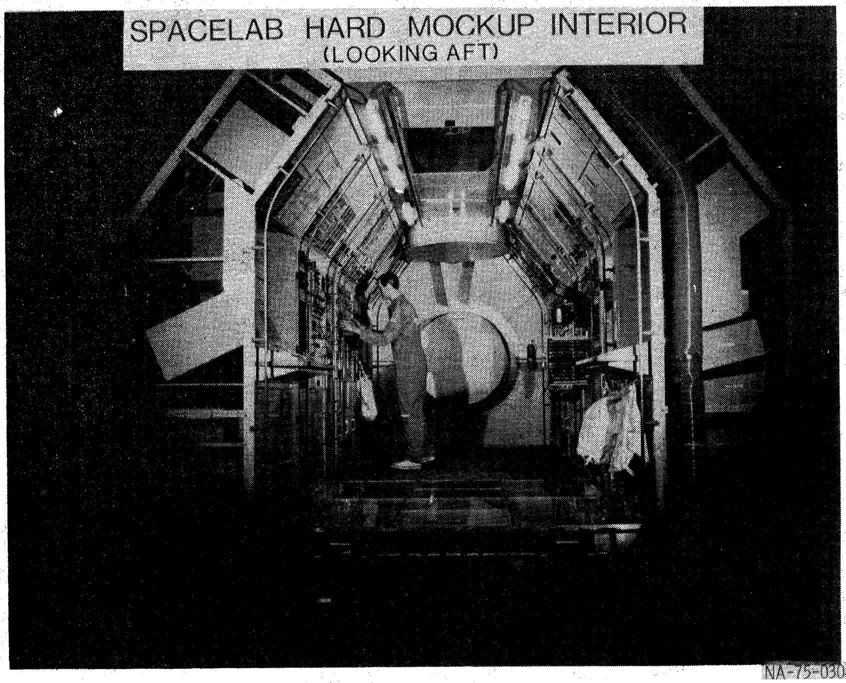
We are also working heavily on integrating payloads, and developing cargo manifests.

Flight crew selection is in progress. We have received over 1,100 applications for both pilot and mission specialists, and over 130 are from females. The selection process will be completed in December of this year.

SPACELAB PROGRAM MASTER SCHEDULE



This shows the master schedule in the Spacelab program (MS77-1484). The schedule has been realigned recently but it still permits the Shuttle schedule to go on. We are scheduling Spacelab flights in 1980. You can see on the top there are flights planned for about July and October and the European schedule is still satisfactory to meet those dates.



NASA FY 78 SPACELAB ACTIVITIES

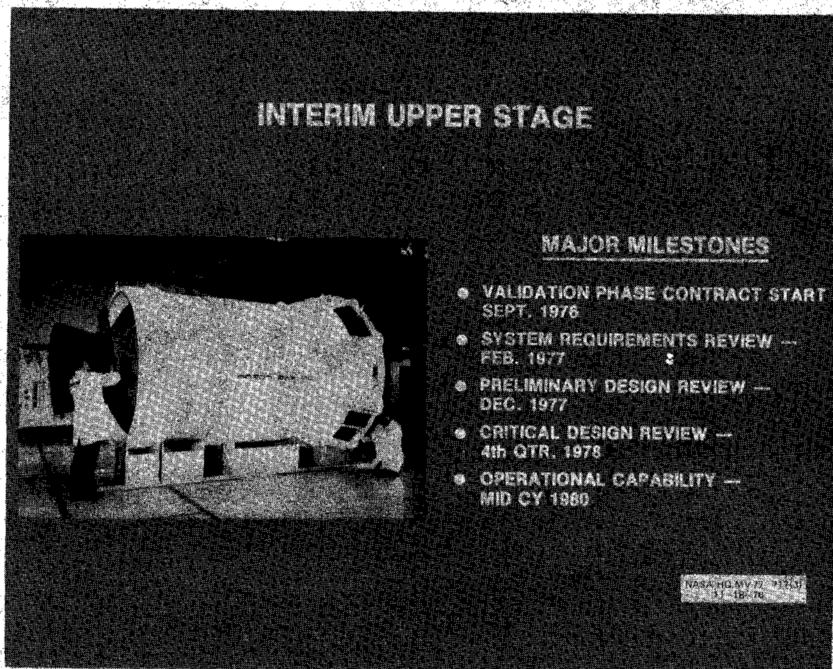
- START MANUFACTURE OF THE CREW TRANSFER TUNNEL
- START MANUFACTURE OF VERIFICATION FLIGHT INSTRUMENTATION EQUIPMENT
- COMPLETE FABRICATION OF MECHANICAL SHUTTLE INTERFACE VERIFICATION EQUIPMENT
- START PREPARATION OF EQUIPMENT FOR THE INTEGRATION OF THE SPACELAB PRIOR TO FLIGHT
- INCREMENTAL PROCUREMENT OF FLIGHT HARDWARE FROM ESA
- START DESIGN OF SPACELAB SIMULATOR

NASA HQ MS77-1482 (1)
1-21-77

This slide (NA-75-0304) shows a view of the mockup of the Spacelab. There are fiscal year 1978 activities planned for NASA in addition to what the Europeans are doing (MS77-1482). We will begin manufacturing the transfer tunnel which will allow movement between the Spacelab and the Shuttle.

We will also begin work on the vertification flight instrumentation which is our responsibility.

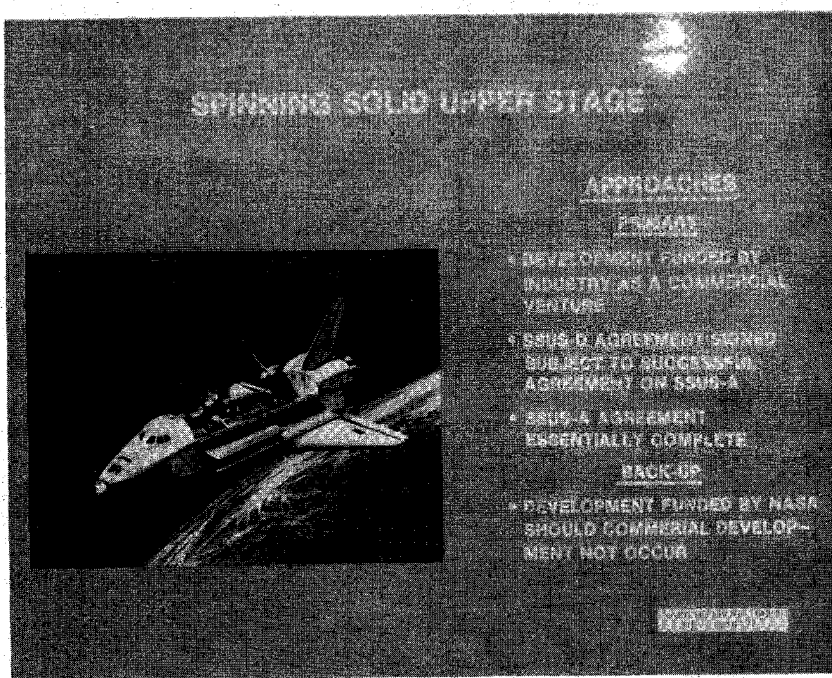
We will complete fabrication of the mechanical Shuttle interface equipment which will be sent to ESA for use in their development effort.



We will also start preparation of equipment for the integration of the Spacelab prior to flight and we will begin the procurement of flight hardware from ESA.

The Interim Upper Stage (IUS) is now under contract (MV77-717). The Air Force awarded the contract which started in September 1976, to Boeing to develop this stage. We are working with the Air Force on the requirements and have a systems requirement review coming up this month, with a preliminary design review scheduled at the end of the year. The critical design review will be in late 1978.

The Air Force's basic configuration will be a two-stage vehicle that can lift 5,000 pounds into geosynchronous orbit. NASA gets the same basic vehicle but mostly we use the IUS in a three- and four-stage configuration for planetary missions.



The Spinning Solid Upper Stages (SSUS) (MV76–3142) are a relatively new addition to the space transportation system, Mr. Chairman. It became apparent that the IUS capability to geosynchronous orbit was quite large compared to our current expendable launch vehicle capability. It is twice too big for the Centaur class payload and four times too big for the Delta class payloads.

The users were not very interested in sharing multiple payloads on a single IUS because they have to get mated with three other users and get ready to go to the same orbit at the same time. The SSUS can carry the same class of payloads; however, each user gets an individual upper stage which we can deploy to where he wants to go, when he wants to go. We can also make the interface of each stage almost identical to that of the upper stage that he uses now. In fact, the contractor who has signed the development contract for the SSUS is also designing it as an upper stage which can be used on the expendable Delta vehicle, so that there will be true interchangeability between the Delta vehicle and the Shuttle. This will greatly facilitate the solution of potential transition problems since having a spacecraft design compatible with either the Shuttle or the Delta vehicle permits late selection of the launch system.

- MULTIMISSION AND PAYLOAD SUPPORT EQUIPMENT — DESIGN AND DEVELOPMENT OF:
  - CARGO INTEGRATION AND TEST EQUIPMENT (CITE)
  - TRACE GAS ANALYZER
  - INTERSITE PAYLOAD TRANSPORTATION EQUIPMENT
  - PAYLOAD SPECIALIST STATION
  - FLEXIBLE MULTIPLEXER/DEMULTIPLEXER
- MISSION CONTROL CENTER (MCC)
  - MODIFICATIONS FOR ORBITAL FLIGHT TEST (LEVEL I) ON SCHEDULE
  - MODIFICATIONS TO SUPPORT MULTIPLE FLIGHT CAPABILITY WILL BE INITIATED IN FY 78

NASA HQ MO 77-1609
1/27/77

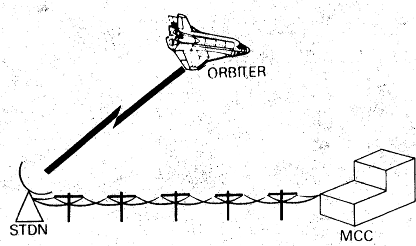
We are continuing with multimission payload support equipment (MO77–1609). A number of items are shown here.

We are also beginning a new project in the fiscal year 1978 budget, Mission Control Center Level II modifications. Let me explain the story of mission control. It has to be modified for the Shuttle. The level one modifications are those necessary to make orbital flight tests possible. It only has a capability to control one Shuttle flight at a time. It also has a lot of R. & D. data capability. It is not configured to do rapid turn around flight planning and so on.

The Level II modifications will add capabilities required for flight rates above 8 to 10 a year. We will be initiating these modifications in fiscal year 1978.

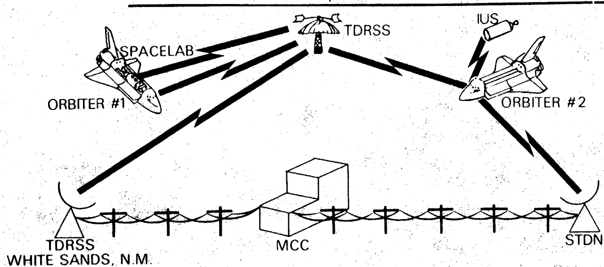
MCC COMMAND & CONTROL REQUIREMENTS

LEVEL I (FLIGHT TEST) MCC OBJECTIVES



- 1 ORBITER CAPABILITY
- FLIGHT TEST MISSION COMMUNICATIONS, COMMAND & CONTROL
- STDN/TDRSS INTERFACE

LEVEL II (OPERATIONS) MCC OBJECTIVES



- 2 ORBITER SUPPORT
- 1 SPACELAB SUPPORT
- 1 IUS SUPPORT
- TDRSS INTERFACE
- STDN INTERFACE
- OPERATIONS MISSIONS, COMMUNICATIONS, COMMAND, CONTROL, SCHEDULING, CREW ACTIVITY PLANNING

NASA HQ MS77-1643 (3)
1-31-77

This chart (MS77–1643) shows a little more detail on the differences between the two modifications and as you can see, Level H modification accommodate considerable more peak loads.

- PAYLOAD AND OPERATIONS SUPPORT
  - PAYLOAD OPERATIONS CONTROL CENTER (POCC) – DESIGN AND DEVELOPMENT WILL BE INITIATED IN FY 78
  - ORBITAL FLIGHT TEST (OFT) SUPPORT – CONCEPT AND DESIGN STUDIES INITIATED IN FY 77 TO INTEGRATE OFT PAYLOADS – DESIGN AND DEVELOPMENT OF INTERFACE HARDWARE WILL BE INITIATED IN FY 78
  - OPERATIONS MANAGEMENT SUPPORT – PAYLOAD INTEGRATION CONCEPT AND MISSION PLANNING STUDIES INITIATED IN FY 77 – WILL CONTINUE IN FY 78
  - OFT PAYLOADS – DESIGN AND DEVELOPMENT OF HARDWARE FOR CANDIDATE PAYLOADS WILL BE INITIATED IN FY 78

NASA HQ MO 77-1680
1/27/77

Now, this is payload and operations support (MO77–1680). Normally in the Office of Space Flight we provide just the transportation, but there are many cases where we found it more economical to provide payload facilities which are normally provided by the user.

For instance, it makes sense to provide a payload operations control center for Spacelab in close proximity to the Shuttle mission control center and to operate it, or at least do the housekeeping.

During OFT, payload support will be provided in the MCC. The payload people will come in and actually work the consoles, during the OFT missions. Our payload people are going out with announcements for opportunity of many payloads to fly and there are substantial amounts of work required of us to integrate these payloads into useful aggregate payloads.

In the operations management support area, there are studies of how we should set up our accounting systems, how we should manage various operational concepts and so on.

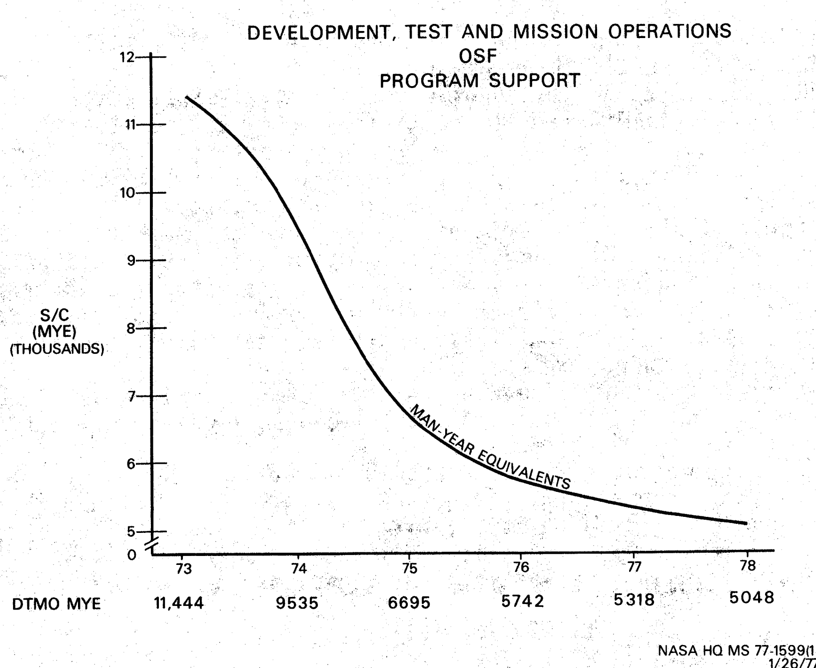
This is going to be hundreds of millions of dollars that we have to manage. Of course, we also have some OFT payloads that the Office of Space Flight itself is planning to develop.

DEVELOPMENT, TEST AND MISSION OPERATIONS
FY 1978 ACTIVITIES
MAINTENANCE AND OPERATIONS

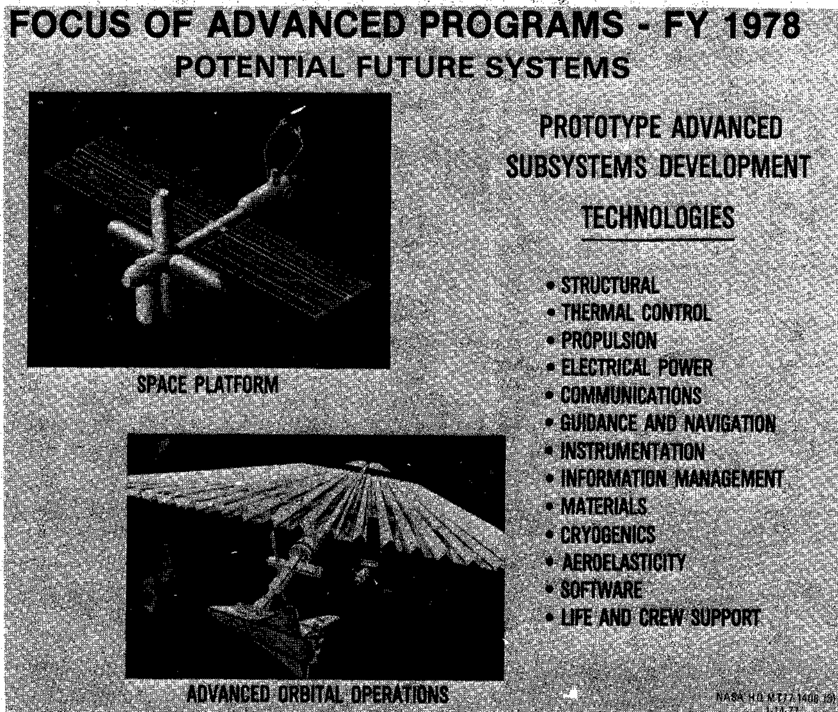
- SHUTTLE TEST ACTIVATION
- LAUNCH FACILITIES RECONFIGURATION AND PREPARATION
- MECHANICAL GROUND SYSTEMS/ELECTRICAL INSTRUMENTATION SYSTEMS
- GROUND BASED DATA SYSTEMS AND SIMULATOR SUPPORT
- MAINTENANCE OF TECHNICAL FACILITIES AND EQUIPMENT (LABORATORIES AND SHOPS)

NASA HQ MS77-1486 (1)
1-21-77

Development, Test, and Mission Operations work that we will be doing in 1978 are shown in this chart (MS77–1486). A lot of this work goes to activating the Shuttle test support and the launch facilities, doing the necessary modification to the Kennedy Space Center ground system and instrumentation, supporting the simulators, and related efforts.



Now, this is always controversial so I would like to show you what has been happening to the Development Test, and Mission Operations support in the Office of Space Flight (MS77–1599) in the last 6 years. It drops from about 11,000 man-years down to around 5,000, Mr. Chairman. We did tell you last year we are going to cut it down and we are cutting it down even this year, even though my people tell me we cannot do that.



Let me just say finally our advanced programs effort (MT77–1408) has been going along well this year. As you know, we have been studying the various space stations concepts, and various solar satellite power concepts, in addition to doing a lot of technology work in the areas listed in the chart. We wish we could do more in this area, in fact, we are sorry that we only have $10 million in the fiscal year 1978 budget, for this.

OFFICE OF SPACE FLIGHT

RESEARCH AND DEVELOPMENT
FY 1978 BUDGET ESTIMATE

(MILLIONS OF $)

PROGRAM/PROJECT	FY 1977	FY 1978
EXPENDABLE LAUNCH VEHICLES		
• SCOUT	(10.7)	(16.0)
• CENTAUR	(90.7)	(55.9)
• DELTA	(43.8)	(55.3)
• ATLAS-F	(6.2)	(9.3)
TOTAL	$ 151.4	$ 136.5

NASA HQ MS77-1457 (1)
1-19-77

The fact that we cut advanced programs from $13 to $12 million in fiscal year 1977 as part of the Shuttle reprograming action should not be interpreted as meaning that NASA or the Office of Space Flight does not believe that this effort is very important. It is a matter of priorities, and we did not reduce our advanced studies area.

Now, on the expendable launch vehicles (MS77–1457) we have the four shown here, Scout, Centaur, Delta, and Atlas-F. The Scout does a specific small job and will remain with us for a long time. The Atlas-F is the vehicle we are using primarily for National Oceanic and Atmospheric Administration weather satellites. We have had a very good year with our expendable launch vehicles.

EXPENDABLE LAUNCH VEHICLES
LAUNCH ACTIVITY DURING CY 1976

100% RECORD - 16 LAUNCHES /16 SUCCESSES

SCOUT — LAUNCHED THREE SATELLITES:

- EXPERIMENTAL COMMUNICATIONS SATELLITE - USAF
- RELATIVITY PROBE - NASA
- NAVY TRANSIT - NAVY DOD

DELTA — LAUNCHED NINE SATELLITES:

- COMMUNICATIONS TECHNOLOGY SATELLITE - NASA/CANADA
- MARISAT-A COMSAT
- RCA-A - RCA
- NATO III-A - NATO
- LAGEOS - NASA
- MARISAT-B - COMSAT
- PALAPA-A - INDONESIA
- ITOS-H - NOAA
- MARISAT-C - COMSAT ★

ATLAS CENTAUR — LAUNCHED THREE SATELLITES:

- INTELSAT IVA-B - INTERNATIONAL COMMUNICATIONS
- COMSTAR-A - COMSAT
- COMSTAR-B - COMSAT

TITAN CENTAUR

- HELIOS-B - NASA/WEST GERMANY

★ LAUNCHED SINCE SEPTEMBER 1976

NASA HQ AD77-1324 (1)
1-12-77

We had a 100-percent success record, 16 out of 16 launches, as shown on this slide (AD 77–1324). We had one launch this year, NATO III–B on January 27, and that was successful too.

EXPENDABLE VEHICLES
1977 LAUNCH SCHEDULE

	J	F	M	A	M	J	J	A	S	O	N	D
COMMUNICATIONS												
U. S. DOMESTIC									Δ			
U. S. MARITIME											Δ	
INTERNATIONAL	*Δ					Δ				Δ		
FOREIGN REGIONAL			Δ								Δ	
EXPERIMENTAL						Δ		Δ				Δ
WEATHER/METEOROLOGY					Δ		Δ	Δ				
NAVIGATION						Δ						Δ
EARTH RESOURCES/GEODESY				Δ					Δ[N]			
SCIENCE/PLANETARY				Δ[N]				Δ[N] Δ[N]		Δ[N] Δ	Δ[N]	
TOTAL LAUNCHES (23)	1	-	1	2	1	3	1	4	2	3	3	2
NASA (6)	-	-	-	1	-	-	-	2	1	1	1	-
OTHER (17)	1	-	1	1	1	3	1	2	1	2	2	2

NASA HQ AD76-1686 (1)
REV. 1-12-77

* NATO III B successfully launched January 27, 1977

Our expendable launch vehicle schehdule for 1977 in this chart (AD 76–1686). We show a total of 23 launches, 17 for reimbursable customers and 6 for ourselves. Mr. Chairman, that concludes my presentation, and I would be happy to answer any questions from you or the other members.

Mr. Fuqua. John, just briefly we have some new members on the subcommittee and I think it might be helpful if you could just give us an explanation. I see you have the models of the Shuttle as well as the 747 and you might briefly explain how the Shuttle works.

Mr. Yardley. Be very happy to. This is sort of the basic, standard Space Shuttle configuration as it sits on the pad.

Mr. Fuqua. You might also explain where it is being manufactured and by what contractor.

Mr. Yardley. The major and the most expensive element of the Space Shuttle is the Orbiter. The Orbiter is the key part of the system that carries all the payloads, and has all the "brains"—the electronics. It has the sophisticated engines, and comes home and gets used over and over again. The orbiter basically has a 500-flight life, with about 100 flights betwen refurbishments. Now the Orbiter itself is made by Rockwell International/Space Division in California and they in turn have literally hundreds of subcontractors across the country. The current negotiated value of the Orbiter development contract will be on the order of $3.1 billion. My recollection is that we have Shuttle contracts and subcontracts in 47 of the 50 States.

Another significant element of the Shuttle system is represented by the Orbiter's three liquid hydrogen-oxygen main engines. That development is done by Rockwell International/Rocketdyne Division at Canoga Park, Calif.

Mr. FUQUA. You might point out there are several major subcontractors on that, the tail, wings, and so on.

Mr. YARDLEY. Yes. Fairchild in New York builds the vertical tail fin; Grumman in Long Island builds the wings; General Dynamics in San Diego builds the mid-fuselage; and McDonnell-Douglas in St. Louis builds the orbital maneuvering system propulsion pad. IBM makes the computers and Minneapolis-Honeywell the avionics. There are at least a dozen more major subcontractors.

In addition to the Orbiter and its main engines, there are twin solid rocket boosters on the configuration at liftoff.

The Orbiter will reach a 100,000-foot altitude and will travel at about 4,000 feet per second at this point, about 2 minutes into flight, these boosters are jettisoned. Parachutes come out and they lower the boosters into the water. They are fished out and shipped back to the manufacturer for reloading with solid propellant. The solid rocket boosters are also reusable. A major contractor on the SRB motor is Thiokol, Wasatch Division in Utah. We also have a number of major contractors on the structures and the thrust vector control, and other systems. We did select a booster assembly contractor, the United Space Boosters subsidiary of United Technologies, Inc., to do the overall assembly and integration.

The external tank is the only major expendable item in the system. It is a fuel tank, which carries liquid oxygen and hydrogen propellants; particular attention has been given to its design so that it will be relatively inexpensive to manufacture. You saw some pictures of giant tools. Those tools are all designed to make tanks on a production line because the operational cost will depend very much on what the tank costs. So, Mr. Chairman, that is given a lot of attention. The tanks are built by Martin-Marietta, at NASA's Michoud Assembly Facility near New Orleans.

At lift-off, the three main engines on the Orbiter and the two solid rocket boosters light on the pad. The solid rocket boosters are jettisoned about 2 minutes into the flight and the tank and Orbiter continue upward. The tank supplies the propellants and the Orbiter supplies everything else. Just before we get into orbit we jettison the tank. The reason we jettison the tank before we get ito orbit is so that it will go into the ocean at a selected area where we will have no environmental problems. The Orbiter continues by itself into orbit and opens its payload doors to discharge or deploy payloads. Some payloads remain in the Orbiter. For example, the Spacelab remains in the Orbiter's large cargo bay and operates as a short-duration space station. The Orbiter, of course, returns the Spacelab to Earth for reuse in future missions.

Now, going to the Orbiter/747 carrier aircraft mated configuration, one of the test series we need to do in the development of this system is to see how it flies because it has to come back and land. That has never been done before. We have what we call an approach and landing test series, the ALT, and this is a configuration that we have chosen for the approach and landing tests. Incidentally, this will also be the configuration we will use to transport the Orbiter around the country.

The Orbiter is too big to move over the road except for short distances like from Palmdale to Edwards AFB. Even then, we had to rebuild some telephone lines and so on.

This is the way the Orbiter separates from the 747 carries aircraft: The Orbiter is tilted up so that when the 747 and the Orbiter are flying together, the Orbiter is really carrying more of the lift for its weight than the 747 is. The Orbiter "drops" the 747. When I say that people will say, "But is that literally true?" It certainly is. We are going to start flying this configuration on the 18th of February and we will spend 9 to 12 months doing all the other tests with this configuration to accomplish the Orbiter approach and landing test series.

That is it, Mr. Chairman.

Mr. FUQUA. Thank you, John. I thought it would be interesting.

What portion, John, if any, of the funds of the funds of the Space Transportation System are for the spinning upper stage rocket?

Mr. YARDLEY. In fiscal year 1978 we are requesting $13.5 million for both the IUS and the SSUS. Now, $5.5 million out of the $13.5 million or 41 percent of that total is for the SSUS. That is sufficient to do either of two things. If we do not get a commercial developer on the SSUS–A we can start the development ourselves with these funds. We already have a commercial agreement on SSUS–D. We have a number of requirements that are pretty firm and we are negotiating right now to do the SSUS–A development without us financing it. Contractors interested in developing the SSUS want to have assurance that there are going to be enough of them used so they will not lose their shirt after investing in a commercial development.

It turns out that the TDRSS decision has been made, and with the COMSAT Intelsat V commitment, we will need funds for procurement of the SSUS–A for those applications. It looks like the $5.5 million will cover these needs in fiscal year 1978.

Mr. FUQUA. Will this supplant the IUS being developed by the Air Force?

Mr. YARDLEY. No; as a matter of fact, as long as you mention it, the problem with the IUS is that it is just not an efficiently sized vehicle for the smaller payloads either from a transition point of view or a cost point of view.

The facts of the matter are that NASA does not have a lot of its own geosynchronous traffic. Our total geosynchronous and planetary traffic amounts to 18 IUS flights and 25 SSUS flights. Use of the SSUS does cut the overall number of IUS flights.

The number of IUS flights anticipated in the 572 traffic module was 197. Now, that traffic model has been reduced to 560, 112 of them are still using the IUS.

Mr. FUQUA. John, over the years we have had some very favorable economic forecasts for the Space Shuttle.

Has there been anything in the last year that has materially altered the economics of the Space Shuttle?

Mr. YARDLY. No; as a matter of fact, it looks better. We have, during the past year, gone through more detailed operational cost, planning analyses in conjunction with our user charge policy formulation. As a result, we think our costs are more solid and are under the same groundrules as they have been in the past.

Every indication, every analysis we have made shows that it is still very favorable. For example, we took the traffic model we have been using and cut the NASA flights in half; then we tested that model against a two orbiter fleet, we found we would have to buy expendable vehicles to accommodate DOD and commercial users.

When we compared that to a five-orbiter fleet where we are only flying half of the NASA traffic, Mr. Chairman, we found that we could save between $5 and $6 billion by buying five orbiters instead of two, because we could accommodate the anticipated DOD and commercial traffic.

The point is, there are going to be many users who are going to fly the Shuttle if they can be accommodated. A five-orbiter fleet is the minimum required.

Mr. FUQUA. The reimbursement policy has not been affected either?

Mr. YARDLEY. Yes, I was going to mention that. I think the reimbursement policy will have a substantial effect on the traffic. We are seeing all sorts of positive indications. This concept of small, self-contained payloads has received a tremendous amount of attention. We have people donating money to universities to set up flights so that the students will have experiments, and there are many other positive indicators. They are sending us checks. We received a down payment on a Delta flight yesterday from the Satellite Business Corp. which has decided to use the Shuttle based primarily on our reimbursement policy and transition planning.

Mr. FUQUA. You have announced at an early date the reimbursement policy then, so people will know what to expect.

Mr. YARDLEY. It is very important. A year ago there was uncertainty, and you know how anything new is. It tends to be viewed with suspicion and alarm. We found very quickly that the only way we were going to make the people believe us was to write it out, coordinate it, and make it official. Establishment of this policy represents a major accomplishment.

Mr. FUQUA. John, one final question. We do not have any surprises, do we, in the development of the Shuttle that you foresee?

I know we have had some problems with the engine.

Mr. YARDLEY. We have a lot of tough testing ahead and there is always the possibility of unanticipated problems. There are none that we know of now.

We have been doing a great deal of soul searching on the hydraulic system, for example, in the last 6 months; we are quite certain that we are in good shape for ALT, but we are only using the hydraulic system for 5 or 6 minutes in ALT and we are not quite confident yet for the orbital flight test phase.

Mike, can you think of anything that particularly disturbs you?

Dr. MALKIN. No, sir, I think you have covered the facts as I see them.

Mr. FUQUA. Mr. Winn?

Mr. WINN. Thank you, Mr. Chairman.

It was the committee's understanding that for space flight operations in the space transportation systems operations category grew that DTMO would decrease. However, DTMO grew from $167 million in 1977 to $173 million while the space transportation systems grew from approximately $19 million to $81 million and I wondered if you could give us—and you touched on it—if you could give us an explanation for how that happened.

Mr. YARDLEY. Well, I think you will find if you look at our last year's projection for 1978 that it hardly changed. What we said in general was that as we go out the next 5 years, as we enter into STS operations, we will reduce DTMO because most of the type of work that is being done in DTMO now we will put into STS operations and make it part of the user charge and bookkeep it in a different way. Our fiscal year 1978 DTMO requirements remain essentially the same as we projected in the fiscal year 1977 budget, including the one-time need at KSC to deconfigure the launch umbilical tower and to modify the crawler transporter.

Mr. WINN. What is the 1978 request?

Mr. YARDLEY. $173 million.

Mr. WINN. That is what you would have liked to have had last year.

Mr. YARDLEY. Yes.

Mr. WINN. So it is really not a great difference.

Mr. YARDLEY. No; there is a curve that shows our plan for DTMO over the next 5 years.

Mr. WINN. The curve would probably cross itself, would it not?

Mr. YARDLEY. I do not know if you can see this or not but the yellow is the DTMO from fiscal year 1978 through fiscal year 1982 and it is pretty flat in the early years. The severe downward level does not start until 1980.

Mr. WINN. Did you say 1980?

Mr. YARDLEY. Yes, sir.

Mr. WINN. Approximately $57 million is allocated for Shuttle-Spacelab payload development.

What is the timeframe of these payloads?

What is the timeframe work that these payloads will be utilized on the Shuttle flights?

Mr. YARDLEY. That $57 million is not, of course, in my budget but I will try to answer your question. Those funds are primarily for payloads for the first three Spacelabs and also for initial work on subsequent payloads.

Mr. WINN. The first three?

Mr. YARDLEY. The first three. There will be some funding for payloads beyond the first three Spacelabs. The flight dates for the first three Spacelabs are about July 1980 for the first flight, October for the second flight, and the third flight will probably be next March.

Mr. WINN. They are not set yet?

Mr. YARDLEY. No. We are still assessing it. The Spacelabs are a little flexible and some of our commercial users are not quite so flexible so we really have not frozen all the schedules yet.

Mr. WINN. What I am trying to figure out is a major portion of the $57 million is scheduled for later operational flights.

Mr. YARDLEY. No. Some of it is, but not the major portion.

Mr. WINN. I know you said the first three.

Mr. YARDLEY. But I want to hasten to add that almost every Spacelab will be somewhat different in its configuration and each of those three is a different configuration, the first of a series. You have a developed payload for say Spacelab 1 and that might fly again on

Spacelab 6 with modifications, so the equipment and the money are applicable over a much longer period of time.

Mr. WINN. So it is spread out and you really cannot pinpoint what the actual, what the major portion is because you are going to be spreading it out.

Mr. YARDLEY. What it will boil down to is you will probably bookkeep it like all the money is used on the first one but when it reflies, the subsequent flights are cheaper, obviously.

Mr. WINN. How is it possible to hold the total cost for Shuttle at $5.2 billion of 1971 dollars if $30 million is reprogramed?

Mr. YARDLEY. When we estimated the $5.22 billion in 1971 dollars for the Shuttle D.D.T. & E., we included some provision for unanticipated problems. The reprograming of $30 million into the fiscal year 1977 Shuttle plan reflects a rephasing of the funding requirement. It does not increase the total cost estimates for D.D.T. & E.

What the $30 million reprograming indicates is that in fiscal year 1977 we have identified some areas that need some of the future year reserve earlier than we had planned but we still think the reserve we have left in future years, even after we apply the $30 million, is sufficient to cover those years. Of course, if we have a lot more trouble in the test programs than we had planned, it might not be enough, but right now it looks like it is.

Mr. WINN. You refer to reserve. How much was the reserve?

Mr. YARDLEY. I would prefer to discuss that privately, if you want. I am not trying to avoid the question, however, you can understand the implications.

Mr. WINN. I will not let you do that.

Mr. YARDLEY. We have a lot of contractors and they would be interested in how much the reserve is, too, I will be happy to discuss it with you, if you want me to.

Mr. WINN. Is the reserve based on a percentage in any way?

Mr. YARDLEY. That is the way you usually express it.

Mr. WINN. But other factors come into consideration also?

Mr. YARDLEY. Yes. We made a lot of studies of this and we studied past programs. From our understanding and our definition of the Shuttle program at the time the development commitment was made, we established a reasonable reserve we felt was adequate for D.D.T. & E. I am sure everybody realizes as you proceed through a large-scale development program you have to balance the overall system. You have to be able to adjust to meet unforeseen technical problems when they occur. It is a question of being able to judge from the state of the art and the program you are doing, how much you need to begin with. What we are saying is that our original estimate seems to be reasonable.

Dr. MALKIN. And the distribution of the reserve would depend on what stage of the program you are in. You try to program it for where you expect the most trouble.

Mr. WINN. I have a few more questions on that. That does bring up a few more questions but I will submit those in writing and maybe it might be easier for you to explain it to us in writing and I will yield back my time to some of our newer members.

Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Downey?

Mr. DOWNEY. Thank you, Mr. Chairman.

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Could you not work out a program where all members under 30 could go on a ride on the Space Shuttle?

I would like to ask you Mr. Yardley about one aspect of your budget that I see decreases that disturbs me from fiscal 1977 on to fiscal 1978 and if you would I would like you to embellish upon what it is going to cost you and that is the advanced programs.

I understand you are going from $12 million to $10 million and I would like to know the sacrifices you will have to make with those cuts.

Mr. YARDLEY. We agree with you. We wish that were not happening. Essentially, we have to cut our program 20 percent. Now, the things we are doing are quite modest to start with. We had hoped to increase it because we feel the time is now to really begin to study in a considerable depth the next major space step, the space industrialization concept; to identify those things which really need that kind of facility and when it ought to be done, and so on. I am sure you read OMB's rationale on the subject. What we are trying to do is tighten our belts and conduct some post-Phase A studies during fiscal year 1978 and try again in fiscal year 1979.

Mr. DOWNEY. If you can give us this information, what was your estimate for 1978? What did OMB reduce it from?

Mr. YARDLEY. We had asked for $14 million in advanced programs, which is now $10 million; we also asked for $15 million to start Phase B studies on space industrialization which were deferred.

Mr. DOWNEY. I am sorry, I am new to the committee but could you define space industralization?

Mr. YARDLEY. What we are talking about is the possibility of a permanent facility in space that would be a base for industrial and other activities. It would be a low Earth orbit space base that could be used for many of the opportunities that we think are going to be opening up in space in the mid-1980's.

We could have large structures for large antennas so that you could have all kinds of new communication possibilities and experimental satellite solar power possibilities, for example. You have to have some facility like that to conduct full-scale materials processing, biological processing and all the other possibilities that the Shuttle era will open up.

We wanted the funds in fiscal year 1978 to start some serious study efforts to define exactly what these possibilities are: and whether they really would be worth doing. Those definition studies were deferred.

Mr. DOWNEY. I am sorry to see your cut there and I hope the committee will take cognizance of that. Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Gore?

Mr. GORE. Thank you, Mr. Chairman.

Thank you, Mr. Yardley, for your testimony here this morning. I enjoyed the briefing you conducted for the new Members of the full committee not long ago and I look forward to working with you and the other folks at NASA.

I have a couple of elementary questions. First, back to the first square. What is the flight life of the solid rocket booster?

Mr. YARDLEY. We are rating them at 20 flights each. Actually, we think some of the components can go further than that. We will not really know until we start gaining experience but basically we think it is about 20 flights, which means each flight only pays for one-twentieth of the new hardware and refurbishment cost.

Mr. GORE. So you will need 50 of those solid rocket boosters per orbiter?

Mr. YARDLEY. Yes, if you made all 500 flights per orbtier.

Mr. GORE. What is the cost per unit of the external tank?

Mr. YARDLEY. About $3.0 million in fiscal year 1975 dollars.

Mr. GORE. So that is the major component of the cost of each lot?

Mr. YARDLEY. That probably is the single biggest piece. You have the liquid and solid propellants themselves which are fairly expensive. I guess that is another $1.7 million. There are also a number of other things such as refurbishments, spares and replacement of wearouts and consumables.

Mr. GORE. In an effort to assist the chairman in developing a complete record I will ask this question. I think you touch on it in your testimony on page 23 where you indicate you are considering an expendable launch vehicle.

Would this necessarily mean buying expendable launch hardware which might never be used?

Mr. YARDLEY. At the present time there does not appear to be any need to do that for the Centaur program. In the Delta program, we are going to buy some long lead material to protect missions which are scheduled on the Shuttle from now to our first full up Shuttle orbital flight. If the Shuttle slips, or if there are problems with it, we will be in a posiiton to fly these missions on the Delta instead. The only thing that would be left over, so to speak, would be maybe $3 to $5 million worth of long lead parts.

Mr. GORE. One final question, Mr. Chairman.

I am concerned in general that the priorities at NASA have not given enough emphasis to the possibility of developing the solar powered satellite to capacity and the small amount allocated to such things as weather research.

If we dramatically step up the funding of the space solar satellite program, if the economics become feasible would the Space Shuttle program be an indespensible element in the construction of these satellites?

Mr. YARDLEY. The answer is yes; but there are two different possible ways to go on that. There is no question you would have to use the Space Shuttle for the next 15 years of development of those giant stations. To actually deploy those giant stations, I am talking about something now that is 50 square miles worth of solar collectors, but to actually deploy those things with the Shuttle using Earth-based materiels would not be economical. You just need a much larger vehicle. Now, there is a way that Professor Gerard O'Neill has been investigating qiute heavily, using lunar materials to build those stations. The energy required to get lunar materials out to the right spot is a lot less. If that were proved to be the most economical way to go then the Shuttle would be sufficient to support that operation from the earth.

Mr. GORE. Don't tell me you are considering strip mining the Moon.

Mr. YARDLEY. There are no environmentalists up there.

Mr. GORE. No further questions.

Mr. FUQUA. Thank you, Mr. Gore.

John, what is the total estimated cost of the Orbiters 3, 4, and 5?

Mr. YARDLEY. The amount projected in the budget run out estimate in fiscal year 1978 dollars is about $1.7 billion for the three of them.

Mr. FUQUA. How much?

Mr. YARDLEY. $1.7 million in the dollars of the fiscal year 1978 budget.

Mr. FUQUA. That is billions of dollars?

Mr. YARDLEY. Yes, sir.

Mr. FUQUA. What would be programed in fiscal year 1979 for the three Orbiters in 1979?

Mr. YARDLEY. The fiscal year 1979 funding requirements for those three orbiters are estimated at approximately $316 million in the dollars of the fiscal year 1978 budget.

Mr. FUQUA. And what would be the cost for the refurbishment of one and two?

Mr. YARDLEY. Our total estimate of that right now is approximately $329 million in the dollars of the fiscal year 1978 budget.

Mr. FUQUA. That is all in the $1.7 billion?

Mr. YARDLEY. No, sir.

Mr. FUQUA. In addition?

Mr. YARDLEY. The $1.7 billion is the total estimate for Orbiters 103, 104 and 105 in the dollars of the fiscal year 1978 budget. The $329 million is the total estimate in dollars of the fiscal year 1978 budget to refurnish Orbiters 101 and 102.

Mr. FUQUA. Mr. Winn has another question.

Mr. WINN. Do we have anything in the way of payloads that the general public is going to feel that it is improving our way of life, not just experiments, but something that would be easy to sell to the public that they are going to benefit by it?

Mr. YARDLEY. Are you talking in the near term?

Mr. WINN. Yes; the near term.

Mr. YARDLEY. The most probable near-term activities would be converting some of the experimental products we have tested on ASTP, like some of the production facilities for pharmaceuticals. There is also a silicon ribbon project being developed for electronic components and several other similar products.

Most of that kind of processing is in the experimental stage and you are probably more familiar with it than I am because of Chuck Mathews' and Brad Johnston's presentations to you.

The satellite solar power is the one that is the greatest interest to everybody. Of course, that is not exactly near term. Maybe I can ask John Disher if he has any light to shed on it.

Mr. DISHER. Yes. Advanced communications capabilities offer a potential of bringing wrist watch radio-telephones to a practical state, for instance. They offer enhanced communications and the potential for cutting down the travel of business people by allowing telephone conferences with three dimensional full size image projection as another example. You cannot talk about this in the 1982, 1983, 1984 periods but more probably in the later 1980's at the earliest, but the potential is certainly there. That is what we are looking for, to develop the potential in that period.

Mr. WINN. I was going to switch subjects, but if you have something you want to add, please do so.

Mr. DISHER. I was going to say that in the materials processing areas, there are a number of pharmaceutical products medications with great potential benefit, though they are currently experimental investigations only.

Mr. WINN. You are not going to show us how to get rid of the common cold, are you?

Mr. DISHER. I have not heard that projected yet, Mr. Winn.

Mr. WINN. Well, some of the earlier lists I saw they keep changing them all the time and I cannot keep up with them. They have not been updated.

What percentage, and I will not ask you what they are but what percentage will be military payload?

Mr. YARDLEY. Let me see. Of our present traffic model it is about 20 percent.

Mr. WINN. You said 20 percent?

Mr. YARDLEY. Around that. We have the numbers here.

Mr. WINN. I think they are going to appear before us next week. It is 20 or 25 percent? That is pretty close.

Mr. YARDLEY. It is approximately 20 percent.

Mr. WINN. In background I am still trying to find something that is going to satisfy the American people when we tell them how much this is going to cost.

Mr. YARDLEY. Well, there is a lot of ongoing effort that will hopefully expand, such as the weather satellites.

Mr. WINN. I realize it is pretty hard to categorize these things.

Are these carryover experiments from the first one to the second that are going to be updated as each one flies?

Mr. YARDLEY. Probably will not be if you talk Spacelab, from the first Spacelab to the second, but they will leapfrog.

Mr. WINN. Thank you very much.

Mr. FUQUA. John, one question comes to my mind going back to my last question.

With the Orbiters 3, 4, and 5, what does this do if you add their cost in 1979, 1980, and 1981 to the total Shuttle cost program?

After 1 and 2 start coming off the peak where does that leave our total commitment year by year for Shuttle development?

Do you have that in a graph form?

Mr. YARDLEY. I think we probably have a graph but not projectable that shows the total combined program cost of this. Here is the Shuttle development commitment, which is the $5.22 billion in 1971 dollars. This was an additional item that was not in the $5.22 billion. Here is how the overall thing looks and what it shows is that the total program including development and production will be lower in 1979 than it is in 1978 and it will continue to come down.

Mr. FUQUA. With 3, 4, and 5?

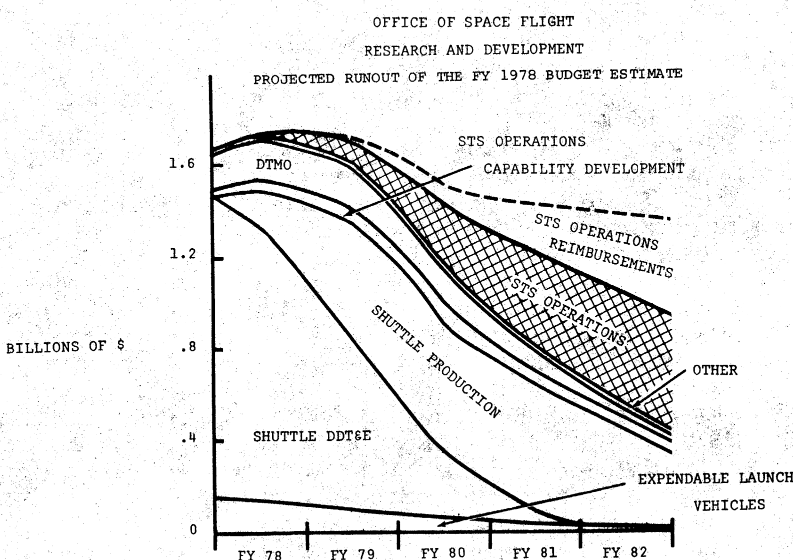
Mr. YARDLEY. Yes; they are in here.

Mr. FUQUA. So then within the total analysis, the NASA budget we will have more funds to work with, at the $4 billion level or thereabouts for other programs such as space sciences and others?

Mr. YARDLEY. Yes. The total Office of Space Flight budget heads downhill in 1979. Now, it is not a big drop in 1979, but it gets bigger as time goes on since the Shuttle development declines faster than the buildup of the production and operations.

Mr. FUQUA. Could you provide us those projections?

Mr. YARDLEY. Sure.
Mr. FUQUA. Mr. Winn?
Mr. WINN. I cannot see that from here. What is the last year at the bottom, the far right side of the chart you have?
Mr. YARDLEY. This is 1982 out here.
Mr. WINN. 1982?
Mr. YARDLEY. Yes.
Mr. WINN. And is 1977 on the left?
Mr. YARDLEY. No; that is 1978.
Mr. WINN. I see.
Mr. FUQUA. You might want to give us those projected operational costs as well as the reimbursement costs.
Mr. YARDLEY. All right, we can do that.
Mr. FUQUA. If you have a draftsman that can put that together for us it need not be elaborate, but something that shows the projection.
[The information follows:]



Mr. Gore, any further questions?
Mr. GORE. No; Mr. Chairman.
Mr. FUQUA. Thank you very much, John, for your testimony here today.
This subcommittee will adjourn to meet again on Wednesday, February 9, in this same room.
At that time we will have Dr. Noel Hinners, Associate Administrator for Space Science, and we will also take up the Office of Space Technology and Office of Technology Utilization.
We stand adjourned.
[Whereupon, at 3 p.m., the subcommittee adjourned, to reconvene on Wednesday, February 4, 1977.]

FIELD HEARINGS

FRIDAY, FEBRUARY 4, 1977

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Kennedy Space Center, Cape Canaveral, Fla.

Mr. Fuqua. We are pleased to be here and look forward to the report you will give us today.

STATEMENT OF MIKE ROSS, DEPUTY DIRECTOR, KENNEDY SPACE CENTER

Mr. Ross. Mr. Chairman, Mr. Winn, members of the staff, we're happy to have all here at KSC. We have planned what we expect will be a productive day. We have handouts of all the viewgraphs we will be using.

Mr. Fuqua. Without objection they will be made a part of the record.

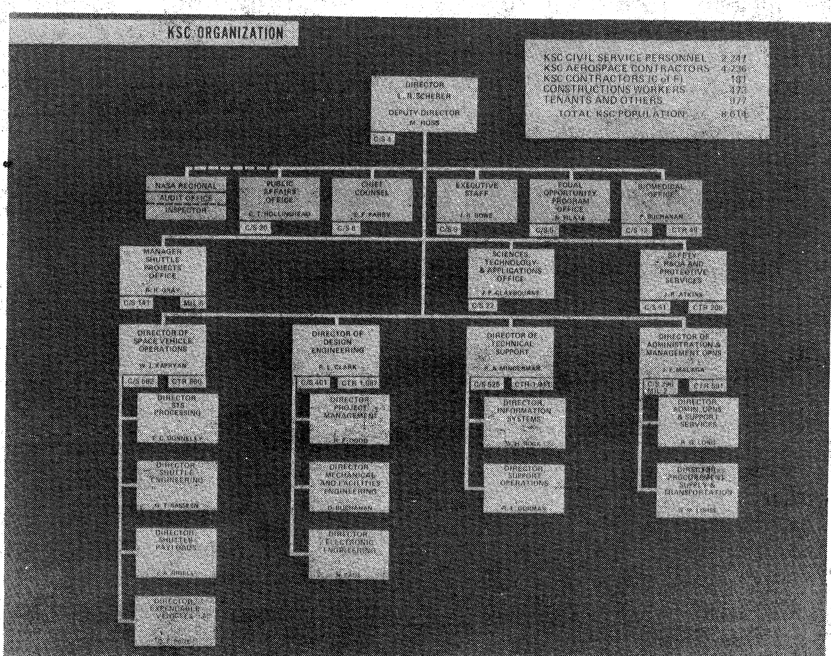


Figure 1

Mr. Ross. Let me start by talking about the personnel and organizational changes made since the last time you were here, and use this viewgraph (fig. 1) to introduce the members of the Kennedy Space Center policy staff who are with us this morning. First of all, Lee Scherer, as you know, is at the Dryden Flight Research Center today for the Orbiter approach and landing test flight readiness review. I talked with him last night and he sends his best regards—he is here in spirit.

Mr. Fuqua. Good.

Mr. Ross. (Figure 1.) At the staff level we have added a Biomedical Office, with Dr. Paul Buchanan, M.D., in charge. Paul transferred to KSC from the Johnson Space Center. The last time you saw this chart we had an ASTP Science and Technology Applications Office. The ASTP was deleted at the completion of the project, but we do have some minor science applications and technology programs, so the office has been retained. Phil Claybourne is in charge of this office, and he will join us later.

Ed Parry is our chief counsel, Jim Rowe is the chief of our executive staff, and Chuck Hollinshead is our public affairs officer.

We have merged safety, reliability, quality assurance, fire, and security into a single office, the safety, reliability, and quality assurance and protective services office, since these are related functions, this is an efficient way to operate. Dr. Bob Gray is the manager of the Shuttle projects office.

Walt Kapryan is director of vehicle operations, Ray Clark is director of design engineering, Pete Minderman is director of technical support and Joe Malaga is director of administration and management operations. Joe transferred to KSC from NASA Headquarters in August 1975.

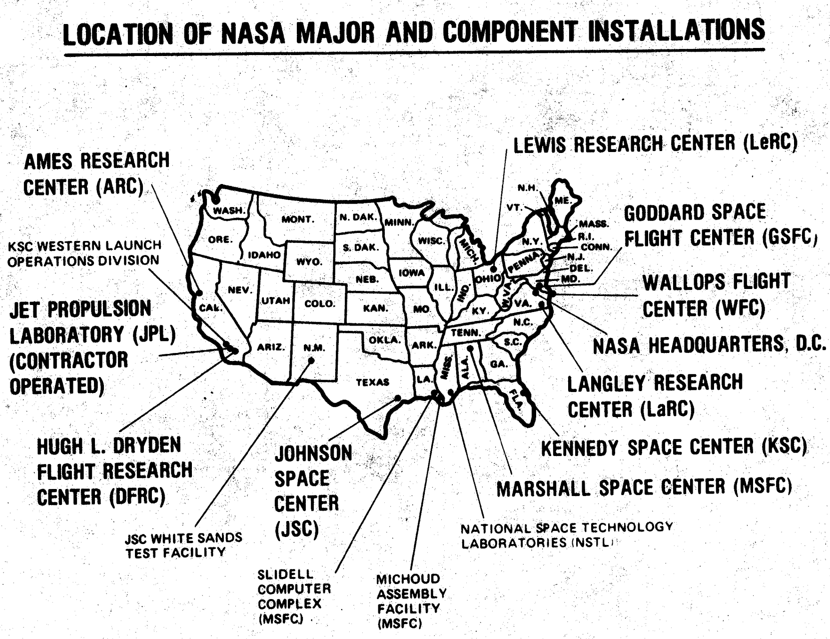


Figure 2

We have reorganized to meet the requirements of the Shuttle program, you recall that we were previously organized to support the Apollo program. For example, we had a launch vehicle directorate, a spacecraft directorate, et cetera. This move already reflects, in fact, does reflect the specific requirements for the space transportation system as we process it through here. I want to use the next chart (fig. 2) to show other locations where KSC people are stationed. We are active at the Dryden Flight Research Center. We have about 50 people there since KSC has the responsibility for the Orbiter ground turnaround operations during the approach and landing test, and has the new hangar for the Orbiter and for the mate/demate device which was used successfully for the first time yesterday. We'll see some pictures of that. We also have representatives at the Johnson Space Center and

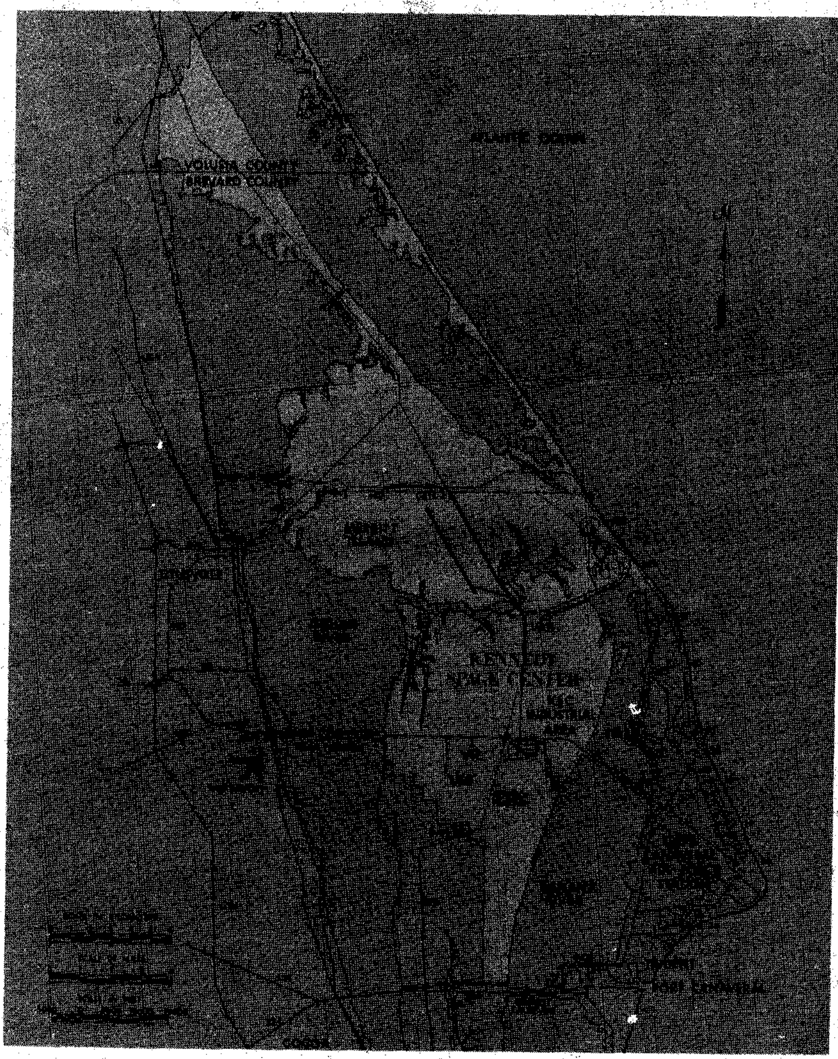


FIGURE 3

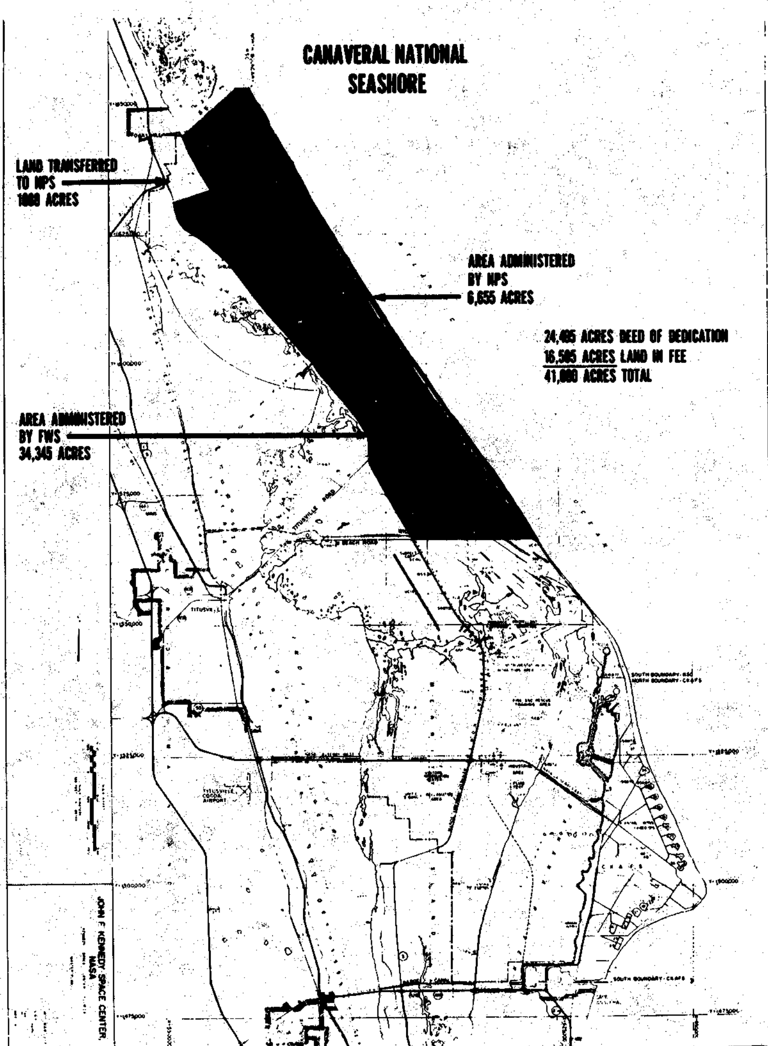


FIGURE 4

the Marshall Space Center, working the interface between centers for the Orbiter, the external tank, and the solid rocket boosters.

Since you are all familiar with this map (fig. 3) we'll go through it rapidly. We did want to show you the Canaveral National Seashore (fig. 4), which was brought into being with legislation in 1975.

Mr. FUQUA. Do you call it Canaveral or Holland?

Mr. ROSS. Canaveral National Seashore. The beach area is administered by the National Park Service, and the water area is administered by the Fish and Wildlife Service.

Mr. FUQUA. Where is the Holland Seashore?

Mr. CLARK. The name in the legislation was changed at the last minute, because they preferred not to use a man's name.

Mr. PARRY. The Seashore Act does prescribe that the Visitor Center in the upper area is to be called the Spessard L. Holland Visitor Center.

Mr. WINN. Where is the range safety office located?

Mr. ROSS. The range safety control officer, located in the range control center on the Cape Canaveral Air Force Station will be used for the Shuttle program. It will continue to be operated by the Air Force.

Mr. FUQUA. If we were to get into larger payloads such as space stations, and solar power stations and they were launched from here, where would be the most logical place? Do you have any room left?

Mr. ROSS. Yes; probably the initial space stations would be assembled in orbit, with subassembly modules launched by the Space Shuttle, from complex 39.

Mr. FUQUA. We were talking about later. There may be a Nova-type vehicle around or something like that.

Mr. ROSS. For these or other heavy lift launch vehicles, the launch sites would be to the north of complex 39.

Mr. FUQUA. Does that infringe on the national seashore?

Mr. CLARK. The interagency agreement between NASA and the Department of the Interior provides that NASA can site any future space program facilities on KSC property within the seashore as long as NASA takes the Interior Department's use under consideration to insure compatibility wherever practicable.

FIGURE 5

Mr. Ross. We do caution the Park Service not to put up permanent buildings—anything that they would have to take down again. Any permanent buildings they put up will go up in this section at the extreme northeast of KSC, in a 1,088-acre site that has been transferred to the Park Service.

The Visitor Information Center (fig. 5) has been very active this past year as in the several previous years. About 1.1 million people paid to take the bus tour and about 25 percent more visited the VIC which is free.

Mr. Frey. Is that up, Mike, or is that about the same?

Mr. Ross. It's down.

Mr. Malaga. It's down slightly, about 2.6 percent.

Mr. Frey. How does it compare to Disney World?

Mr. Ross. Our attendance so far this year is down about 17 percent from last year. Disney doesn't give out figures, but the other major attractions, such as Cypress Gardens, Silver Springs, St. Augustine, and others, are down between 25 and 40 percent. Now, oddly enough, the counts at the Florida highway tour stations show that the number of tourists coming into Florida are down only about 10 percent.

Mr. Fuqua. What about places like Sea World or some of the others?

Mr. Ross. Sea world is down, between 25 and 40 percent for the year.

Mr. Fuqua. In the past, you have gotten figures from Disney World, I thought.

Mr. Ross. We don't get official figures from them.

Figure 6

In addition to the 1.1 million taking the tour and another 300,000 visiting here, we had about 600,000 visiting the bicentennial exposition on science and technology (fig. 6).

Mr. FREY. You've incorporated the Apollo 11 launch show in the bus tour, haven't you?

Mr. ROSS. We did for the Christmas season and we will again as soon as we get equipment, so the show can be completely automated. That's the firing room No. 3 show. We want to bring that down to the point where a single attendant can push a button and the entire show goes on and then at the end of the show it recycles. Otherwise we couldn't afford it as long as we keep the bus tour price at the level it is now.

Mr. FREY. What about the advertising we did on "To see a launch, dial 800–423–2153," did that have any impact?

Mr. ROSS. Yes, a significant number of people come to KSC for the expendable launch vehicle launches. For example, for the NATO launch last week, TWA sold 17 bus loads of admissions. The public buys tickets for a regular bus tour on the night of the launch and they are taken to the viewing site for that launch, and if there is a launch, they see it from a good vantage point. If there is not a launch, they don't get a rain check. That has been very popular with the public.

(Fig. 5) This building, on the right, Hall of History, is new. It was acquired as a part of the exposition. The new food service facility, cafeteria, is in the lower left corner of this picture.

Mr. FUQUA. You moved the cafeteria out of the other building?

Mr. ROSS. Space is now used for space applications exhibits. Here is a picture of the exposition (fig. 6). This was a very successful show with 600,000 visitors during the 101 days it was open.

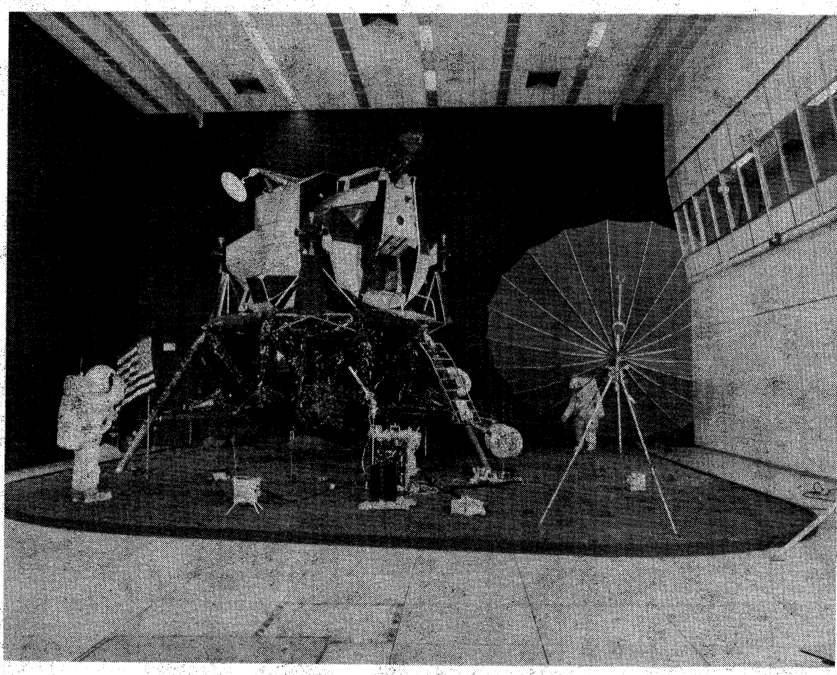


FIGURE 7

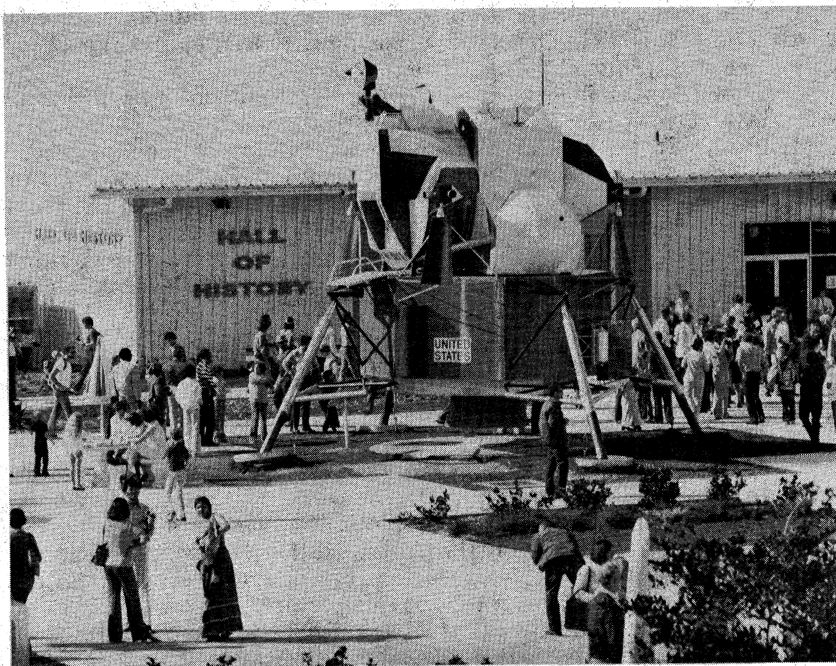


FIGURE 8

FIGURE 9

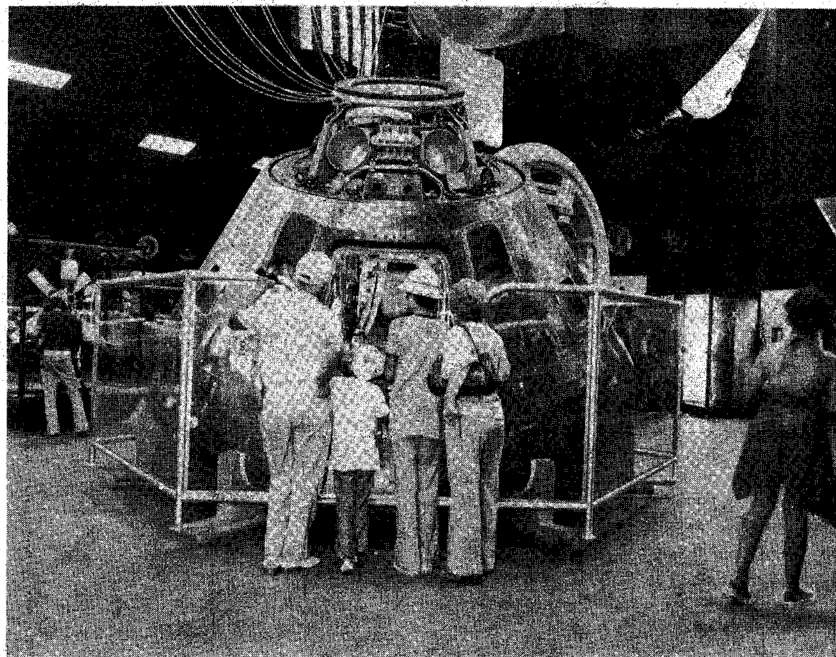


FIGURE 10

This display (fig. 7), a part of the bus tour, is in the flight crew training building. The Lunar module is the one Dave Scott was going to use. It was not equipped to handle a Lunar rover and by the time Dave was ready to fly, the Lunar rover was ready, so this module was set aside, and the next LM was used to go to the Moon.

Mr. ROSS. Then we show a display on the simulated lunar surface, the Apollo lunar surface, experiments that the astronauts are deploying, which is still operational on the Moon. This is the Hall of History (fig. 8) and here are a couple of pictures o fthe exhibits and displays inside (figs. 9 and 10). This has been extremely popular.

Mr. FREY. Did much of that equipment come from the exposition?

Mr. ROSS. Some, about 20 percent of the NASA exhibits used at the bicentennial exposition are now being used at the VIC, the remaining are at other NASA centers.

Mr. FREY. But these are artifacts.

Mr. ROSS. Yes, many are artifacts. These are the property of the Smithsonian Institute and are on a long-term loan to NASA.

The next two viewgraphs (figs. 11 and 12) show the extensive use of Apollo/Saturn facilities for the Shuttle program. The only major

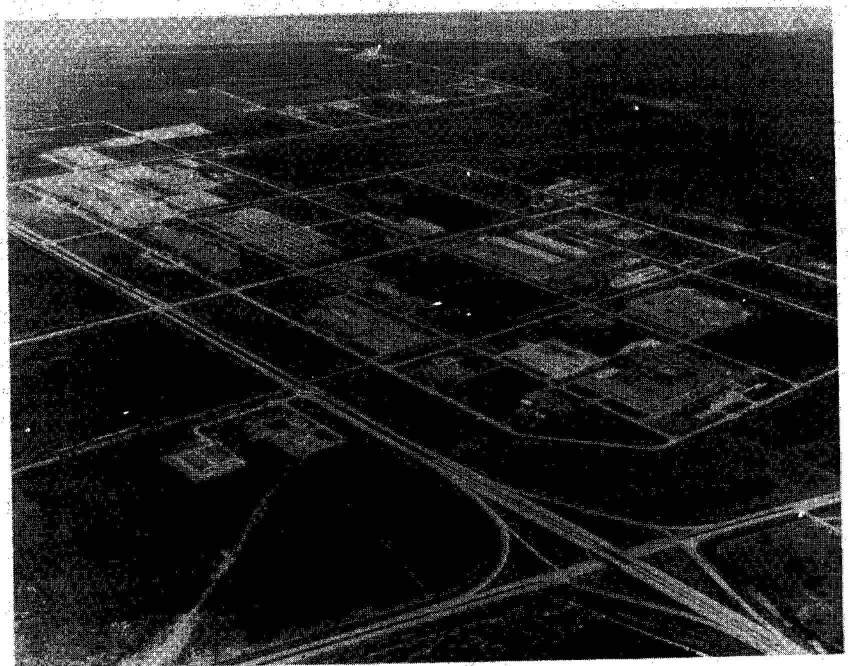


FIGURE 11

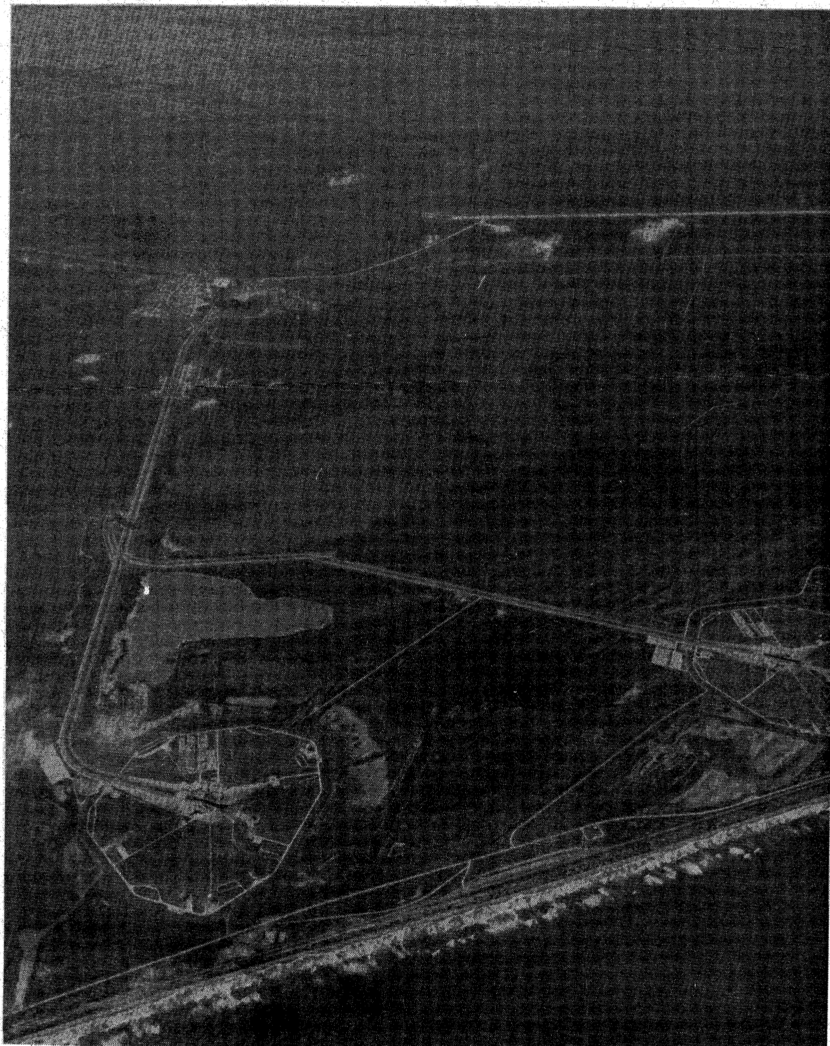


FIGURE 12

facility in this industrial area we are not going to use is the antenna site. We found that's not needed so we closed it down; but we will use the operations and checkout building, the fluid test complex buildings and the Spacecraft assembly and encapsulation facility will play a major role in our payload checkout and we'll see that a little later. At complex 39, we'll use the VAB, both launch pads, the converter compressor facility, and the runway which you landed on this morning. Launch pad A is being modified now for the Shuttle. We will use the cape industrial area (fig. 13) facilities which we have been using to check out the automated spacecraft which are presently launched with the expendable launch vehicles. We'll also use this hangar and the barge dock for receiving, cleaning and disassembly of the solid rocket boosters. They will be towed back to the mainland through the port locks to the cape and will be brought ashore here and disassembled, washed-down, and shipped back to the manufacturer for complete refurbishment and reloading of the solid propellant.

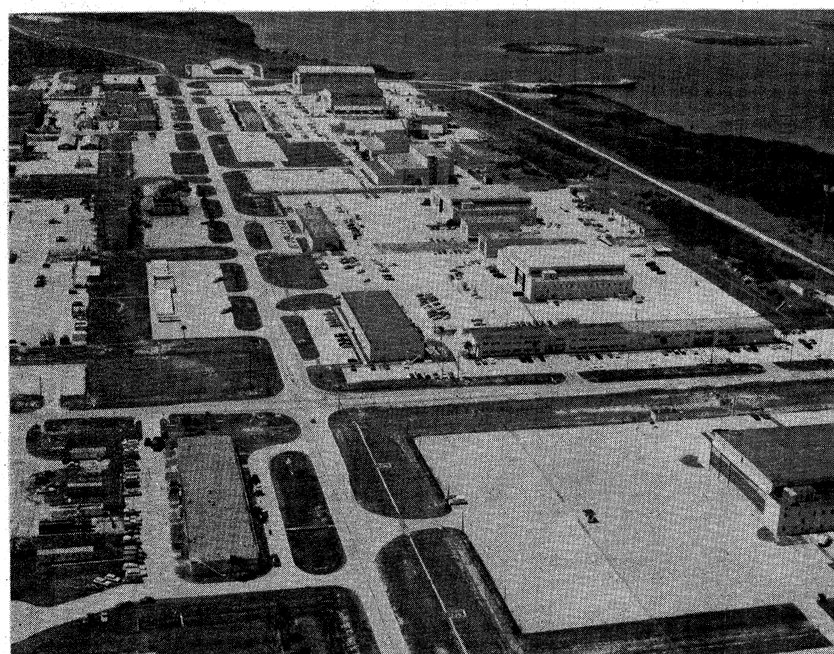


FIGURE 13

KSC LAUNCH SCHEDULE

CY	1977	1978	1979	1980	1981	1982	1983	1984
MANNED PROGRAMS								
SHUTTLE	△ FCF △ FAL		△ FMOF	△ OPER SHUTTLE				
SPACE LAB				△				
INTERIM UPPER STAGE				△				
SPIN-STABILIZED UPPER STAGE				△				
EXPENDABLE VEHICLES								
DELTA – ETR	▲△△△ △△△△ △△△	△△△△ △△△△ △	△△△△△ △△	△△△ △△				
DELTA – WTR	△	△		△	△△△			
ATLAS/CENTAUR – ETR	△△△△	△△△△ △△△	△△△△ △△△	△△△△				
ATLAS – F – WTR		△△△	△	△	△	△	△	△
TITAN/CENTAUR – ETR	△△							

FAL – FIRST ORBITER APPROACH & LANDING
FCF – FIRST CAPTIVE FLIGHT
FMOF – FIRST MANNED ORBITAL FLIGHT

▲ LAUNCHED △ SCHEDULED

REVISION 1-28-77-1

FIGURE 14

The next viewgraph (fig. 1) shows our schedule for Shuttle and expendable vehicle launches. The orbiter was towed to the Dryden Flight Research Center last Monday and we have some pictures of what we want to show you.

Mr. WINN. We probably saw them on TV.

Mr. ROSS. Yes, that was good coverage. The first orbital flight is scheduled for March 1979, and the Shuttle will be operational in 1980, as shown. In the meantime we have a very active program with the expendable launch vehicles, with 18 scheduled this year, 20 next year. We launched one, NATO, last week. We don't show Scout launches, since we're not involved in those, so you see some differences between our totals and those reported elsewhere.

Mr. FUQUA. That's mostly at Wallops isn't it?

Mr. ROSS. Yes; Wallops and the western test range. We do have a crew at the western test range to launch the Delta vehicles. For this year, there will be 18 launches, 13 will be reimbursable to NASA and 5 are NASA launches.

Mr. FUQUA. I see in your other chart that after 1980 you don't plan on any more expendable launches here.

Mr. ROSS. The schedule shows approved and funded flights only. The out years tend to fill up the page as you come within 3 years of the launch date. We expect a phase-in of Shuttle usage, and there may be some more expendable launch vehicles than we show on this chart. This is only accurate for the coming 3 years.

Mr. FUQUA. The point I was making is that you will, I assume, be using the Shuttle after 1980?

Mr. ROSS. Yes; we will, as rapidly as possible.

Mr. FUQUA. With that schedule going out to 1984 at the western test range, does that mean they're not going to be ready?

Mr. ROSS. The operational date for the western test range is——

Dr. GRAY. 1982 or 1983—it's further out. The expendables are used until the Shuttle is available at Vandenberg.

Mr. FUQUA. You show them as far as 1984.

Dr. GRAY. Well those are the Atlas-F class missions which would likely transition to Shuttle.

Mr. ROSS. These are here to show there is a mission and if the Shuttle is ready to launch that mission, then the Shuttle will be used.

Mr. FREY. But the dropoff is going to be quick, Mike, so nobody's going to say with our mission profile that we are really using both anyway.

Mr. ROSS. Just as rapidly as we can use the Shuttle, we will stop using expendable launches because they are so much more expensive.

Mr. FREY. Is there going to be a significant dropoff?

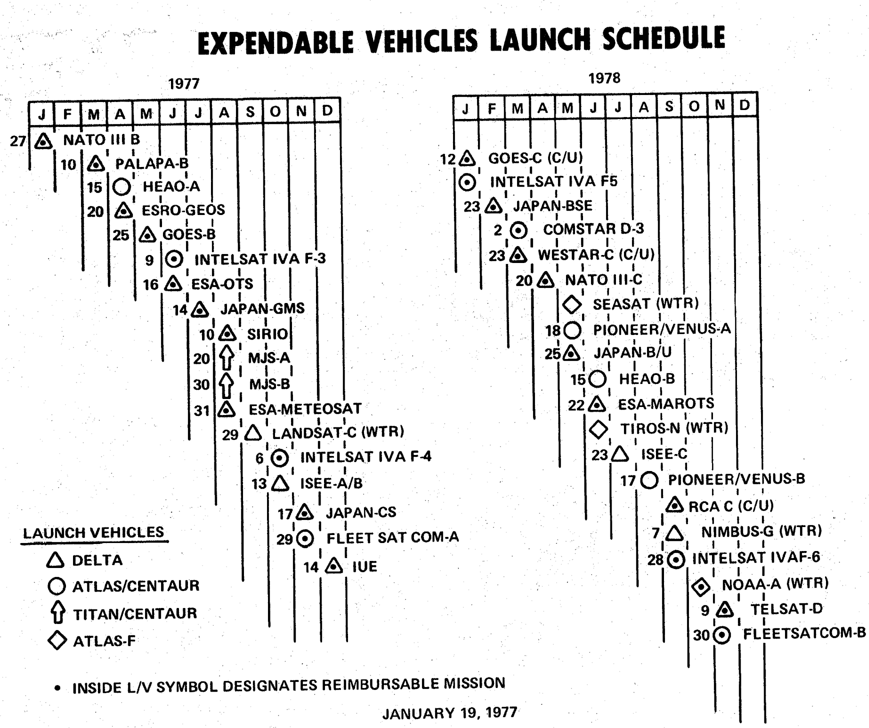


FIGURE 15

The NASA launches here—figure 15—include the Mariner-Jupiter-Saturn, MJS, and the International Sun-Earth Explorers. This is a joint mission with the European Space Agency. The United States is building spacecrafts A and C and ESA people will furnish spacecraft B and these will be launched as a pair and go into a highly elliptical orbit of 190,000 by 160 miles and once they are in orbit, they will be separated, and operated at a controlled distance from each other.

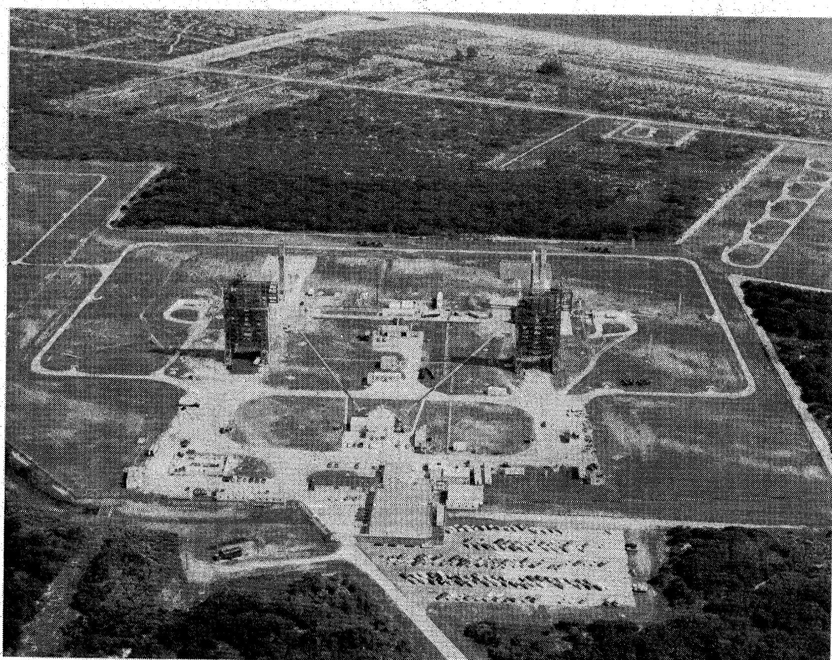


FIGURE 16

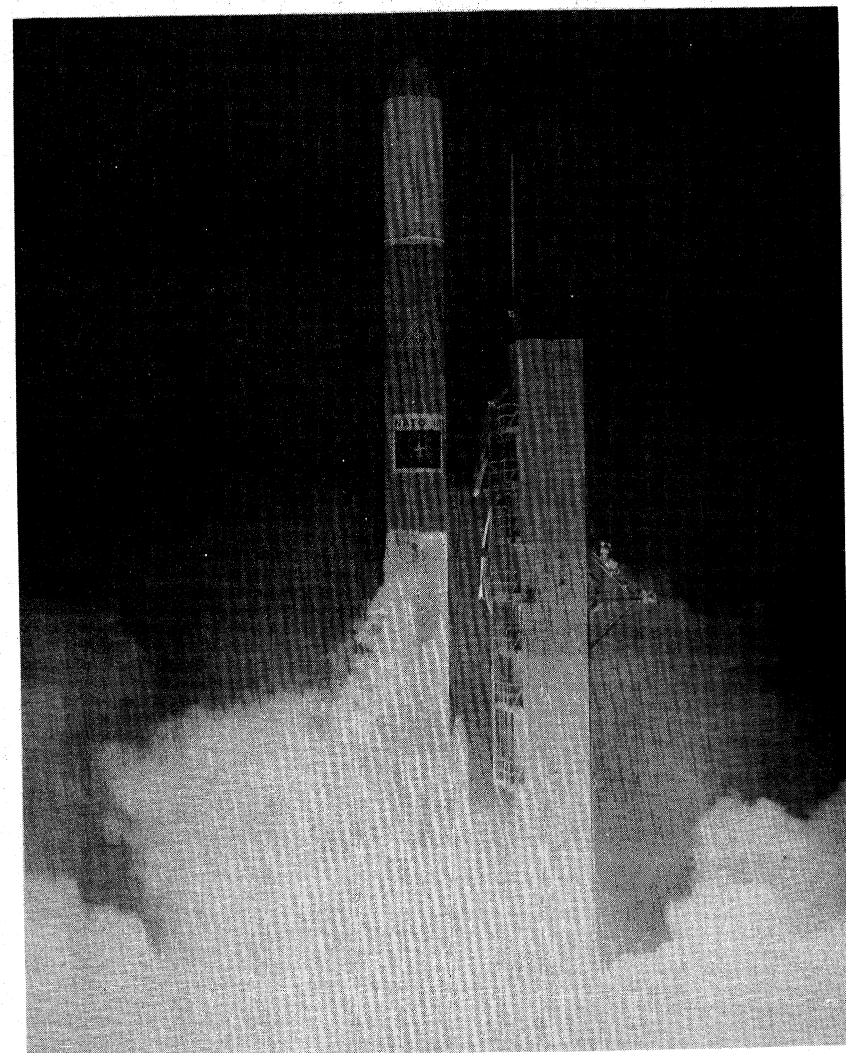


FIGURE 16–A

Now a quick look at the expendable launch vehicle program—Figures 16 and 16A. This NATO vehicle was launched last week, a successful launch, so our record so far——

Mr. FUQUA. Is this a communications satellite?

Mr. ROSS. Yes, it is. We had 13 launches last year, and all were successful for a 100-percent record. We hope to do the same thing this year.

Mr. FUQUA. Who built the payload for that?

Mr. ROSS. Ford Aerospace and Communications Corp.

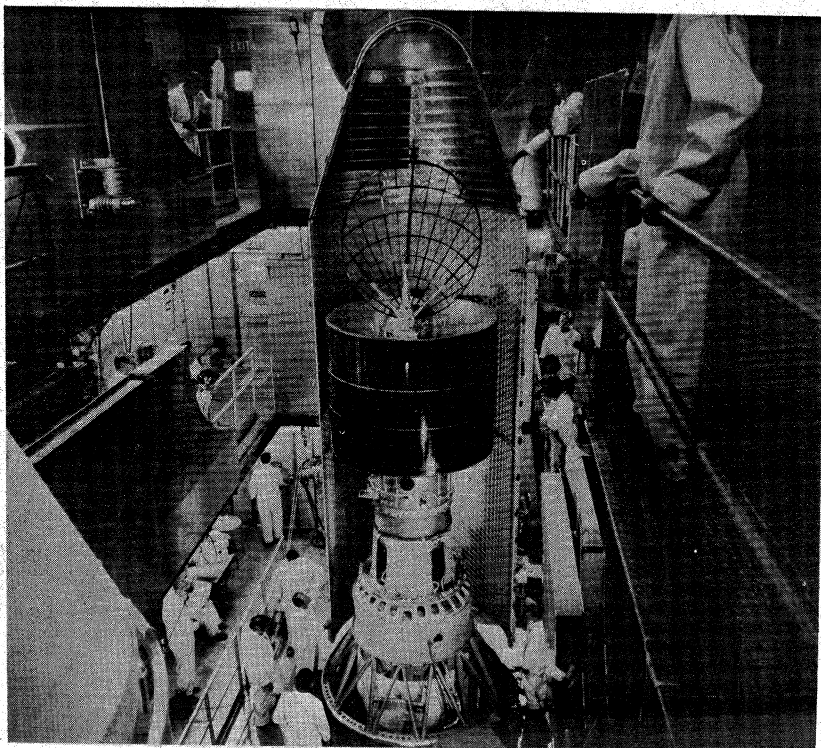


FIGURE 17

Mr. Ross. This is Westar, a representative payload for a Delta—figure 17. This Westar is used for facsimile transmission of the Wall Street Journal. It's transmitted from a plant in Massachusetts and received by a station in Orlando, page by page, and then is printed by offset press. A very practical use, we get the Wall Street Journal in good time.

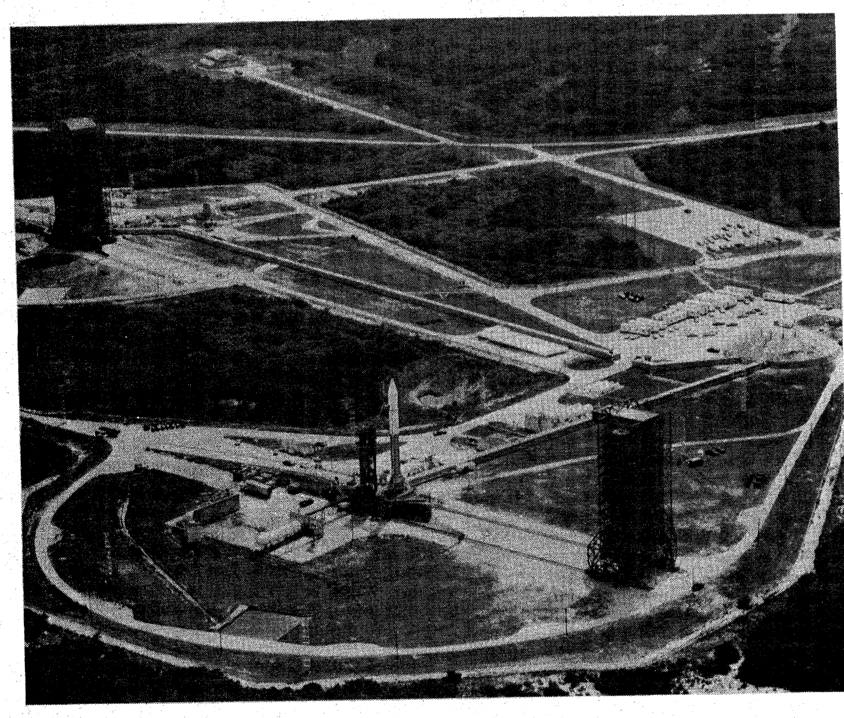


FIGURE 18

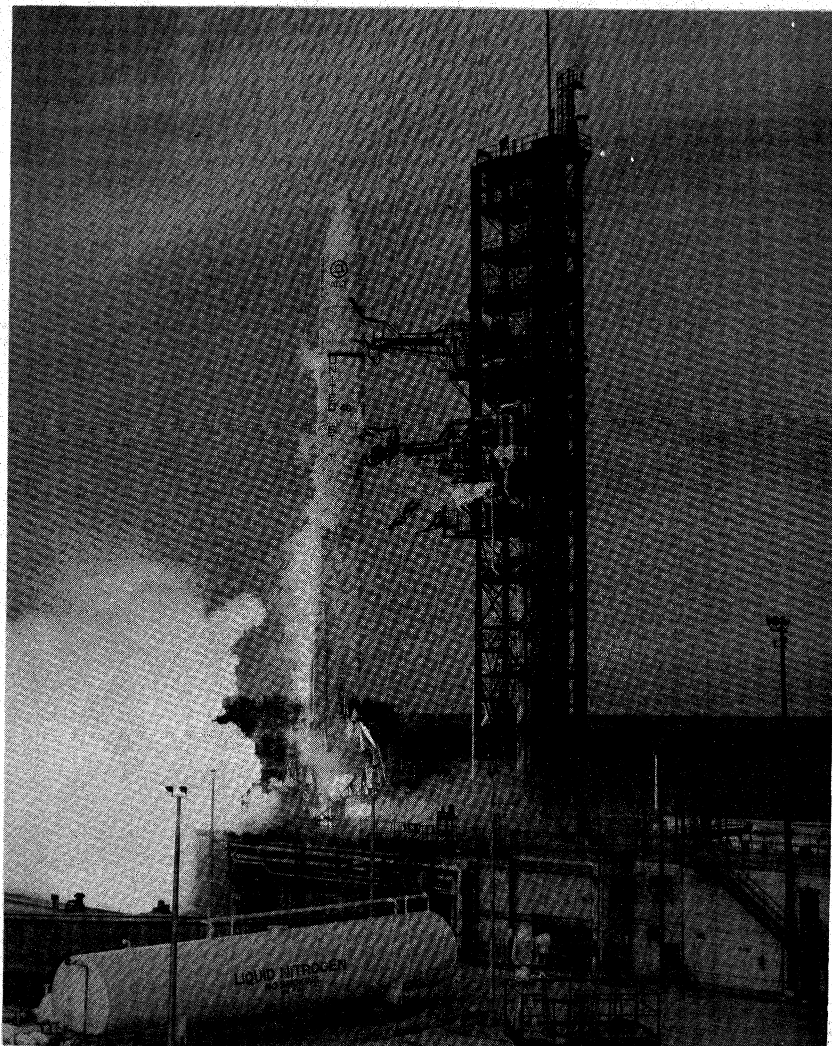


FIGURE 19

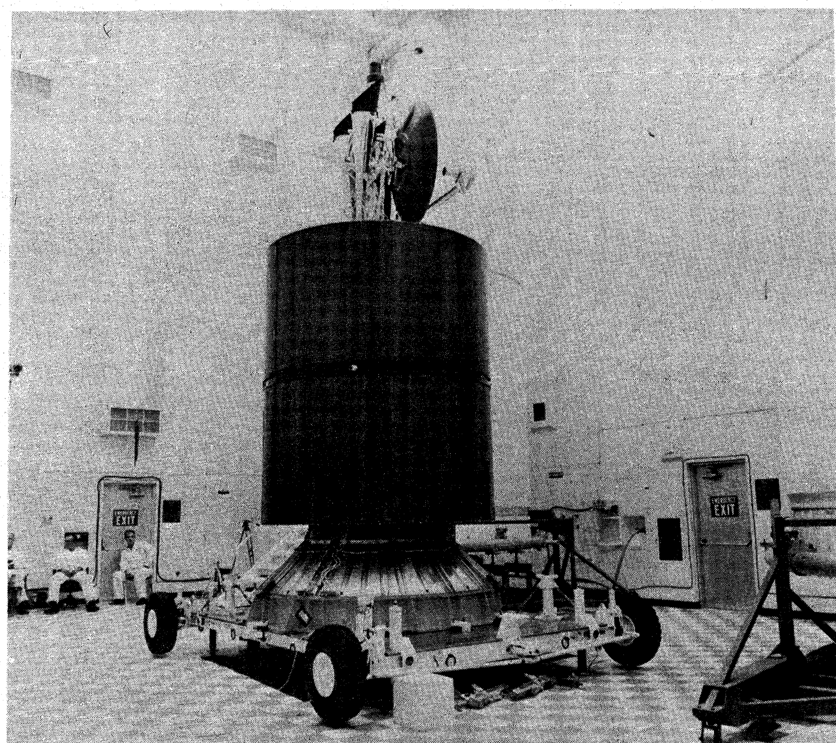


FIGURE 20

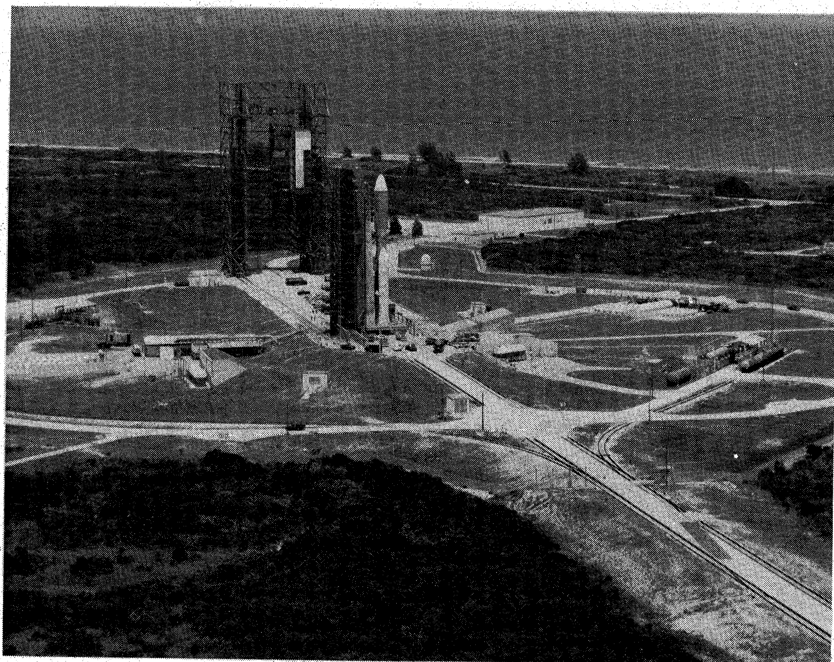


FIGURE 21

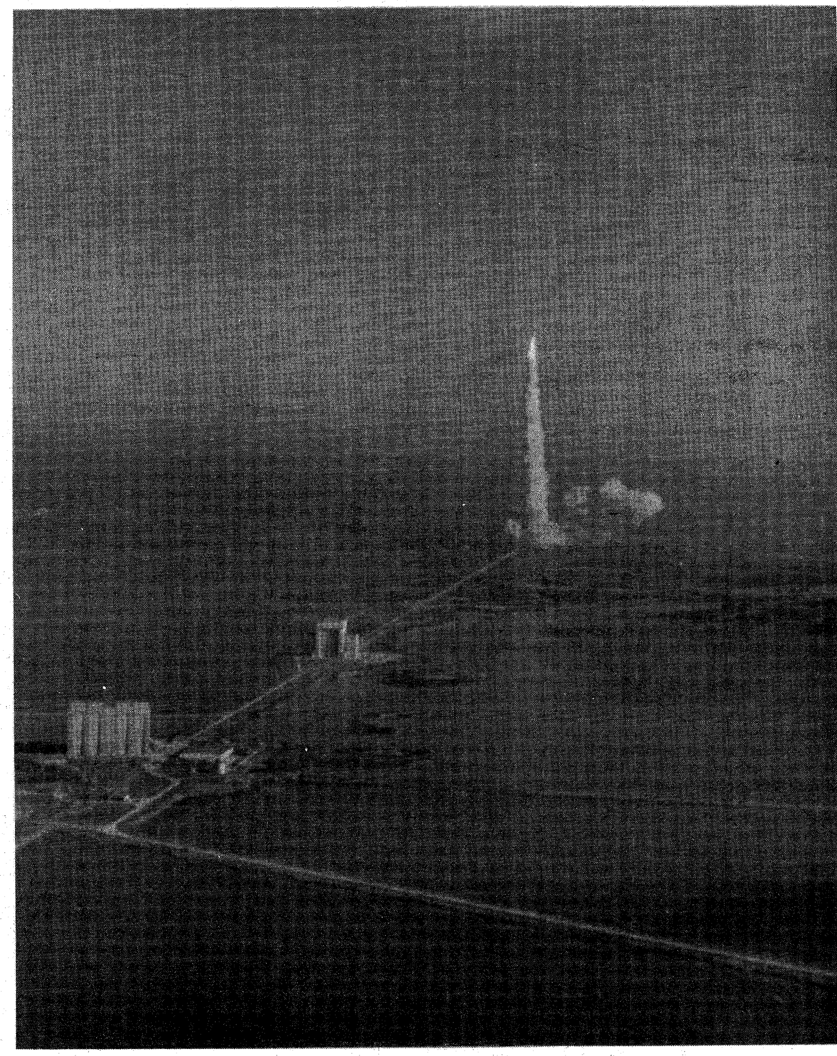


FIGURE 22

Next, the Atlas-Centaur Complex—figures 18–19—this was a Comstar launch. The spacecraft was built by Hughes, it is owned and operated by Comsat General and leased to A.T. & T. who in conjunction with GTE, operate communications capability with 14,000 telephone circuits that cover all 50 States and Puerto Rico. This is Intelsat 4—figure 20—which is representative of the payloads carried by Atlas-Centaur.

Next, the Titan-Centaur launch pad——figures 21 and 22. We will have two launches from pad 41 this summer—the Mariners to Jupiter/Saturn. This is the Viking spacecraft—figure 23.

Here is the Orbiter—figure 24—on the day of rollout at Palmdale. The Orbiter was towed to the Dryden Flight Research Center last

Monday—figure 25. Then it was placed in the mate/demate device which we see over here—figure 27—raised free of the transporter, the landing gear lowered and the Orbiter was lowered to the ground. Here it is being towed to the hangar for weight and balance test—figure 26. That test was completed yesterday, and the Orbiter will now go back into the mate/demate device to be lifted. This 747 will be towed directly under it and the two will be mated and taken to a hangar for mated ground vibration tests which will take place next week. One of the mods on the 747 are these mounts, forward and aft, for receiving the Orbiter.

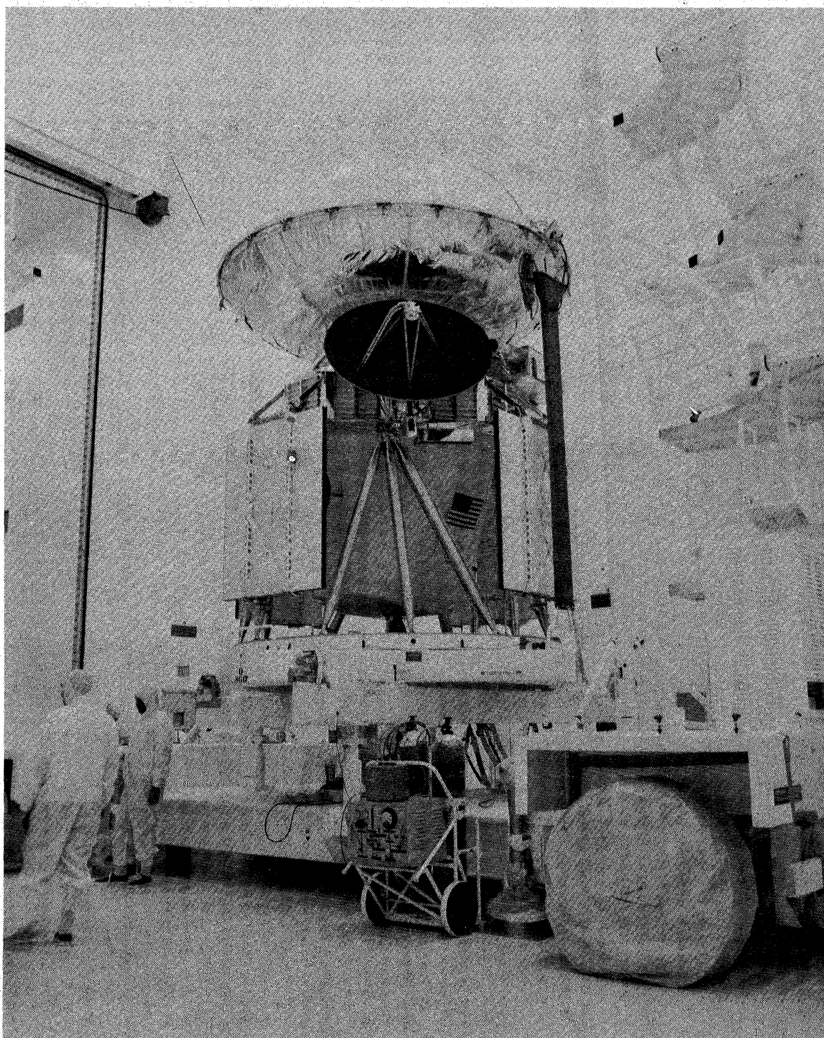


FIGURE 23

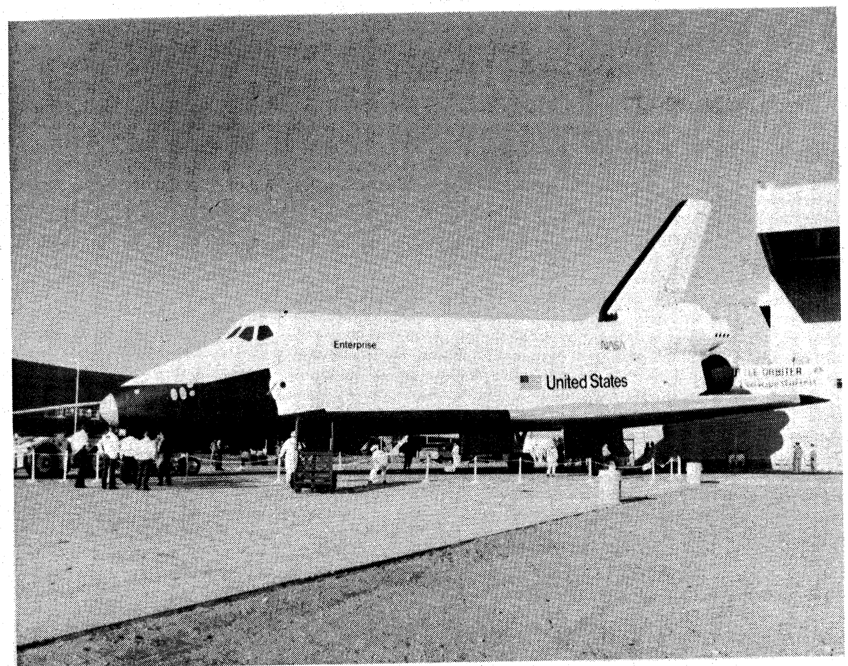


FIGURE 24

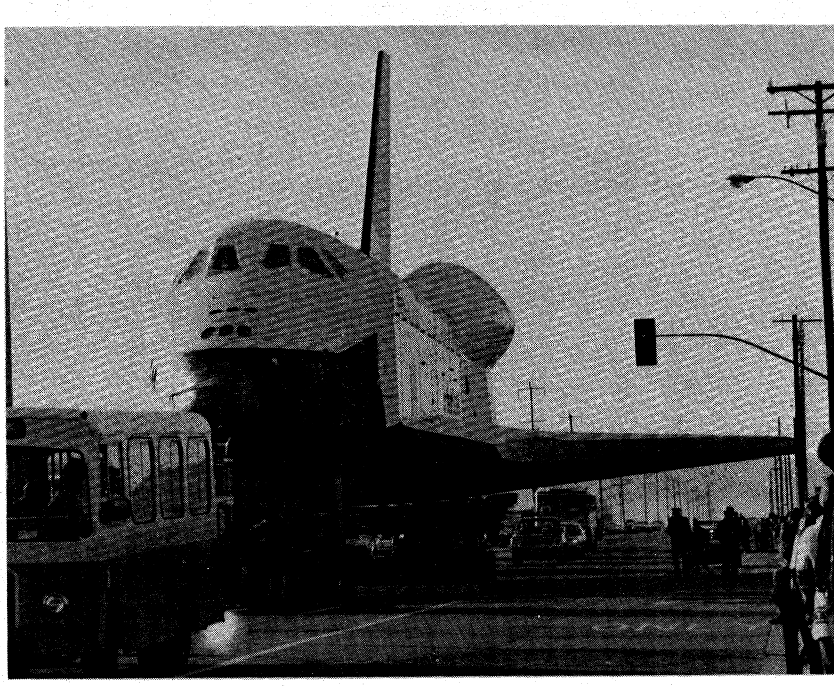


FIGURE 25

FIGURE 26

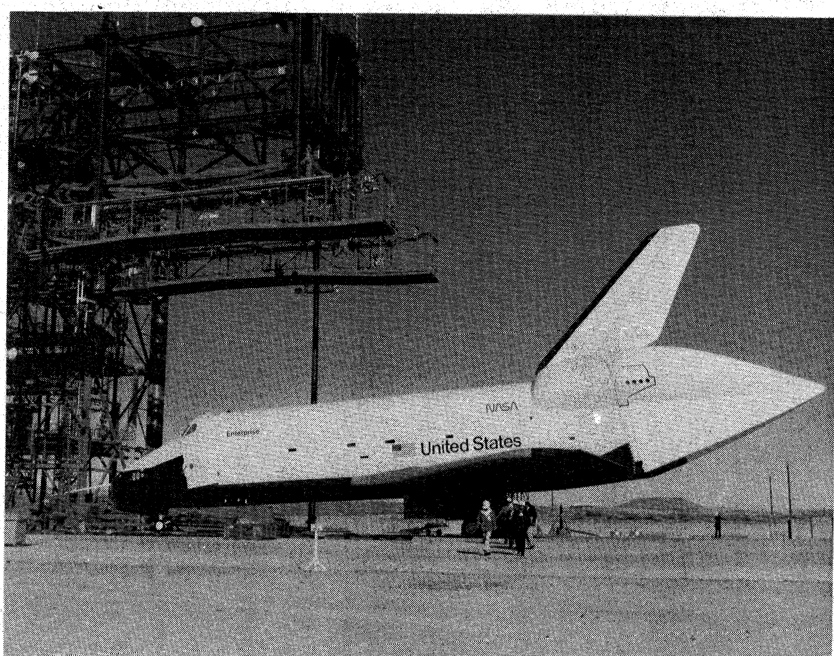


FIGURE 27

Mr. FUQUA. How does that lift work?

Mr. ROSS. Three hooks come down here powered by winches on the ground to pick up the Orbiter at the lift points. We'll see a model of this in the model room as soon as we're through here. You'll get a real good feel for how this whole device works, including these work platforms which can be lowered to provide access to of the Orbiter.

Dr. GRAY. There are attach points on the side of the Orbiter.

Mr. ROSS. The Orbiter is about the size of a DC-9, or the height of a Delta [figures 28 and 29].

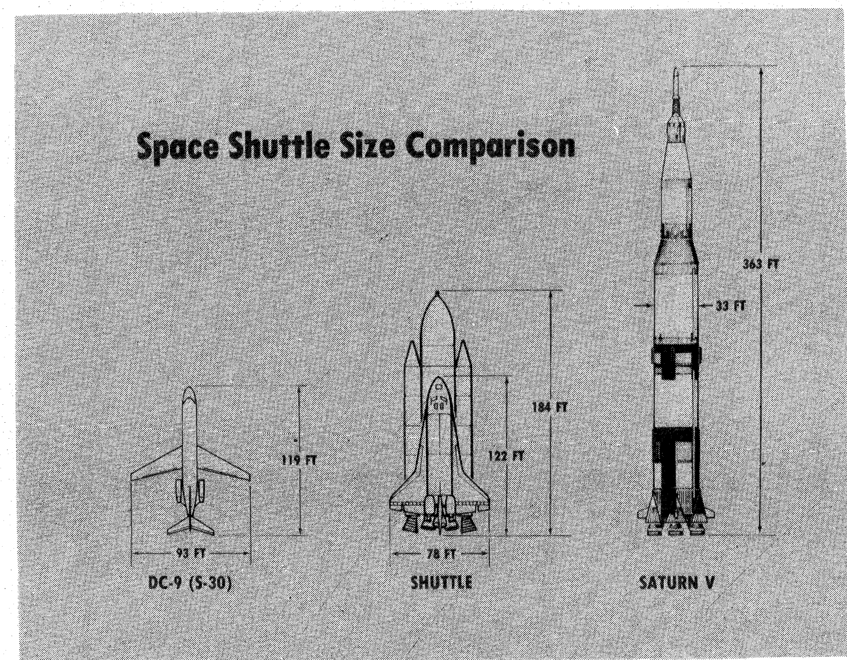


FIGURE 28

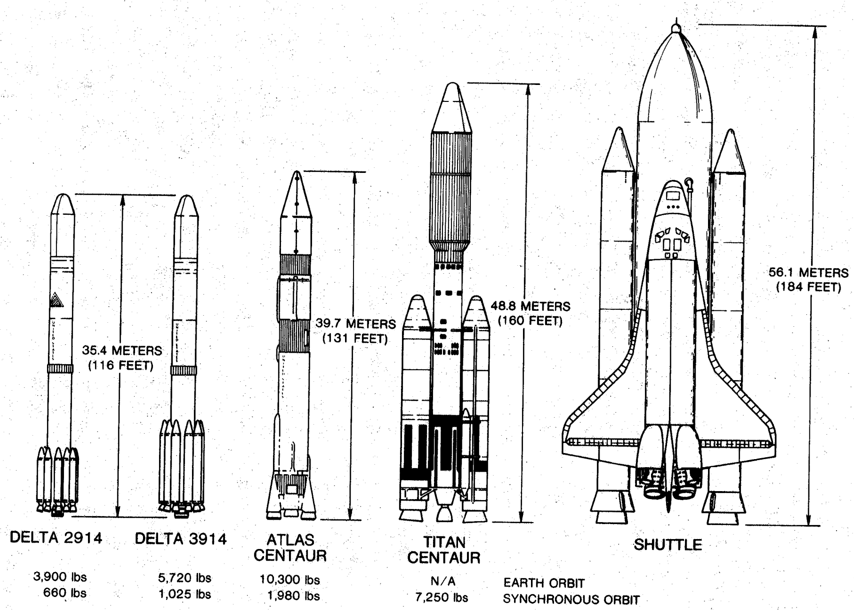


FIGURE 29

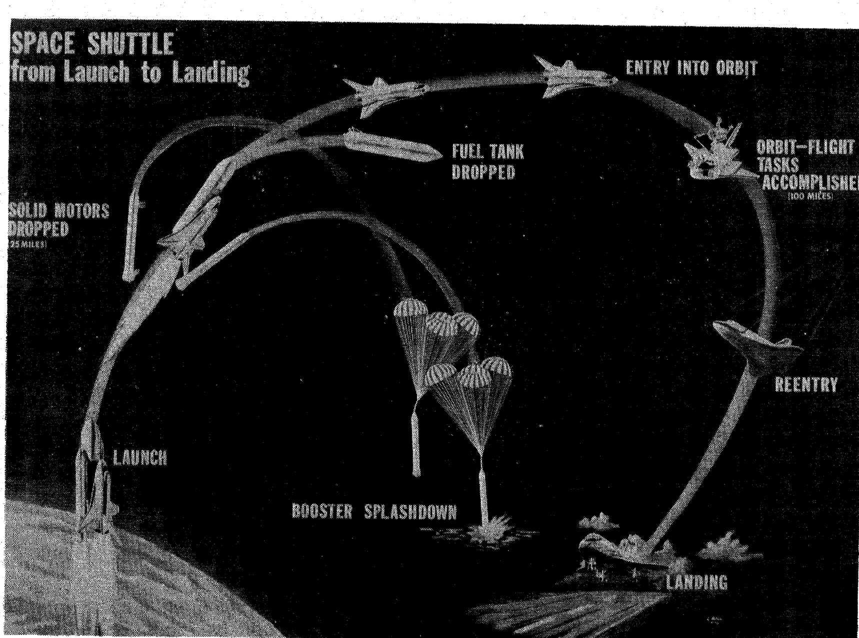


FIGURE 30

KSC MAJOR SHUTTLE FACILITIES

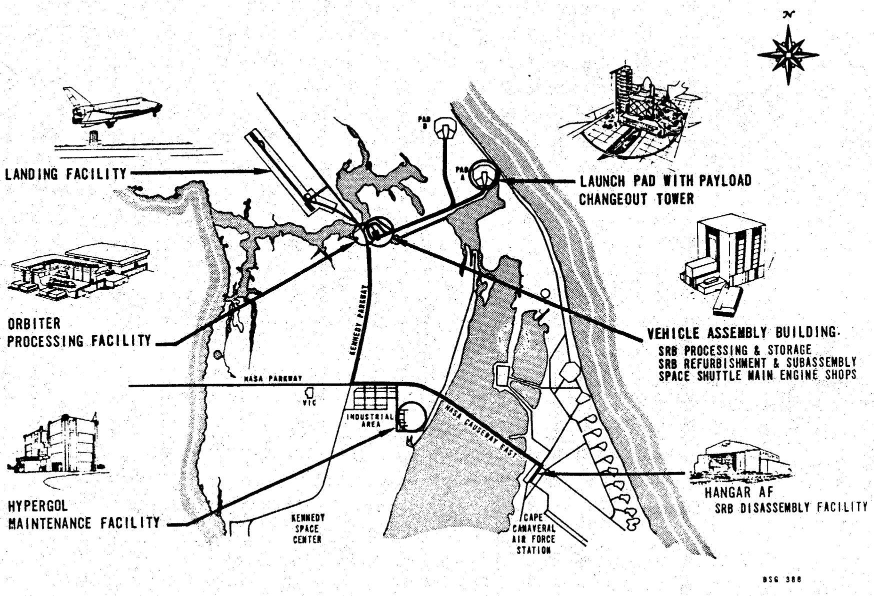


FIGURE 31

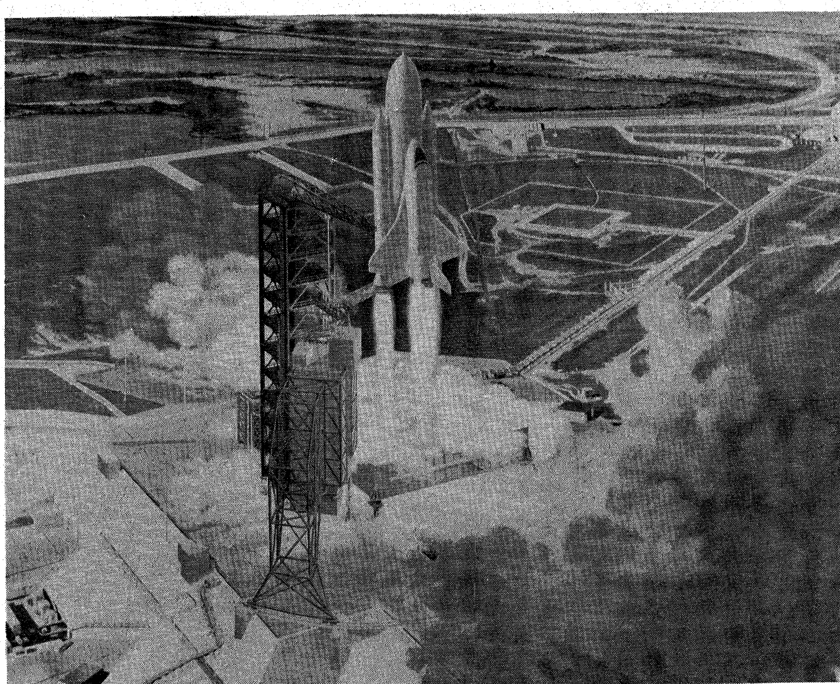


FIGURE 32

Here is the Shuttle mission profile [figure 30]. The first launches will be at pad 39A [figure 31] and the most significant change at the launch pad is the addition of a payload changeout room [figure 32] so payloads can be installed while the Orbiter is at the launch pad. The Air Force plans to use that almost exclusively. NASA will use that for some payloads, and will install some payloads horizontally in the Orbiter processing facility. Also we took the umbilical tower off the mobile launcher and reinstalled about two-thirds of it right at the launch pad, in a permanent installation.

Mr. FREY. Do you use the escape hatch chair for the launches like you did on other launches?

Mr. ROSS. There are ejection seats for the pilot and copilot for those flights with only two people aboard.

Dr. GRAY. We have the ingress/egress arm which will be used similarly to its use on Apollo.

Mr. CLARK. We only have the slide wires—we don't have the slide tubes down inside of the pad, we took those out. We only use the slide wires as emergency egress.

Mr. FREY. We're talking about getting in and out of the cabin, you mean? If he goes for a ride, how is he going to get out?

Mr. FUQUA. That was my question also.

Mr. ROSS. While the vehicle is on the pad, the crew will egress from the Orbiter through the side hatch, cross the access arm and jump in one of five two-man slide-wire baskets to slide down to the ground and then proceed to a bunker. Essentially the same slide-wire system as we had for Apollo. We don't have the rocket-propelled launch escape system.

Mr. FREY. How long would that take—2 minutes?

Mr. ROSS. That's from the time they leave their seat and get to the ground. When you have to you can get out in a hurry.

Dr. GRAY. Since their seats are on the upper deck, they have to leave them and go to the lower deck, open the hatch, through the hatch to the egress arm, across the arm to the tower and then down the slide wire to the ground.

Mr. ROSS. They can leave their seats and be outside the Orbiter in less than 30 seconds.

For the recovery of the booster (fig. 33) we will use this hangar as the receiving facility after they're towed back to the mainland. The Orbiter processing facility (fig. 35) will be the first stop for the Orbiter after it has landed (fig. 34) and has been towed along the tow way into a bay where we have work stands (fig. 36) for complete access to the Orbiter for safing, deservicing, removal of the payload, refurbishment of the thermal protection system and any other systems on the Orbiter that need refurbishing, and for installation of a new payload if the payload is scheduled for horizontal installation. The Orbiter is then towed next door to the VAB (fig. 37) where in the meantime the solid rocket booster and external tank have been assembled. The Orbiter is attached to the tank, and the complete assembly is rolled out to the launch pad.

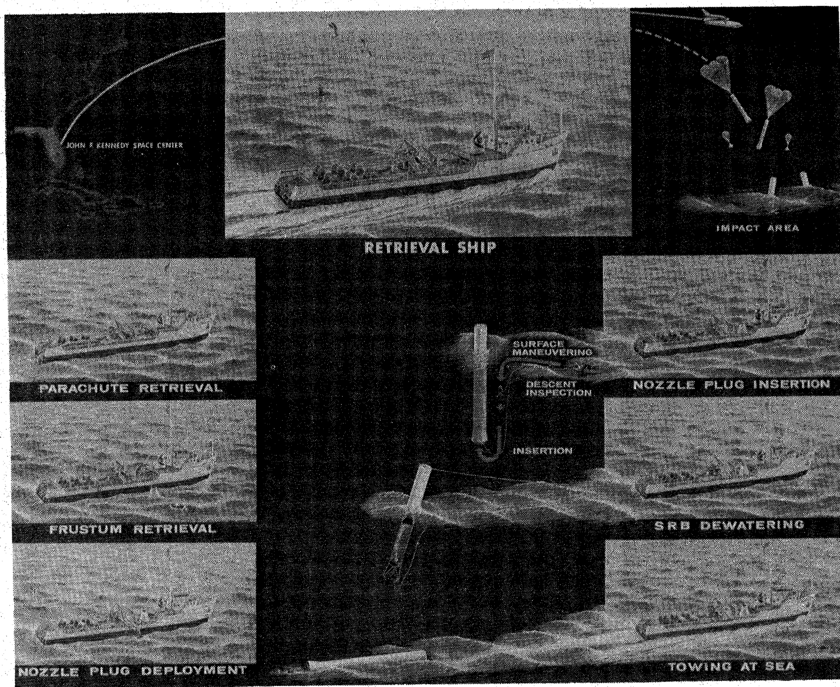

JOHN F KENNEDY SPACE CENTER
RETRIEVAL SHIP
IMPACT AREA
PARACHUTE RETRIEVAL
SURFACE MANEUVERING
DESCENT INSPECTION
INSERTION
NOZZLE PLUG INSERTION
FRUSTUM RETRIEVAL
SRB DEWATERING
NOZZLE PLUG DEPLOYMENT
TOWING AT SEA

FIGURE 33

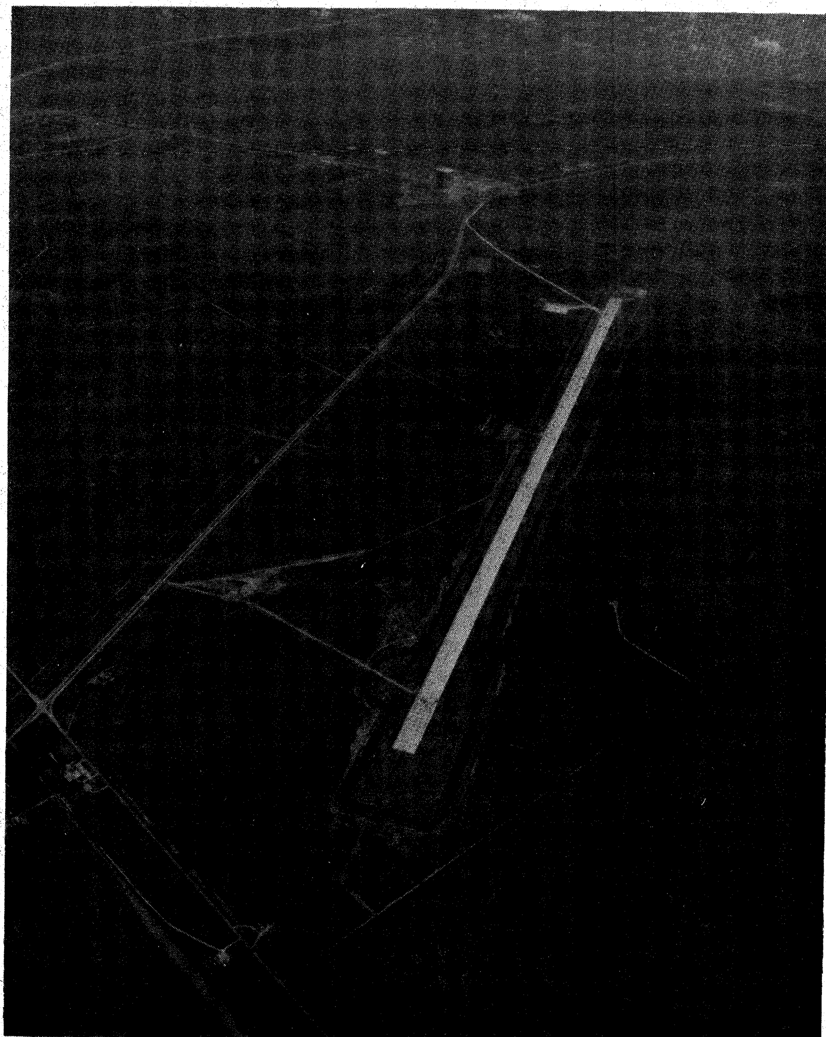


FIGURE 34

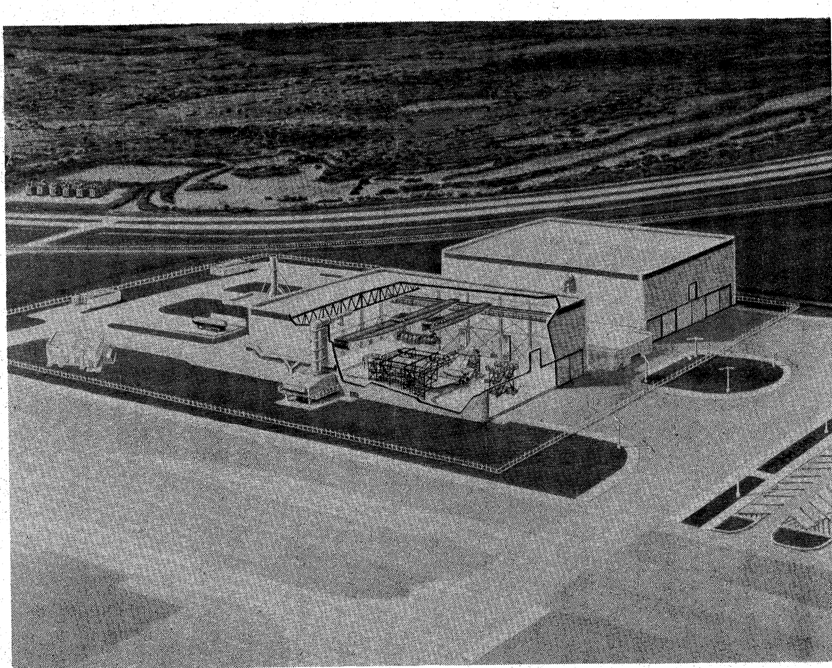


FIGURE 35

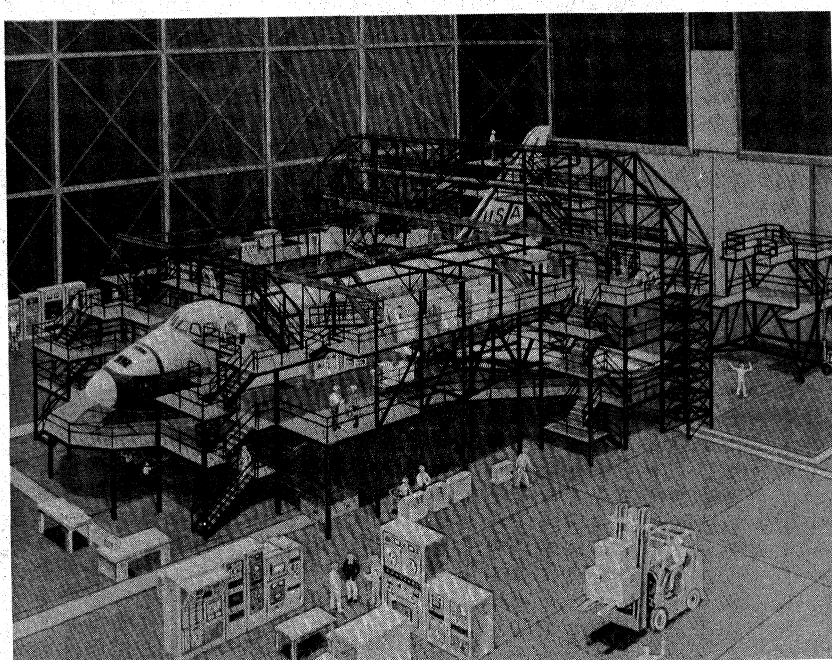


FIGURE 36

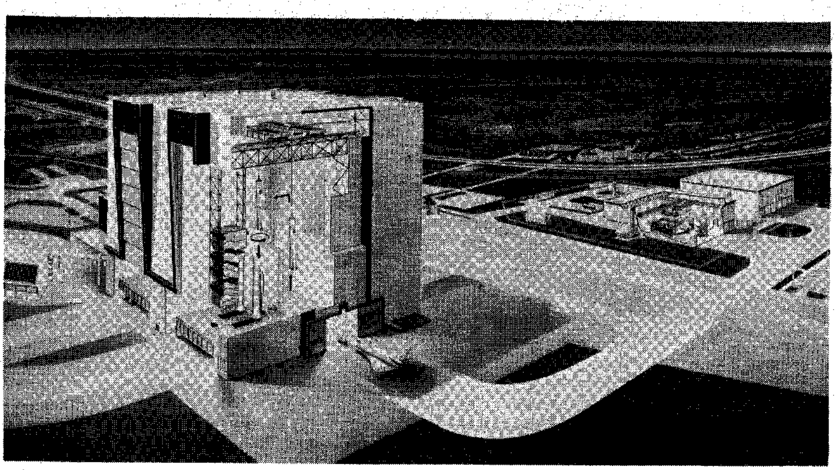


FIGURE 37

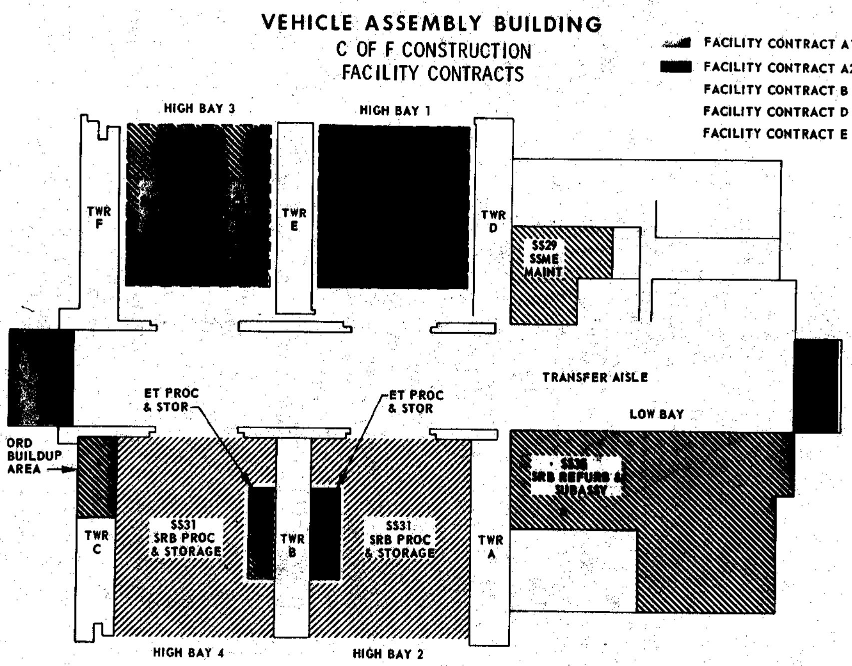


FIGURE 38

High bay No. 3 and No. 4 (fig. 38) will be used for our so-called first flow. Assembly and checkout of the Shuttle, SRB processing and storage, and external tank processing and storage will take place here also. Portions of the SRB's that we refurbish will go to the low bay area.

Mr. Frey. Do you have any percentage figure that we could use or talk about because I think you have done a super job in using the existing facilities. I've never really seen an overall figure percentage in terms of either cost or investment in what we're using for the Shuttle.

Mr. Ross. I'd say we're using approximately 95 percent or somewhere between 95 and 100 percent, of the facilities we used on Apollo. The new facilities we've built have been only the Orbiter processing facility, and the runway.

Mr. Frey. I don't think that you've really been given enough of a pat on the back for that. I think that that's super, really. The Government has gotten it's money's worth out of this.

Mr. Ross. Thank you, Mr. Frey.

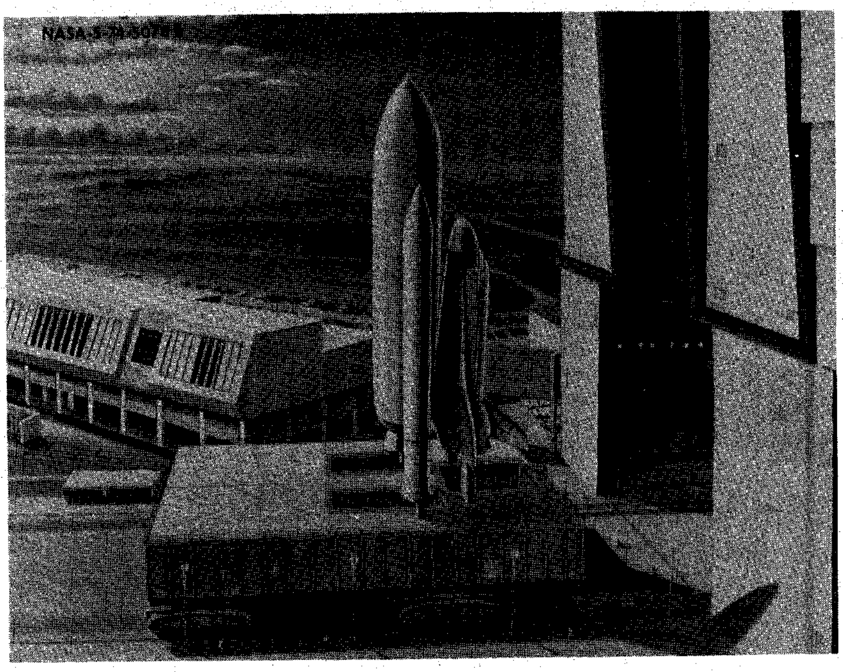


Figure 39

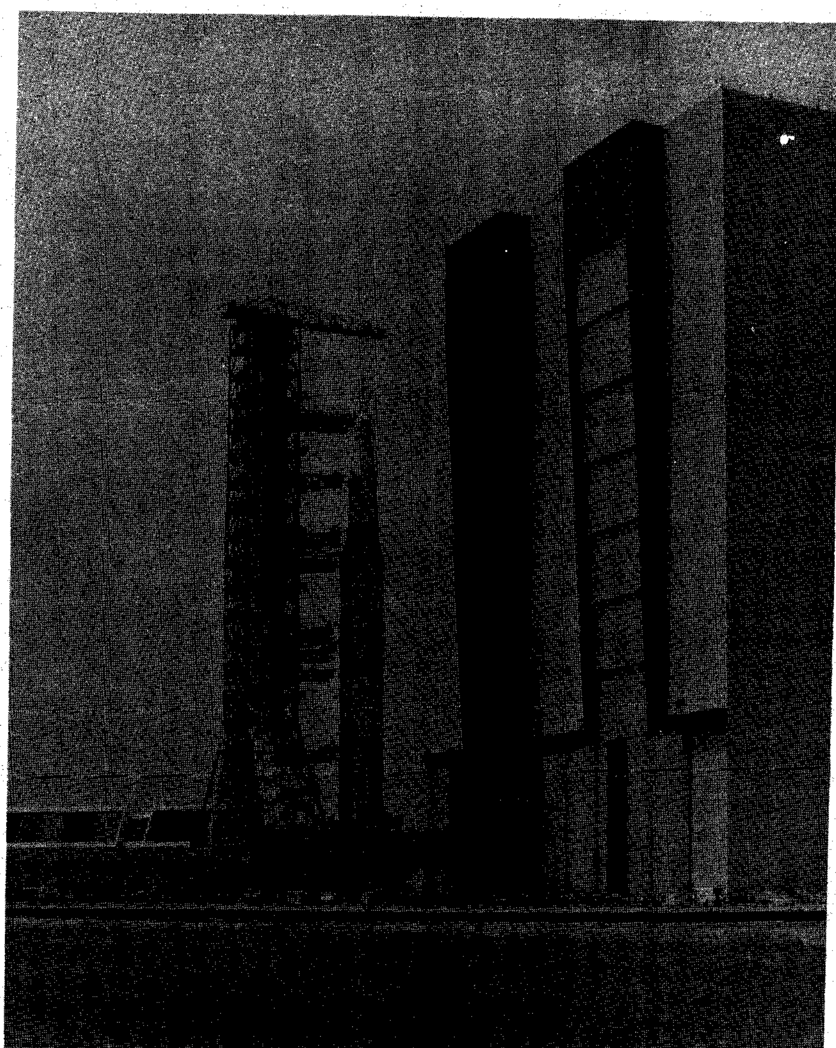


FIGURE 40

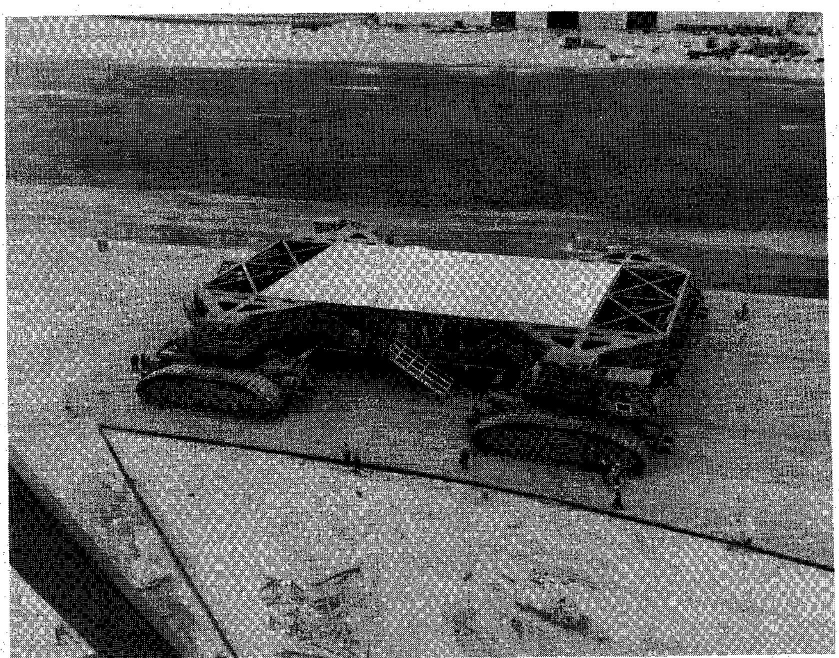


FIGURE 41

Then we will roll out (fig. 39), on the reconfigured mobile launch platform—reconfigured to provide exhaust paths both for the solid rockets and the three main engines in the Orbiter similar to the Apollo rollout (fig. 40). We use the same crawler-transporter (fig. 41) with no modifications from Apollo. The Crawlers by the way, were designated a National Historic Mechanical Engineering Landmark yesterday by the American Society of Mechanical Engineers. And I think Ray Clark, in his talk, indicated that they are good for another 5,000 miles.

Mr. CLARK. They're going to have to be good.

Mr. ROSS. Work on the Crawlers started in 1962 and we will be using them for at least 10 more years, into the 1980's and 1990's.

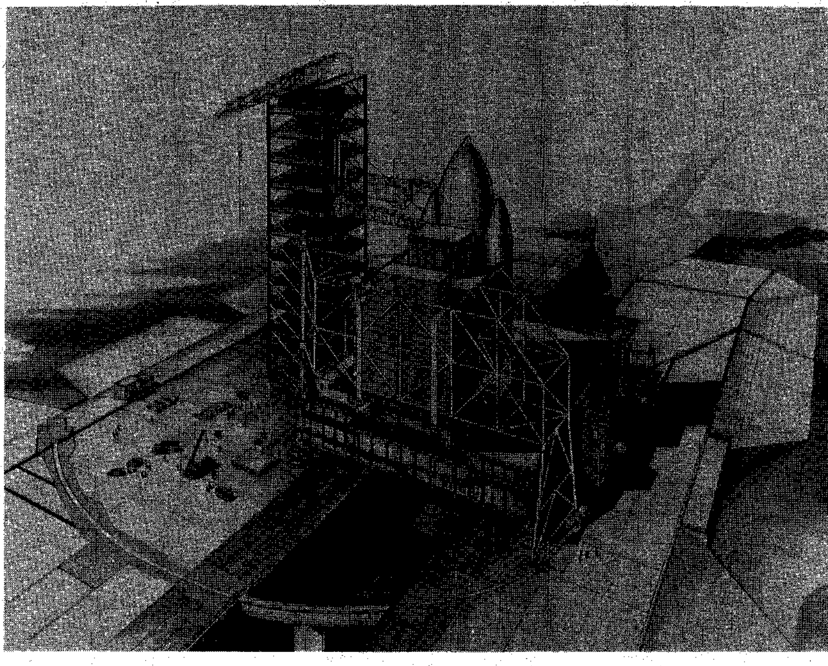


FIGURE 42

This is the pad configuration (fig. 42) as it will look with the payload changeout room and the Space Shuttle access tower, same hammerhead crane——

Mr. FUQUA. And that rolls away?

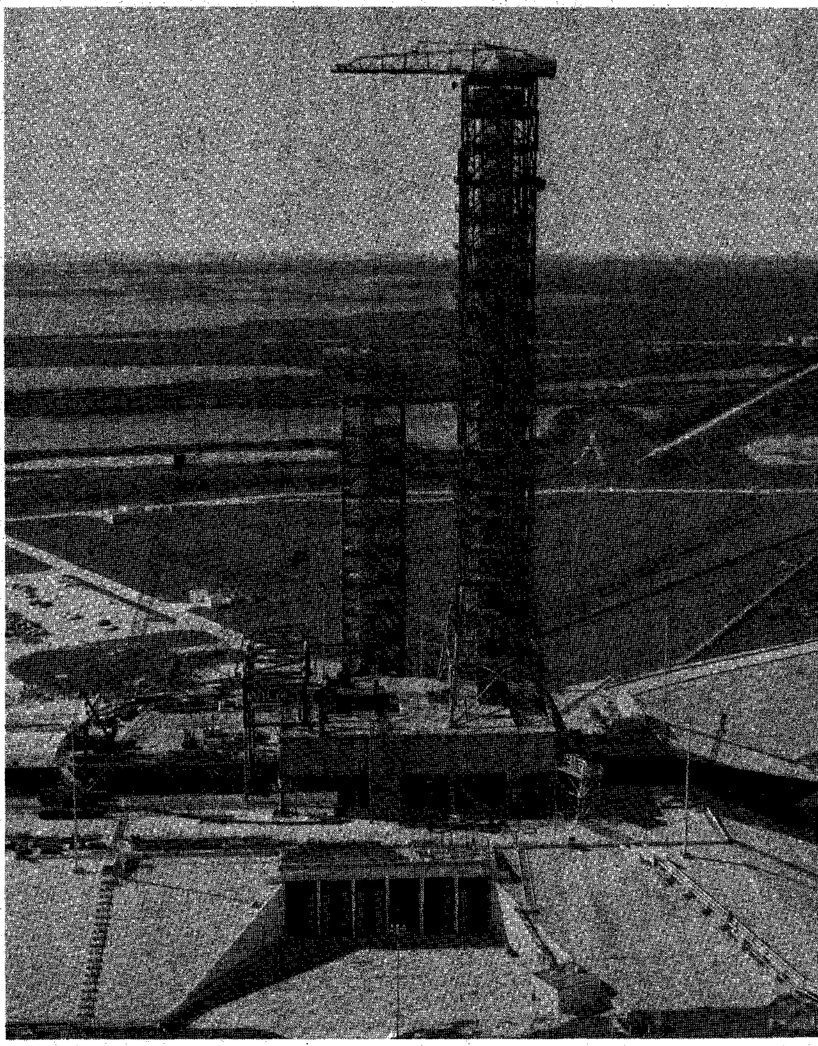


FIGURE 43

Mr. Ross. Yes; this swings aside on these tracks to the packed position. We can see this under construction over here (fig. 43) in fact we are using one of the mobile launchers to provide it support for the main beams at the bottom of the payload changeout room. This tower is complete.

I wanted to bring up this picture (fig. 44) to show the simpler operation we will have on Shuttle. You recall we had nine service arms; five of which swung aside only after the vehicle lifted ¾ inch. They were very expensive to maintain and operate. For the Orbiter we'll have only two access arms, the one for crew access into forward cabin, and one for a hydrogen vent line.

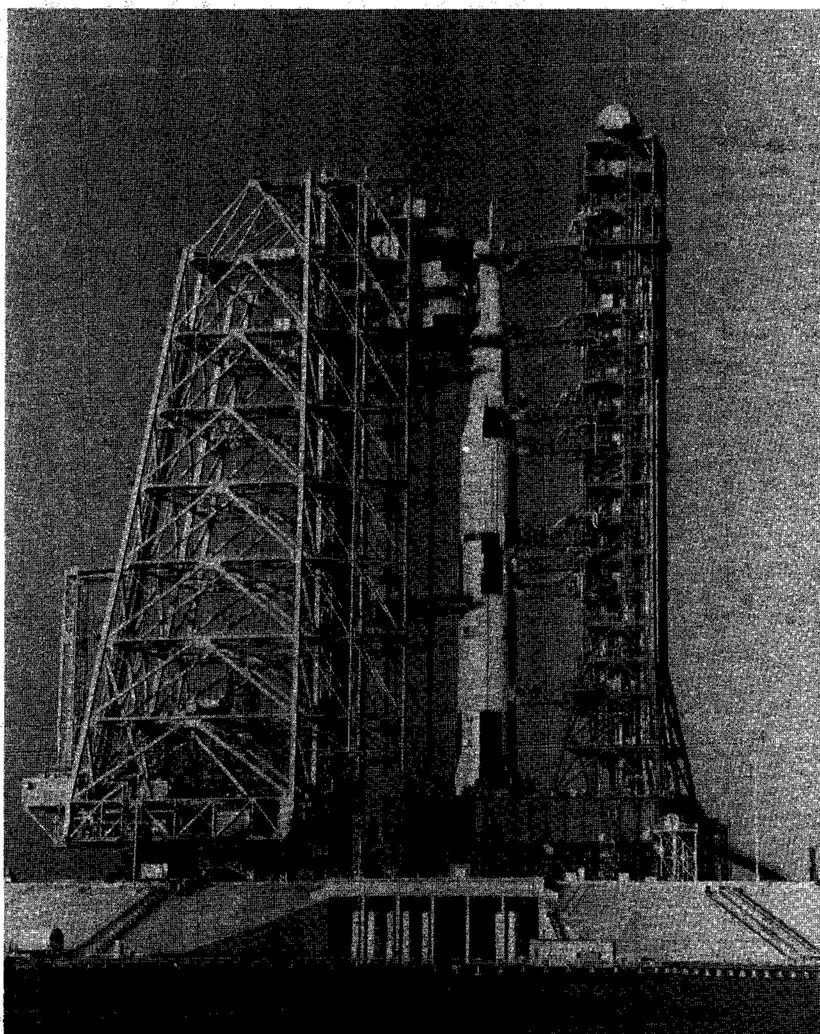


FIGURE 44

Mr. FUQUA. Do you have a chart on the abort, in case there is an abort, the procedure?

Mr. ROSS. We don't have a chart in this morning's briefing, but the Orbiter will have the capability to return to the launch site and land on the runway in case of an off-pad abort.

Mr. FUQUA. Suppose at lift-off there was a problem.

Mr. ROSS. If there is a problem, that says the crew should not go into orbit, they would return to the Shuttle runway, without going into orbit. If this should happen later on, there is also a mode that calls for a once around abort and return to launch site. Or they could land at Edwards, the secondary landing site.

Mr. FUQUA. Suppose that 1 minute after lift-off there is a problem. Fuel is not flowing properly, for example.

Mr. ROSS. Or the main engines don't work.

Mr. FUQUA. Yes; or two of them cut out or something like that.

Mr. ROSS. They continue until solid rocket booster burnout.

Mr. FUQUA. They have to wait until the SRB's burnout?

Mr. ROSS. Yes. There is no capability to jettison a burning SRB.

Mr. FUQUA. That would be dangerous, too, I guess.

Dr. GRAY. It's not possible as a matter of fact to separate mechanically. The only options you've got, as long as they have the ejection seats, you could use the ejection seats. Once they are taken out, and they are only flown for the first few missions, the only option you've got is to continue to SRB burnout at which time you can separate.

Mr. FUQUA. That's 2 minutes?

Dr. GRAY. Yes; that's about 2 minutes. Then, if two of the three main engines are still working, in other words, the problem did not involve them, you can return to launch site or proceed to orbit and return to a landing site from orbit.

Mr. FUQUA. Can you jettison the big fuel tank?

Dr. GRAY. The external tank? It would depend on which way you go. The big fuel tank would stay with you if you proceed to orbit, and the fuel tank would stay with you on a return to launch site. This is because you'd have to power the engines to turn the Orbiter around and bring it back to the mainland. You would then drop the tank off the coast and the Orbiter would then coast to the KSC runway. Now if the problem was failure of more than one of the three main engines, after the solids shut down, you would separate the Orbiter from the tank and ditch it in the Atlantic Ocean, that would be the only remaining alternative.

[Material submitted for the record follows:]

SHUTTLE LAUNCH ABORT REVIEW

SCOPE OF REVIEW

INTRODUCTION AND OVERVIEW

RETURN TO THE LAUNCH SITE

ABORT ONCE AROUND/ABORT TO ORBIT

OVERALL BACKGROUND

- ABORT CAPABILITY PROVIDES PROTECTION AGAINST FAILURES WHICH ARE BOTH CREDIBLE AND CRITICAL

- INHERENT IN THE SHUTTLE DESIGN, CREDIBLE FAILURES DO NOT RESULT IN A LOSS OF CRITICAL FUNCTION
  - THIS IS ACCOMPLISHED IN THE SHUTTLE DESIGN BY:
    - SELECTION OF COMPONENTS WITH GENERIC RELIABILITY
    - REDUNDANCY
    - SAFETY MARGINS

LOSS OF CRITICAL FUNCTION

- NO PLANNED ABORT PROTECTION AGAINST THE FOLLOWING HIGHLY IMPROBABLE CRITICAL FAILURES - RESULTING IN A LOSS OF CRITICAL FUNCTION
  - ET RUPTURE/EXPLOSION
  - SRB BURNTHROUGH
  - MAJOR STRUCTURAL FAILURE
  - COMPLETE LOSS OF GUIDANCE AND/OR CONTROL
  - FAILURE TO IGNITE 1 SRB
  - LOSS OF THRUST FROM 1 SRB
  - SSME OR SRB TVC HARDOVER
  - FAILURE TO SEPARATE ORBITER FROM ET
  - NOZZLE FAILURE
  - PREMATURE SRB SEPARATION
- THESE FAILURES ARE HIGHLY IMPROBABLE BECAUSE OF THE SHUTTLE DESIGN: GENERIC RELIABILITY, REDUNDANCY, SAFETY MARGINS

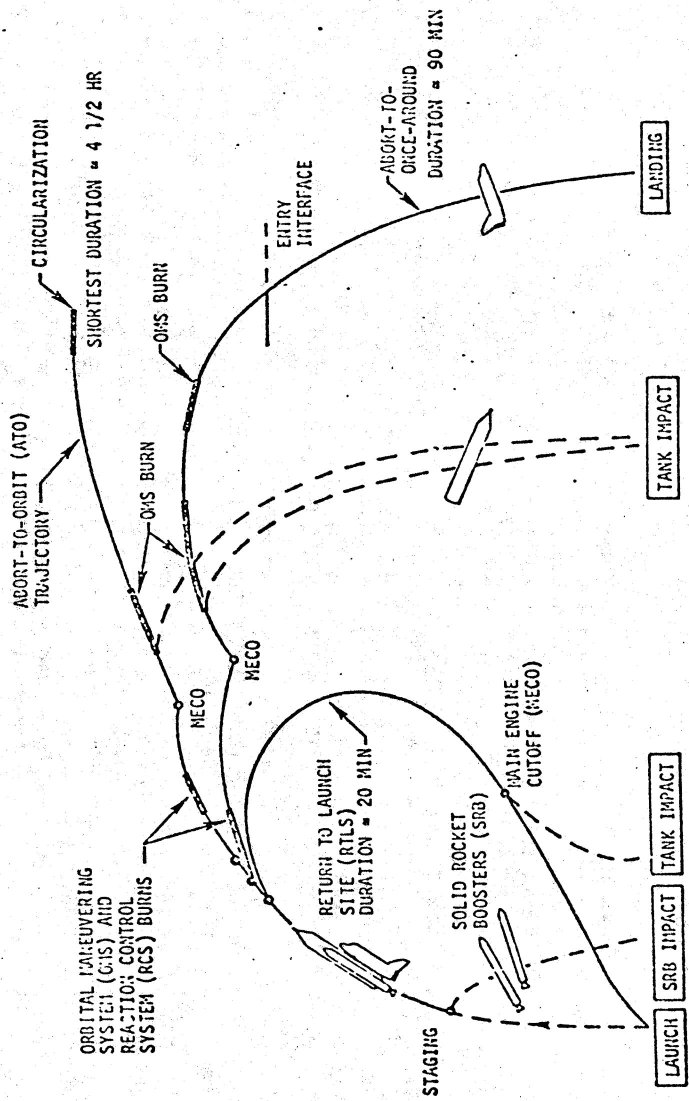
TYPES OF ABORT

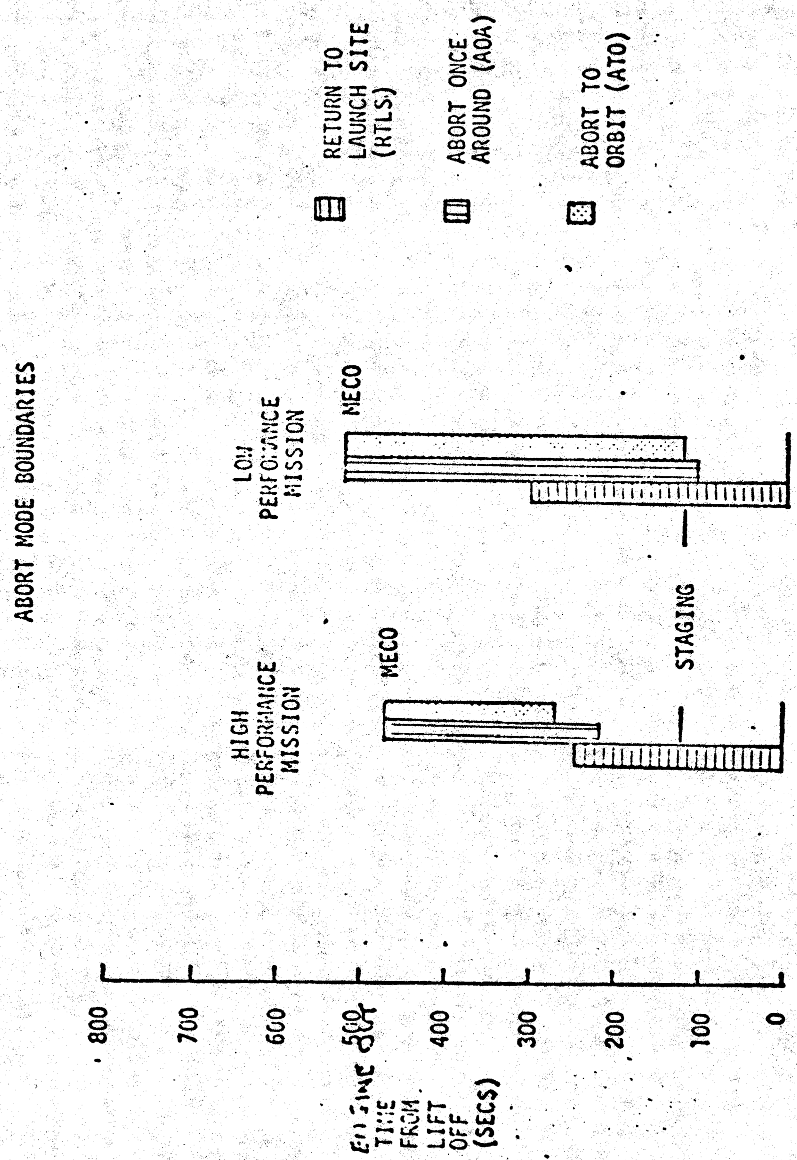
- THERE ARE TWO CATAGORILS OF ABORT CAPABILITY; INTACT AND CONTINGENCY
- FIRST LET US CONSIDER THE INTACT TYPE, THE FOUNDATION OF THE SHUTTLE ABORT CAPABILITY

	INTACT
DEFINITION	○ SAFE RETURN OF PERSONNEL, PAYLOAD, AND ORBITER TO RUNWAY
DESIGN CRITERIA	○ PROTECTION AGAINST COMPLETE OR PARTIAL LOSS OF THRUST FROM ONE ORBITER MAIN ENGINE ○ OR LOSS OF THRUST FROM ONE ORBITAL MANEUVERING SYSTEM ENGINE
ACTUAL CAPABILITY	○ PROVIDES THE NECESSARY ABORT CAPABILITY FOR OTHER FAILURES. EXAMPLES INCLUDE • LOSS OF 2 COMPLETE AVIONICS STRINGS • LOSS OF ONE HYDRAULIC AUXILIARY POWER UNIT • SOME LIFE SUPPORT SYSTEM FAILURES • LOSS OF ONE ORBITER MAIN ENGINE PLUS ONE ORBITAL MANEUVERING SYSTEM ENGINE

5

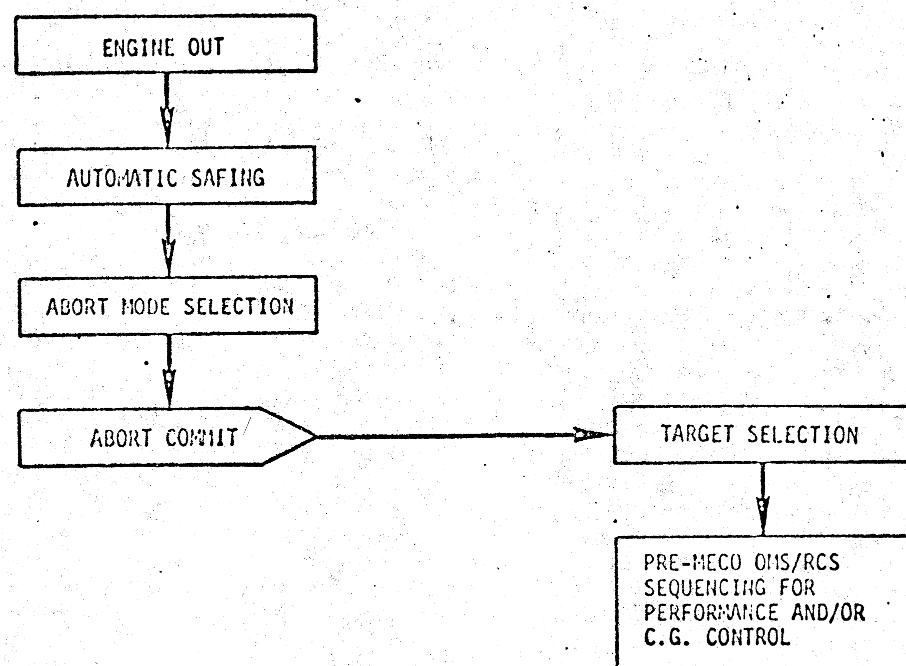
TYPES OF INTACT ABORTS





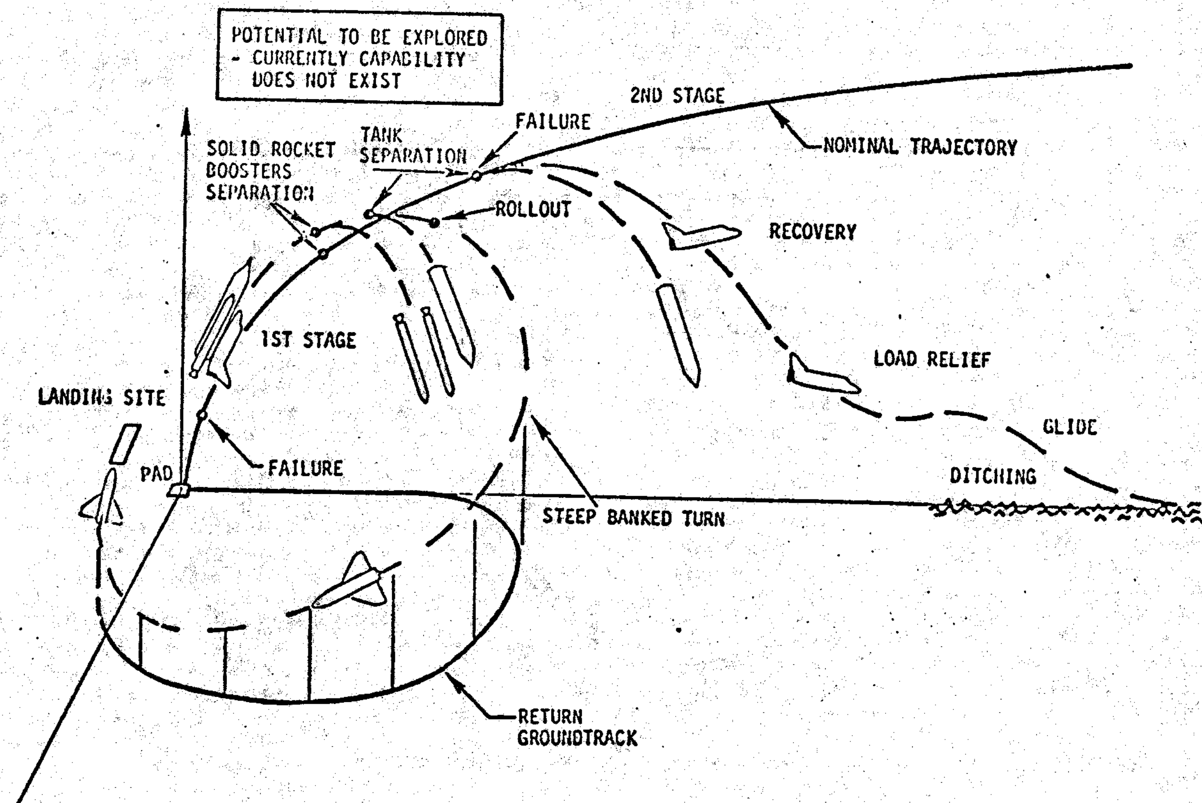
ABORT MODE BOUNDARIES
HIGH PERFORMANCE MISSION
LOW PERFORMANCE MISSION
MECO
MECO
STAGING
RETURN TO LAUNCH SITE (RTLS)
ABORT ONCE AROUND (AOA)
ABORT TO ORBIT (ATO)
TIME FROM LIFT OFF (SECS)
800
700
600
500
400
300
200
100
0

KEY EVENTS IN AN INTACT ABORT



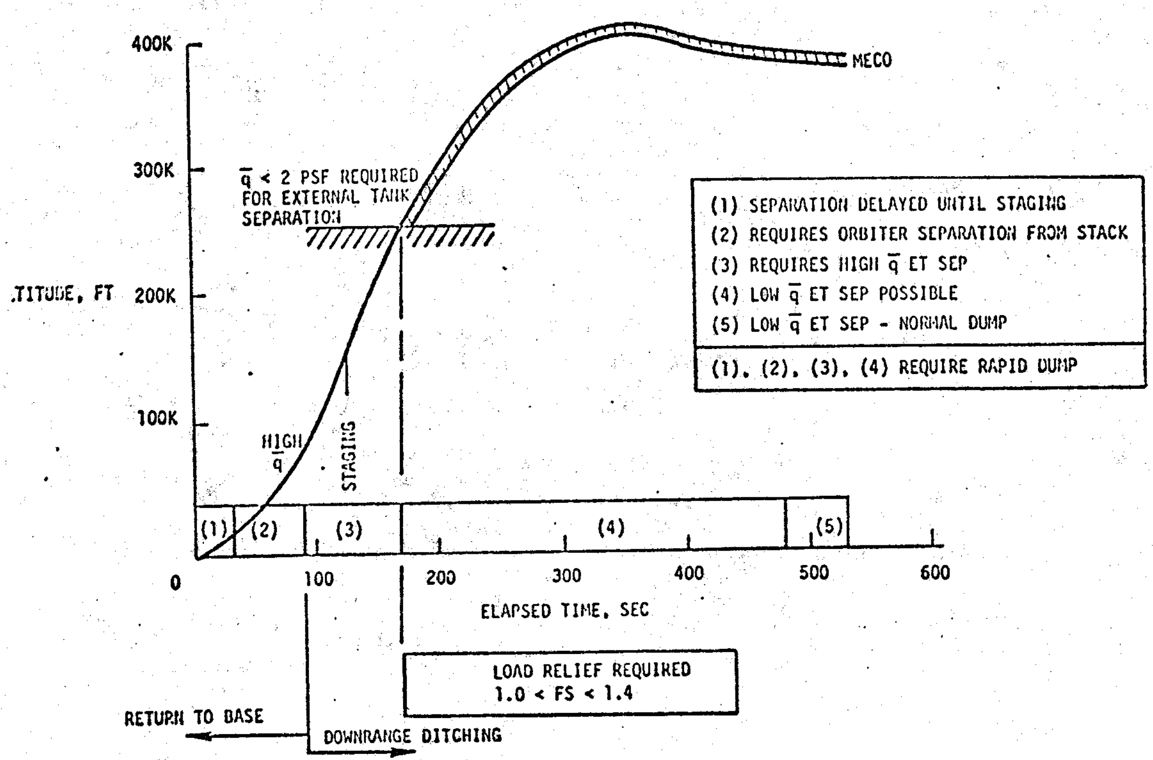
CONTINGENCY ABORT EVALUATION AREAS

8



REPRESENTATIVE CONTINGENCY ABORT EVALUATION AREAS
(ALL ENGINES OFF)

9



COMPLEMENTARY ONBOARD AND GROUND ABORT CAPABILITY SUPPORT ROLES

ABORT CATAGORY	ONBOARD	GROUND
INTACT	AUTONOMOUS CAPABILITY AUTOMATIC SAFING TARGET SELECTION FROM PRE-MISSION STORED CONSTANTS OMS/RCS SEQUENCING CLOSED LOOP GUIDANCE CONTROL	SYSTEMS EVALUATION ABORT MODE SELECTION
CONTINGENCY	POTENTIAL BEING STUDIED AND FURTHER DEFINITION IS PLANNED BEFORE SHUTTLE CRITICAL DESIGN REVIEW (CDR)	SYSTEMS EVALUATION BACKUP NAVIGATION NOMINAL-ATO-AOA -ALTERNATE SITE -DITCHING-ABORT DOWN-MODING TARGET SELECTION

SUMMARY

- INTACT ABORT: COMPLIANCE WITH THE DESIGN CRITERIA ACTUALLY AFFORDS AN EXTENSIVE PROTECTION AGAINST MANY COMBINATIONS OF FAILURES
  - INTACT ONBOARD CAPABILITY IS GENERALLY WELL DEVELOPED AND READY FOR INTEGRATED GUIDANCE NAVIGATION AND CONTROL PROCEDURES VERIFICATION
- GROUND SUPPORT: INDIVIDUAL ABORT SOFTWARE PROCESSORS ARE WELL ADVANCED AND INTEGRATION WITH REAL TIME CONTROLS AND DISPLAYS IS UNDERWAY
- CONTINGENCY ABORT: POTENTIAL IS BEING STUDIED - FURTHER DEFINITION BEFORE SHUTTLE CDR
  - EXTENT OF CAPABILITY DEPENDS ON IMPLEMENTATION APPROVALS, IF ANY, FOLLOWING DEFINITION OF POTENTIAL
  - MANUAL TECHNIQUES AND PROCEDURES WILL BE FULLY EXPLORED IN PREPARATION FOR ORBITAL FLIGHT TEST

Mr. ALLEN. Ditch the tank?

Dr. GRAY. No; ditch the Orbiter.

Mr. FUQUA. I guess we're talking about sinking in 2 seconds?

Dr. GRAY. No; it does better than that. They have run some studies on ditching. It ditches very nicely, as a matter of fact, it's got a good flat-surface bottom and it ditches very, very well and does not sink very rapidly, apparently, from the initial studies, it does not break up. But that's your option then, you have the main engines to get back to the launch site, but because of the velocity you have going down range, you need to use the tank and main engines.

Mr. FUQUA. What would you do, if suppose, you were able to limp enough with the main engines but maybe not achieve orbit. Would you ditch the expendable tank in the ocean, a certain distance from the runway?

Dr. GRAY. Yes; right. What you do on a normal return to launch site, again, you have a lot of downrange velocity and you must now turn it around and obtain velocity back toward the mainland, so you do burn the engines using propellants from the tank, until you have proper velocity position and altitude to get back to our runway, and then you would shut the engines off, jettison the tank, and coast on back to the landing site.

Mr. FUQUA. You probably have to have enough altitude, too.

Dr. GRAY. Yes.

Mr. FUQUA. Then you have enough energy left to get back.

Dr. GRAY. That's what you'd use the main engines for—to gain altitude and get velocity back in this direction.

Mr. FREY. In terms of the locale and people's safety, they're still comparatively better off than they were during Apollo?

Mr. ROSS. With regard to the general population?

Mr. FREY. Yes; I 'm talking in terms of the people around this area, you're really a lot better off. Is that true or not?

Mr. ROSS. No; we were safe on Apollo/Saturn because people were outside the launch danger area and had the vehicle flown back toward the west rather than programed east then the range safety officer would have terminated thrust so that there would not have been an impact of any objects where people were.

Dr. GRAY. That's probably not true that we're better off than Apollo, because somebody's going to ask the question as we get closer, how safe is it. Well you have an entirely different situtaion. In the first place, you have the landing situation which in itself is an entirely different situation. Naturally, it involves some safety considerations just as the launch does. There is a possibility it might not land on the runway. Now the launch phase is probably no safer than Saturn. We say it is safer in some ways, because we have a much more reliable vehicle, but we do not plan to carry a destruct system on the Shuttle once it becomes operational, so that in case of a deviating vehicle, if the crew cannot control it, we have no way to destruct it as we did on Saturn. But, we say that it is inherently a safe vehicle. We don't anticipate having that kind of a problem, but you probably could not say it's safer than Saturn. Whether you can say that it is less safe or not——

Mr. FREY. That's what I am really after.

Mr. MINDERMAN. Early in the Shuttle program, we, jointly with the Eastern Test Range, ran a safety study on the operation and the emphasis we put on the program was to design redundancy into the vehicle to provide the safety through the design of the flight hardware as opposed to trying to achieve it by an add-on package. So we feel we have adequate safety but we've achieved it in a different way.

Mr. FREY. I would think that in the back of your minds is a way to approach this and not let the thing become an issue all of a sudden.

Mr. MINDERMAN. Absolutely.

Dr. GRAY. Yes, well, Congressman, as you know, there have been very rigorous safety requirements here for range safety and the same requirements still apply.

Mr. FREY. I'm on your side. The only thing I am saying is that I think that we ought to be prepared for any questions.

Mr. GRAY. The point is that we have done an awful lot of studies and we are able to discuss the safety aspects. We have the information and the data that would help us with that.

Mr. FUQUA. I'm sure of that, but as we get closer and closer to launch time, more and more questions are going to be asked. I have already been asked several times, you know, what is the abort capability. Not so much that some pilot is going to buzz Cocoa Beach with it, but what happens to those people if there is a problem.

Dr. GRAY. It's a good thing to mention because we give talks around very frequently and we don't address this and it might be very well for us to start incorporating some of those kinds of topics.

Mr. FUQUA. I think the press occasionally picks it up and says something about it. I think that it was Newsweek that had a big feature this week, an update on Shuttle. You're going to get more and more people thinking about the Shuttle and they're going to ask questions and one of them is going to be how safe is it, or how are the guys going to escape, or something like that. Not so much the pilots aboard, but you're going to have nonpilots. What's going to happen to them? Are they going to be back in that cargo bay?

Mr. ROSS. Well, that's a good thought. Thank's for that input. We'll prepare some material on this for future presentation.

Mr. KAPRYAN. At lift-off the scientists are not going to be in the cargo bay, they're going to be——

Mr. FUQUA. Yes; I know that.

Mr. KAPRYAN. They won't go back there until they are completely in orbit.

Mr. MINDERMAN. And for the initial flights we do have a conventional range safety system. So that for the first flights of the Shuttle as far as the civilian population is concerned we are taking our classical approach. Now, we did that because with ejection seats if the crew were to eject then you have an unmanned vehicle and we treat it like an unmanned vehicle.

Mr. FREY. It's soon going to become a reality. So why allow a big fuss to come up here over nothing.

Dr. GRAY. Well, we have an attendant problem with things like sonic booms. We've been doing a lot of advanced work on that too because we will get sonic booms on reentry and landing here. And they will affect different areas. So we have done quite a bit of work on trying to establish the footprints of those and we are going to start some discussions around on the effects of those.

Mr. FUQUA. The other thing that I think people are going to express concern about is the liftoff to make sure that the Shuttle doesn't break up and go in three different directions, that is, the two solids spearing off and going somewhere by themselves. Also, vibration I know is being tested. I'm saying that people's concern is that it will hold together.

Dr. GRAY. We understand, that's very good.

Mr. ROSS. We'll address that point.

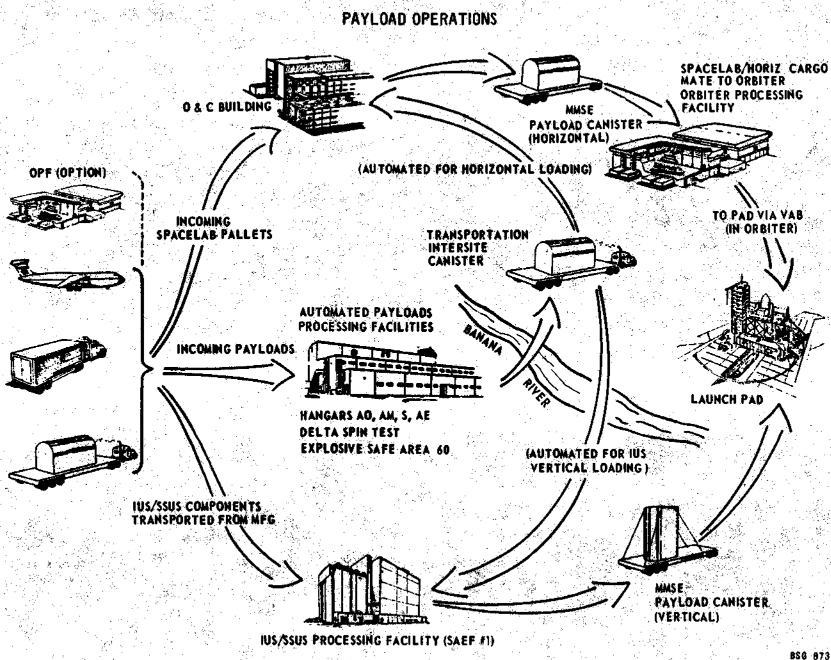


FIGURE 45

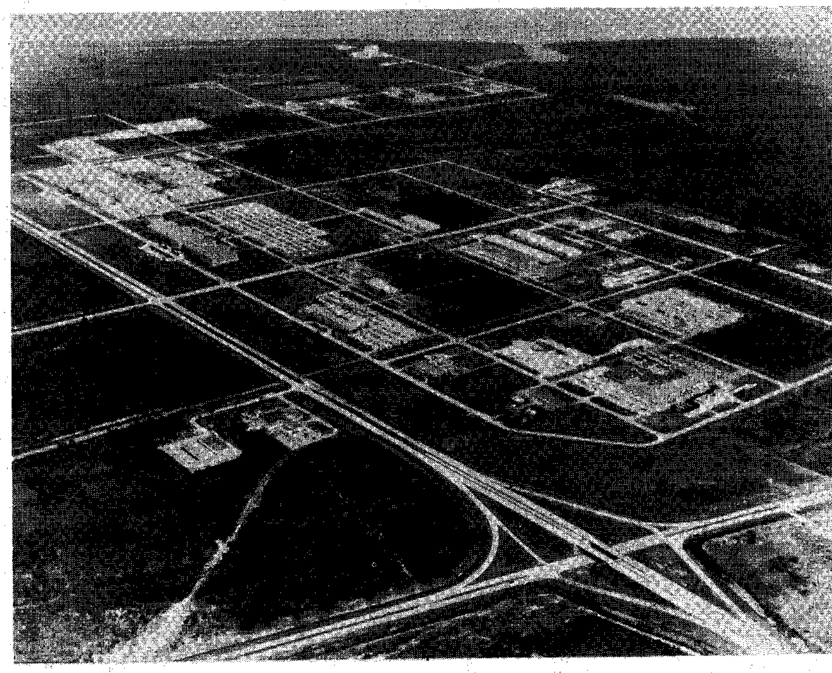


FIGURE 46

FIGURE 47

Let me run rapidly through what happens to payloads here and this is important because payloads are the reason we have Space Transportation System. This is really the payoff. First, (figs. 45, 46, and 47) we receive payloads either by a returning orbiter bringing a payload back from space, or airplane or truck or special carrier. Automated payloads will go to facilities on the cape for offline inspection and checkout, similar to the way they are handled in the expendable vehicle programs. Next, they will take one of two paths. They'll either come to this facility in the fluid test complex, the spacecraft assembly and encapsulation facility (SAEF 1) for assembly, checkout for compatibility with the orbiter and for transportation to the launch site, vertically. All vertically handled payloads will go through SAEF 1. There they might be mated with a propulsive stage which would transport the payload from an Earth orbit to a synchronous orbit or from Earth orbit out on a planetary mission.

Payloads that are designed for horizontal handling, after checkout on the cape, will go to the operations and checkout building, to the same high bay area in which we checked out the Apollo command and service modules and the lunar modules, again for checkout to establish the compatibility with the Orbiter. We will have integrating checkout equipment to be sure the payload fits in the Orbiter and to be sure that any electrical and power interfaces are proper. Then it will be transported horizontally to the Orbiter processing facility for installation in the Orbiter and then to the launch pad.

Mr. FREY. Where is the classified route?

Mr. ROSS. The classified payloads will be Air Force payloads and our agreement with the Air Force calls for them to provide any processing facilities to meet unique requirements of Air Force payloads. Now, if the Air Force says we would like to run this classified payload through your SAEF 1 building we can do that. They will probably install all of their payloads vertically, so any that we handle for them on the off-line mode will go through SAEF 1 and then directly out to the launch pad. I would imagine that there will be some payloads that they will check out completely on the cape and bring directly to the payload changeout room at the pad. They are pretty strong for the factory-to-pad concept, where they bypass all of the off-line facilities.

Mr. FREY. Mike, this is more of a local question. One of the things that seems to be a plus for the community around here is a lot of people with payloads are going to want to have some kind of a, not a plant, but some kind of a processing facility or a place where they can process a payload when it comes back or work on it here. Looking at that concept, I assume that you don't necessarily think that is so. You think that most payloads are going to be flown in and that you are not really going to have things develop around here. Is that the way it looks now?

Mr. ROSS. Mr. Frey, I wouldn't expect that there would be offline processing requirements for facilities outside the Space Center or the Cape Bob, do you have anything further on that?

Dr. GRAY. There is one exception at this time and that is Spacelab. You're probably familiar with Spacelab. Spacelab will come back and will have a full factory-type refurbishing operation here at KSC.

Mr. FREY. I'm not talking as much about that, Bob. It seems to me that if you are putting an experiment together, say if you are doing it in California, you can do a lot of things in California, but always there are last minute things and last minute problems, when you bring it back there may be initial things that must be done here before you take it back to the lab.

Mr. ROSS. We expect the requirements to be met just as they have been for the payloads we are handling for the expendable launch vehicle missions.

Dr. GRAY. And that goes from a communications satellite which is here about 3 weeks with 20 guys or so to a Viking-type payload where there were several hundred here for 9 months or so. So we'll have all ranges. The places where the work gets done are the little payload labs that we have here and on the Cape and there is experiment work and assembly work that will get done for all payloads, but it varies because of payloads. And then on return payloads you'll have to recycle them also, but they will always go back to a factory somewhere else for major work.

Mr. CLARK. It is possible that it could be done at Radiation or at McDonnell Douglas plant.

Mr. FUQUA. There was some talk about a railroad.

Mr. ROSS. Yes. Let me call for the viewgraph on that, and while we're waiting, I'll go on with payload pressing.

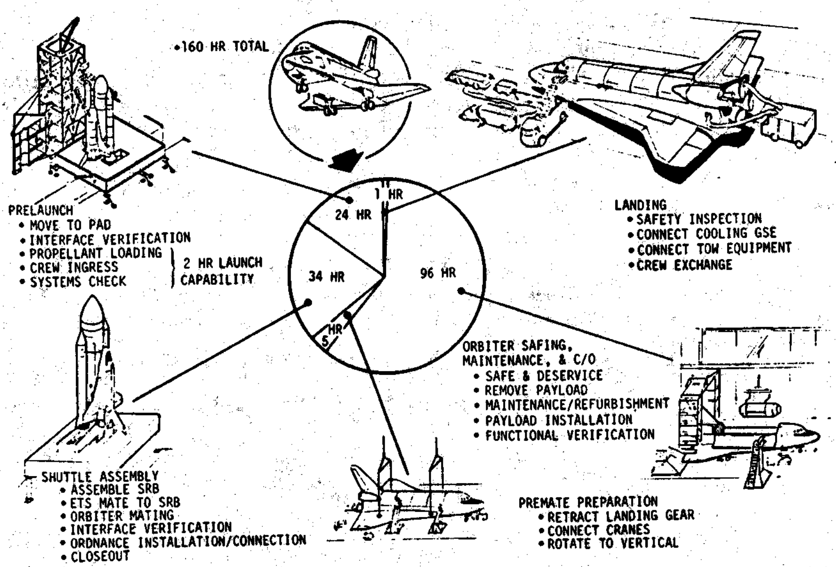


FIGURE 48

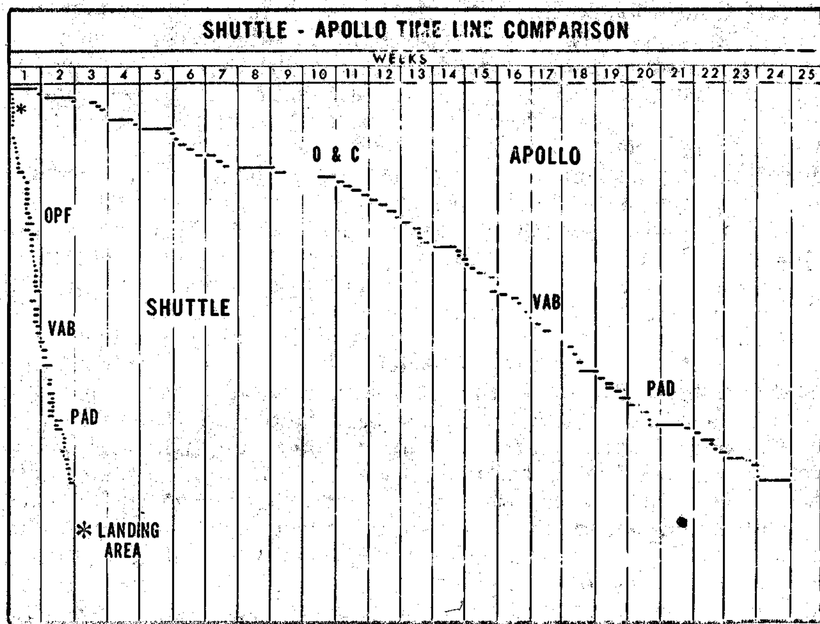


FIGURE 49

Once the Orbiter lands on the runway, it takes about an hour (fig. 48) to get equipment connected to it and to tow it to the orbiter processing facility. There it will take about 96 hours to do all the things we talked about before. Then we take it over to the VAB, assemble it, and move out to the launch pad for final checkout and countdown. This whole process, once we get to the operational period, should take 160 hours. That's our goal. Our target is 160 hours, two shifts, for a 2-week turnaround time. And with this turnaround time we can get this advantage (fig. 49) over the Apollo/Saturn, which took about 24 weeks for checkout and launch.

Mr. FUQUA. That's where you save your money.

Mr. ROSS. Yes, that's one place, and we'll see another on the next couple of viewgraphs, where we decrease the number of people required for checkout because of the automated equipment we now have, the Launch Processing System. The railroad that the port authority wants would service this area (see fig. 3, p. —). They are perfectly happy bringing it only to the north side of the port. The existing railroad starts over here on the mainland, crosses the railroad bridge over the Indian River, and runs down here through our industrial area. It also runs south on the Cape side to service the Titan integrated test and launch complex. The port authority would prefer the Cape route because that is the least expensive. The next preferred route would be from our industrial area, across the NASA causeway, and then South through the Cape. The least desirable, from their point of view would be to run south from our industrial area and across the

Bennett Causeway, because this requires a lot more trackage and a bridge. Of course, they would have to build a bridge to come across the NASA Causeway, also. That's why they like the Cape route. The Air Force is saying that this has a significant impact on present operations, for example, the Trident launch program is going to move from the old Polaris complexes to launch complex 37. It has such a large hazard area that when the Trident is being counted down, the main Cape road is closed. That happened during the first Trident launch here a couple weeks ago. A railroad on the Cape could inhibit future expansion of Air Force activities. It could for NASA also, but probably not to the extent that it would for the Cape, since it goes right by all this industrial area and some of their launch complexes.

Mr. Ross. The requirement for a railroad is questionable, too. The port authorities say, we won't interfere with your operations because we are only going to run six trains a month. At that rate, when you consider that the railroad would cost between $5 and $15 million, depending on the route, and there is only a $100 savings per railroad car over equivalent shipment by truck, it looks as though a railroad would never come close to paying for itself. About 6 months ago, the Brevard Council commissioned a management consulting firm to study the future of the port. This was the URS/Coverdale and Colpitts Inc. Study. They have just one paragraph on the railroad in their report saying that they looked at the need for it and conclude that there is none, that the expected expansion of port activities is not dependent on a railroad. They submitted a list of 17 recommended actions and didn't mention the railroad.

FIGURE 50

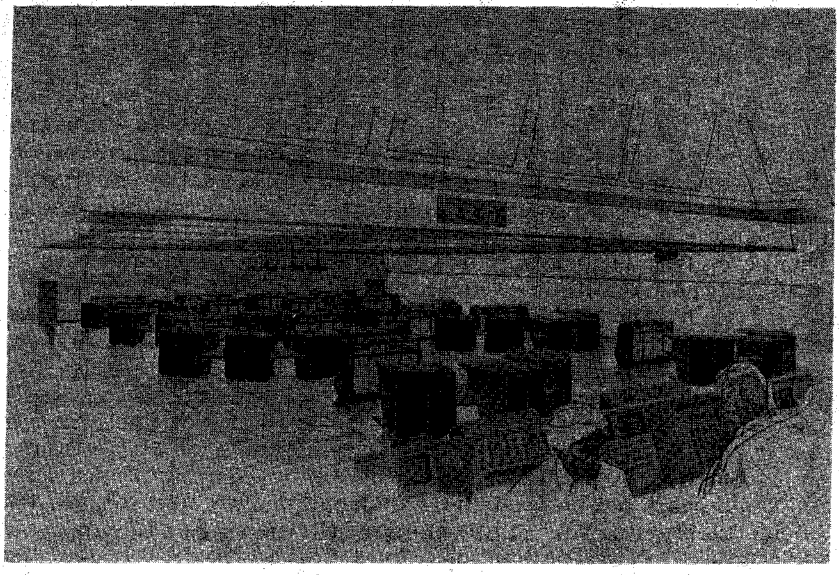


FIGURE 51

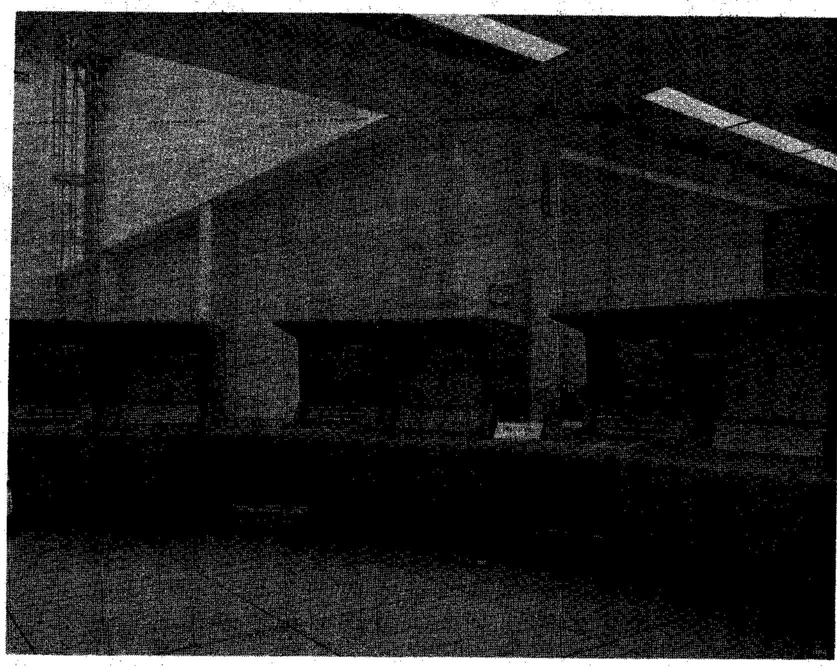


FIGURE 52

To return now to Shuttle costs, this is another of the reasons that we can operate the Shuttle much more inexpensively (fig. 50). This is one of the firing rooms for Apollo/Saturn. About 300 consoles, about 400 people. Now, the new launch processing system, is shown here pictorially (fig. 51) and over here (fig. 52) we see the first set of actual hardware that was recently received. This system will require 50 consoles and around 50 to 100 people. Now there is another interesting point here, too, Mr. Frey, concerning the use of resources from Apollo. These are the same cabinets as used in Apollo, but turned upside down. There are many cathode ray tube displays in the console, and with inverted cabinets the light incidence problem is reduced. This work is being done by Martin-Marietta in a facility at Denver. The very first set of prototype equipment was shipped to Marshall and it is being used to checkout the solid rocket boosters. These consoles are extremely flexible. There is a minicomputer in each console and with a software change you can change the configuration of the console so that it can checkout one system this morning and another system this afternoon. The Apollo/Saturn consoles were completely dedicated and could check out one system. If we have time we want to show you a demonstration of this equipment this afternoon. For the approach and landing tests at Dryden, the orbiter on the 747 will look first like this (fig. 54) and separating shown here (fig. 55). For a feeling of the size of the vehicles, we have a sketch showing the 747/orbiter in front of our headquarters building (fig. 53). We're on the fourth floor and it just comes even with the top of the orbiter.

KSC—HDQ BLDG 747 / ORBITER

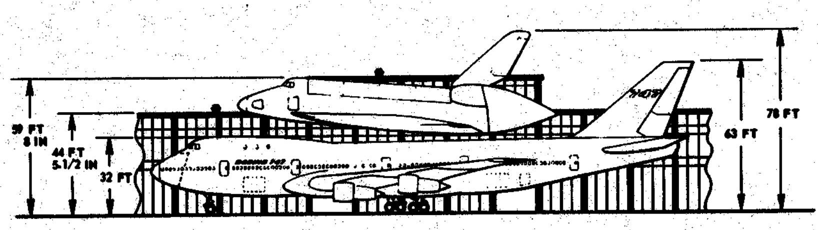


FIGURE 53

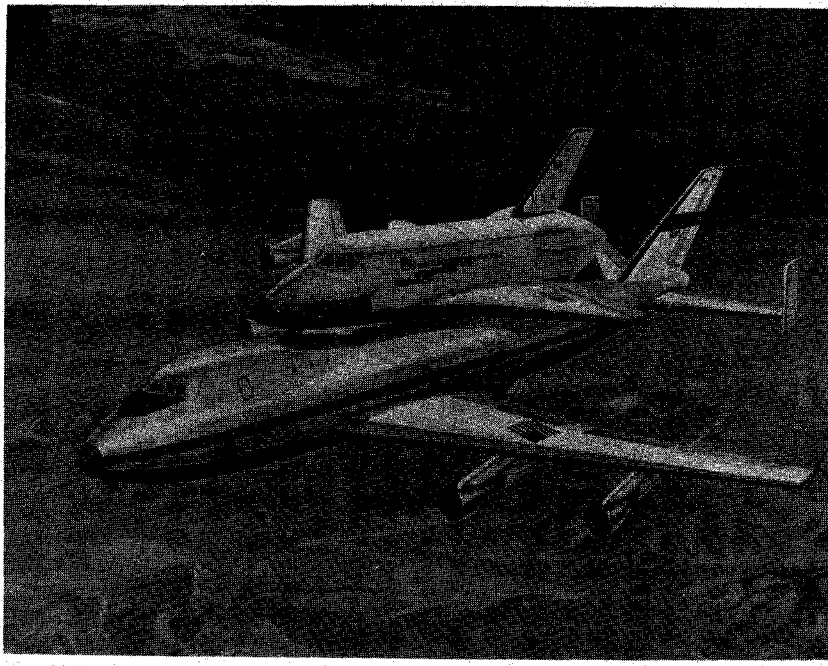


FIGURE 54

FIGURE 55

APPROACH AND LANDING TEST SCHEDULE

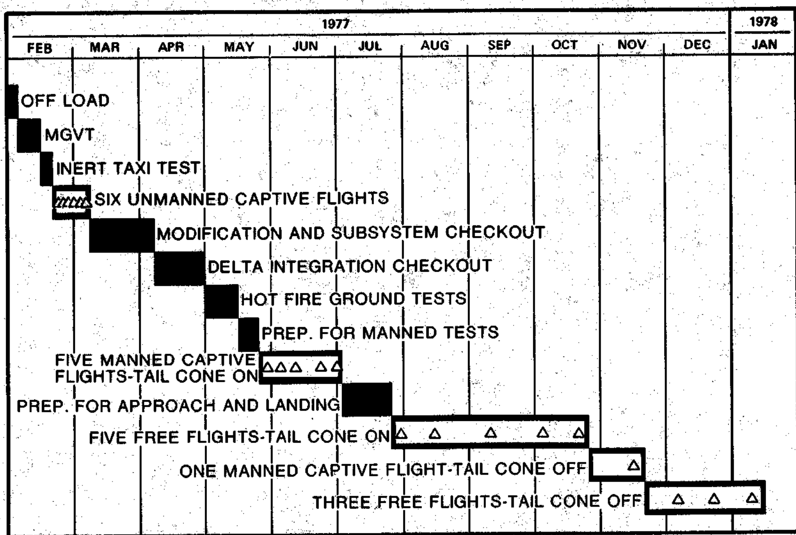


FIGURE 56

Looking at the schedule (fig. 56), the mated ground vibration test is scheduled for next week. They are slightly ahead of schedule. The six unmanned captive flights, flights with no crew in the orbiter, will take place starting no earlier than the 17th day of February. Taxi tests are scheduled for the 15th. Once these are successful, there will be five flights with the pilot and copilot manning the orbiter, but they will not separate from the 747.

Mr. FREY. What's the difference with the tail cone on and the tail cone off?

Mr. ROSS. The tail cone reduces aerodynamic drag caused by the blunt aft end of the orbiter and increases the 747 maximum altitude. It also reduces drag and turbulence around the 747 aft control surfaces. There will be five free flights with the tail cone on and then a series of tail-cone-off flights as shown.

Let me just pass over this (fig. 57) because we will go to the model room and see it first hand. This picture (fig. 58) shows the mate/demate device at Dryden Flight Research Center. This is the one used the other day to remove the orbiter from the transporter, at the top of the picture, the new hangar that was built for the orbiter.

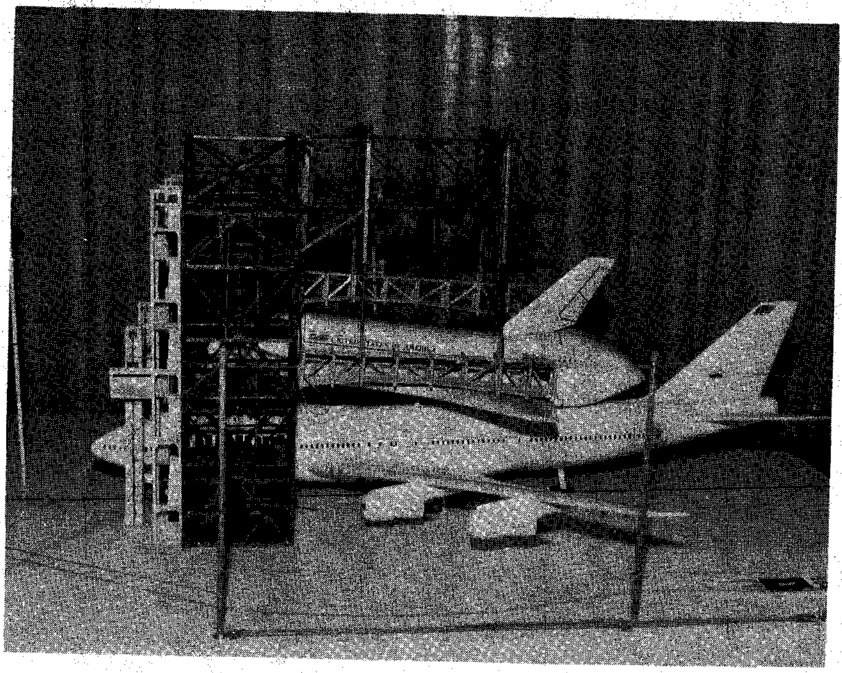


FIGURE 57

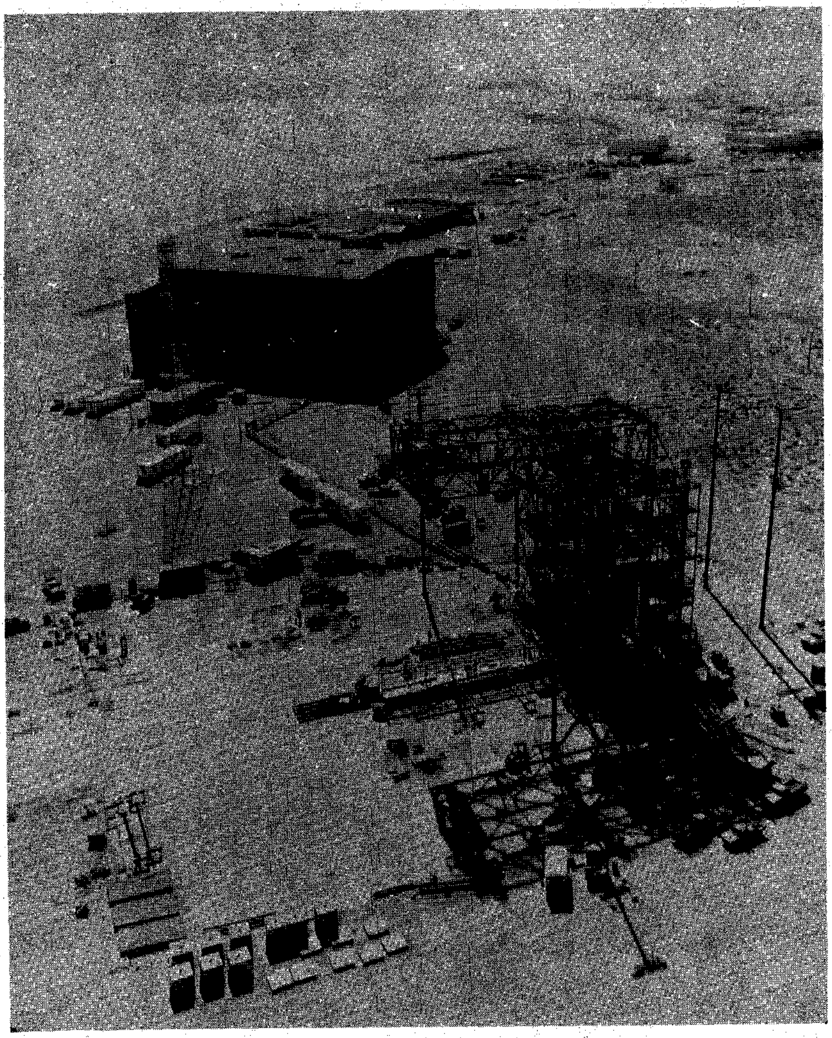


FIGURE 58

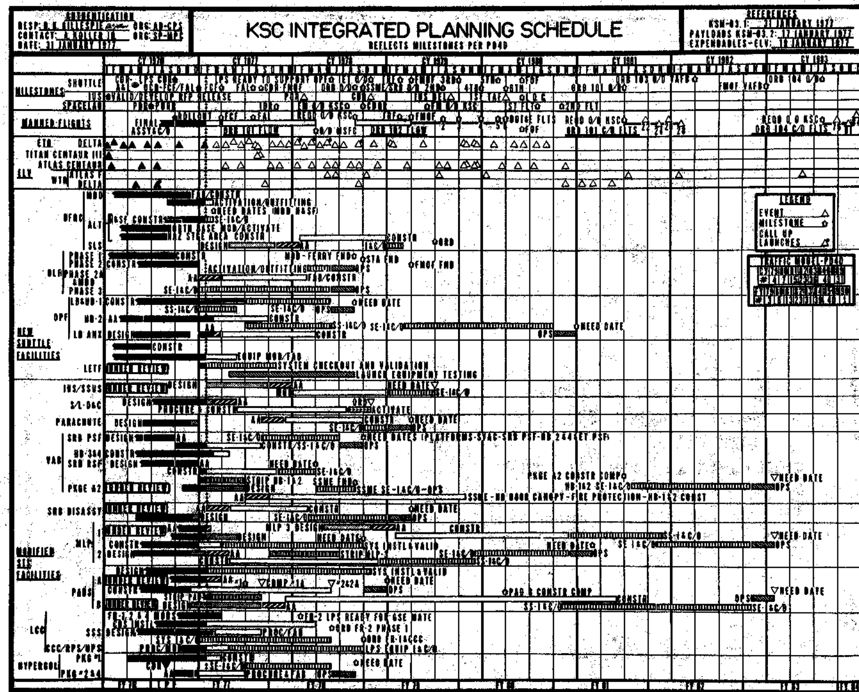


FIGURE 59

This schedule (fig. 59) is an overview of that we use to track the interrelationship of the various milestones at Shuttle program levels 1 and 2 with the detailed operations we have going on down here. With a time period from 1976 to 1983 it shows milestones, such as major hardware deliveries, tests and flights; the manned flight schedule; the expendable launch vehicle flight schedule; new Shuttle facilities at Dryden and Kennedy, with design, construction, and activation dates; modified facilities at Kennedy with the same type of dates. This is in your handout for reference.

Mr. FREY. I want to stop here. Are you going to cover or can we put in the record the cost of the construction of facilities, up to date and what we have this year?

KENNEDY SPACE CENTER
SPACE TRANSPORTATION SYSTEM
C OF F PROGRAM
FY 74 - FY 77 SUMMARY

2/4/77

($000)

PROJECT	FUNDS APPROPRIATED FY 74	FY 75	FY 76	FY 77	TOTAL
● ORBITER LANDING FACILITY	17,300	11,980	-0-	-0-	29,280
● ORBITER PROCESSING FACILITY	-0-	17,280	8,160	3,750	29,190
● LAUNCH COMPLEX 39	-0-	35,355	13,110	12,855	61,320
-VAB, PHASE 1					
- MLP # 1 & 2					
- PAD A					
- LCC					
● SOLID ROCKET BOOSTER FACILITY	-0-	-0-	5,240	8,700	13,940
● HYPERGOL MAINTENANCE FACILITY	-0-	-0-	6,940	-0-	6,940
● LAUNCH EQUIPMENT TEST FACILITY	-0-	-0-	1,960	-0-	1,960
● APPROACH & LANDING TEST FACILITY	-0-	2,940	1,680	460	5,080
● SHUTTLE/CARRIER AC MATING FACILITY	-0-	4,200	1,660	1,700	7,560
● EMERGENCY ELECTRICAL POWER	-0-	-0-	2,200	-0-	2,200
● O & C MODIFICATIONS FOR SPACELAB	-0-	-0-	-0-	3,570	3,570
TOTAL	17,300	71,755	40,950	31,035	161,040

FIGURE 60

KENNEDY SPACE CENTER
SPACE TRANSPORTATION SYSTEM
C OF F PROGRAM
FY 78 FUNDS REQUEST

2/4/77

PROJECT	($000)
● LAUNCH COMPLEX 39	40,700
- MLP #2	4,900
- LAUNCH PAD B	27,100
- VAB, PHASE II	8,700
● SOLID ROCKET BOOSTER FACILITY	1,730
- PARACHUTE	
● DREDGE BARGE CHANNELS	2,090
● SAEF-1 MODS FOR VERTICAL PAYLOADS PROCESSING	6,410
TOTAL	50,930

FIGURE 61

Mr. Ross. Yes, we are going to show you a viewgraph of the Shuttle C of F program for the past 4 years and also for fiscal year 1978. [fig. 60 and 61] These are figures you are already familiar with, we just want to put them in the record, but did want to show you what we have planned for the fiscal year 1978. These are the figures and for just some feeling of time here, on the three large ones. Launch pad B which will be a portion of our so-called second flow facility capability, construction will start next February. The design will start this year. Construction for second flow through the vehicle assembly building will start this October and for the Spacecraft assembly and encapsulation facility we will start construction next January.

Mr. Fuqua. Mike will this give the capability of launching up to 60 launches a year?

Mr. Ross. We will launch 40 a year from here and 20 a year from the Western Test Range. There has also been some conversation of launching 45 a year, from here. If we can meet the 160-hour turnaround it should be possible to exceed slightly the 40 year, providing the spacing of the launches is right. If they are not too bunched up as a result of several successive missions being in orbit for a long period of time, we should be able to launch slightly over 40 a year.

Mr. Fuqua. How many could you launch with those facilities here?

Mr. Ross. These include the second-line facilities, which are needed to make the 40-a-year rate.

Mr. Fuqua. Could you do 45?

Mr. Ross. We think we can do 45.

Mr. Frey. And how much more, you don't have to break it down, but by fiscal 1982, what are you going to have to spend for construction.

Mr. Fuqua. Is that pretty much the bulk of it, Mike?

Mr. Ross. This is the bulk of it, but there is additional work for expansion of the hypergolic system facilities, I have a chart on that but not in this presentation.

Mr. Frey. Can you put that in the record?

Mr. Ross. Yes, I'll put that in.

Mr. Frey. What would you be asking for in 1979?

Mr. Ross. You are asking for the runout charts. We did specifically get that information, and as soon as we break up here I'll get it.

Mr. Frey. I'd like to know what else is down the line that we need to do.

Mr. Fuqua. What are 1979 and 1980 like, besides runout cost of new facilities?

Mr. Ross. Jim Rowe will get that. We can come back to that.

Mr. Kapryan. There are really no new major facilities planned, other than those that have already been defined.

Mr. Fuqua. How about a pad C.

Mr. Ross. No, we are not showing anything that significant. There are some relatively small extensions of capacity that we are currently showing here, as I say one would be the hypergolic systems handling facility.

Mr. Kapryan. We are giving consideration to taking the third mobile launch platform and modifying it for the Shuttle program. I don't think that shows up anywhere here.

Mr. Rowe. It doesn't.

Mr. FREY. Is everything still on track with the European space community?

Mr. ROSS. Yes, they have exceeded what they had hoped their cost would be. As I recall they started out with $400 million. I see in the figures announced the other day it was $575.

Mr. FREY. Are they still having trouble with the French.

Mr. ROSS. I haven't heard that.

Mr. MALAGA. They did have a good second design review.

Mr. ROSS. Yes, you recall they did have problems getting the preliminary design review ready last fall. They pulled back, regrouped, and NASA sent some people over to help, and they held a very successful preliminary design review. They are now looking for additional ways to reduce costs.

Mr. FUQUA. I think what the French are getting into, Lou, is with their resources.

Mr. FREY. They're still locked in on a percentage basis. The work has got to be done. You put 20 percent of the money in and 20 percent of the work is done in your country.

Mr. FUQUA. The West Germans are putting in over one-half of the money.

Mr. ROSS. Here is the information on C of F runout costs. We're showing about $50 million total for fiscal years 1979, 1980, 1981. The largest requirement is for completion of launch complex 39, with lesser amounts for the hypergol logistics area, chemical disposal area, solid rocket booster facility, crawler-transporter maintenance facility, and still less for miscellaneous modifications.

Mr. FREY. So, there still is a big lump left?

Mr. ROSS. Yes, for the completion of the pad B mods and second mobile launcher.

Mr. FREY. That's roughly $50 million?

Mr. ROSS. Yes, about $48 million.

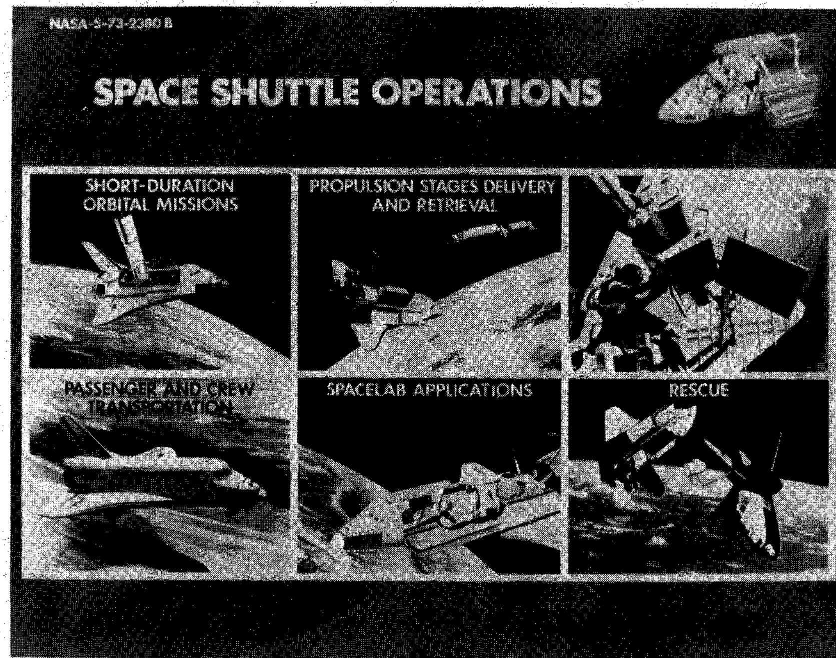


FIGURE 62

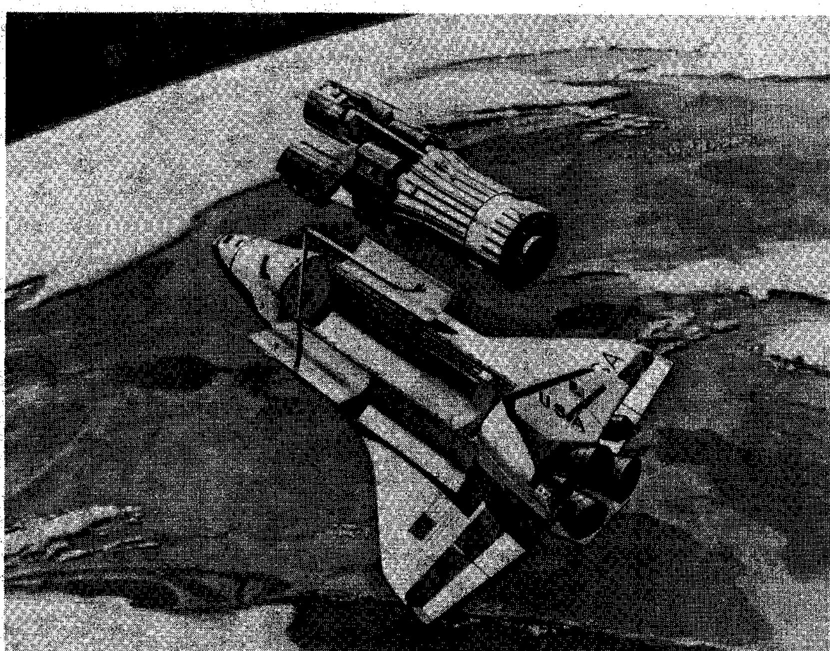


FIGURE 63

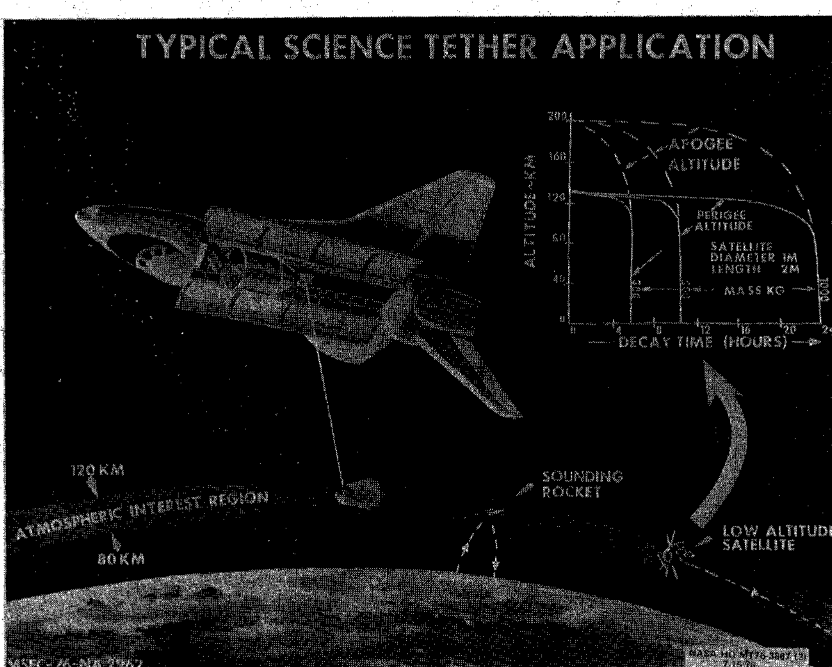


FIGURE 64

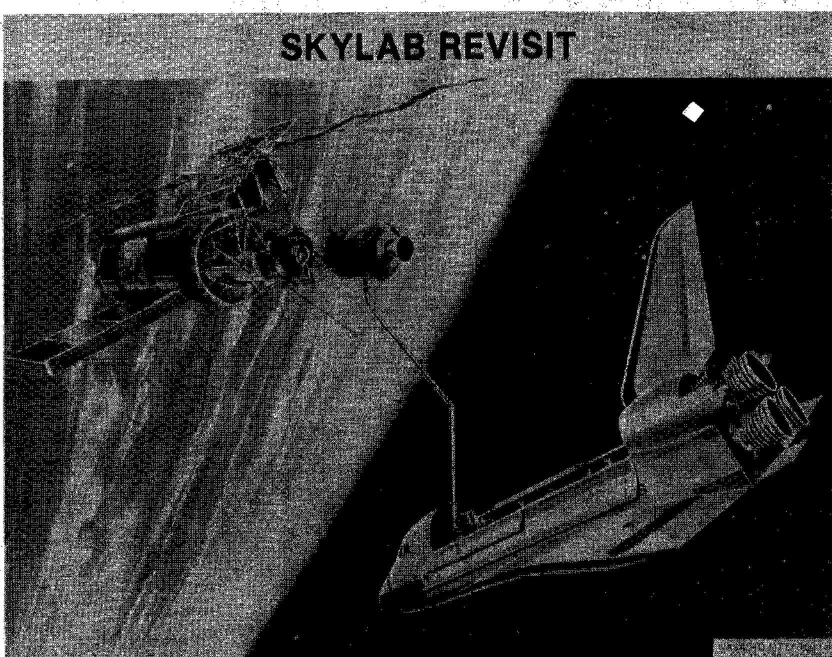


FIGURE 65

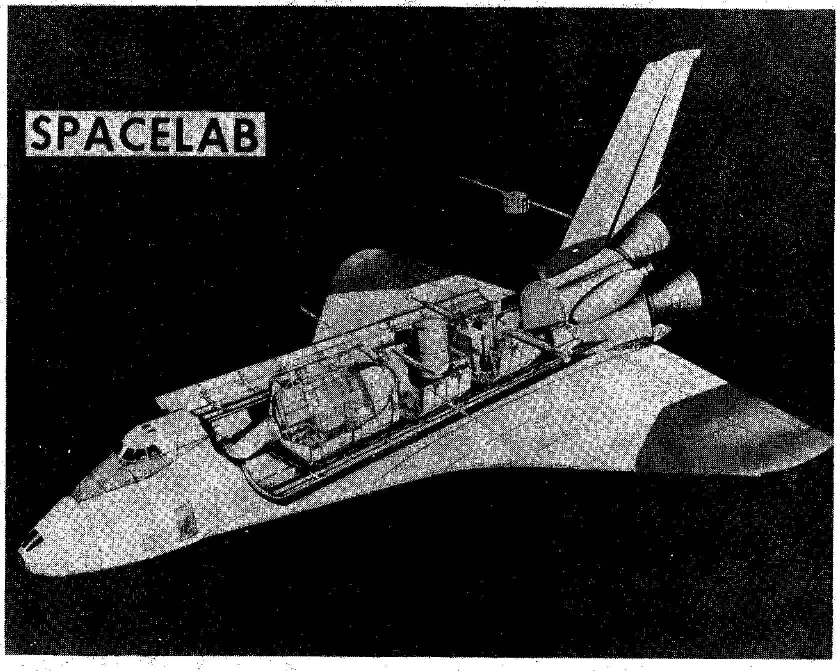


FIGURE 66

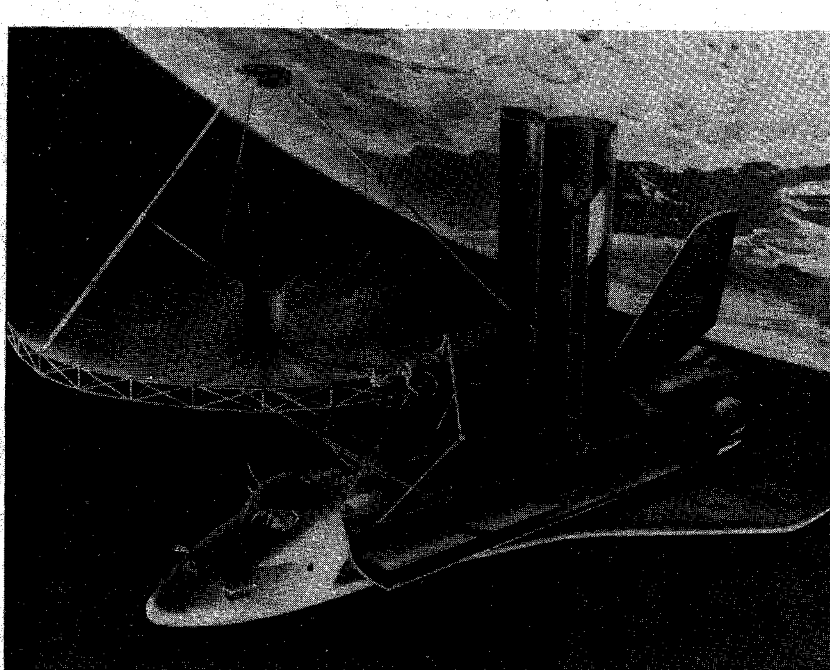


FIGURE 67

Next, we wanted to show you some viewgraphs (figs. 62, 63, 64, 65, and 66) depicting possible future uses of the Shuttle. A large array (fig. 67) is shown being assembled in space. With the use of large structures and large amounts of power in space then whatever you have on the ground to interface with it can be small in size with a small amount of power. Some arrays might be 150 feet to several miles in sizes.

Mr. FREY. Where are we with Dr. Ehricke? Seven years ago he briefed us on the conversion of energy to microwaves?

Mr. ROSS. Work on this has been done recently by Boeing in studies for NASA. Their studies involved the use of heavy lift launch vehicles, three launches a day, 5 days a week for assembly and operation of very large solar power stations developing 10,000 megawatts of useful power on Earth per station. Their cost estimates provided electricity on a transmission line on Earth for about 2½ cents a kilowatt-hour. For comparison I pay 3½ cents a kilowatt-hour at home. Our industrial rate is 2½ cents a kilowatt-hour at KSC. So the studies show technical feasibility and logistics and financial feasibility. I think those are really exciting.

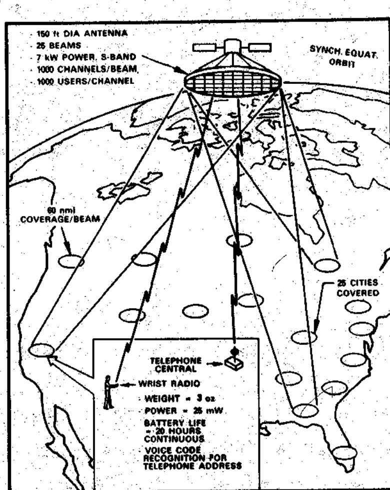
FIGURE 68

PERSONAL COMMUNICATIONS WRIST RADIO (CC-9)

- **PURPOSE**
  To allow citizens to communicate through exchanges by voice, from anywhere.
- **RATIONALE**
  Mobile telephones are desirable, but should be wrist worn. Uses include emergency, recreation, business, rescue, etc.
- **CONCEPT DESCRIPTION**
  Multichannel repeater and wrist transmitter-receivers connect people anywhere. Voice code recognition address (phone-number).
- **CHARACTERISTICS**

• WEIGHT	9,200 lb
• SIZE	150 ft dia. antenna
• RAW POWER	21 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	1
• LIFE/SERVICING PERIOD	10/3 Years
• TIME FRAME	1990
• IOC COST	200 M

- **PERFORMANCE**
  1,000,000 people in each of 25 cities can communicate, 25,000 simultaneously, using normal voice.



- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and tug
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assembly on orbit
• SUBSYSTEMS	Attitude control; antenna; processor
• TECHNOLOGY	Large multibeam antenna; multi-channel transponder; LSI processor, multiple-access techniques
• OTHER	Wrist transceiver, LSI technology

FIGURE 69

These next few charts, which will complete this presentation, are from a study by the Aerospace Corp., where they looked at a variety of applications of the concept of large structures and large amounts of power in space. This first viewgraph (figs. 68 and 69) shows a communications system using an antenna 150 feet in diameter, in synchronous orbit, weighing about 9,000 pounds and consuming about 21,000 watts of power. On the ground is a little wrist radio that weighs 3 ounces, and uses 25 milliwatts of power. With this radio, the wearers can establish communications from wherever they are in the country to the satellite, to the telephone central for patch into a phone line. The studies indicate that this system could be on line by 1990 with an initial operational capability cost of $200 million. Let's look rapidly at a couple more——

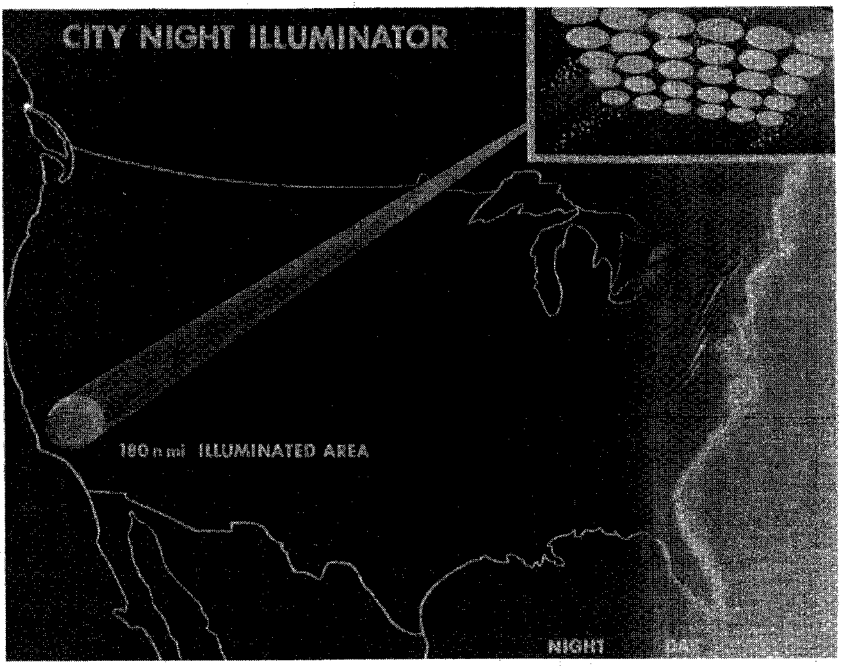


FIGURE 70

NIGHT ILLUMINATOR (CS-6)

- **PURPOSE**
  To provide night lighting without earth-based energy, pollution, street lights, cables, trenches, etc.
- **RATIONALE**
  Alternative energy sources are needed and may even prove economical.
- **CONCEPT DESCRIPTION**
  Large area reflectors in space reflect the image of the sun onto the earth. Multiple satellites used to minimize weight and construction difficulties.
- **CHARACTERISTICS**
  - **WEIGHT** 150,000 lb
  - **SIZE** 12 mirrors each 1000 ft dia
  - **RAW POWER** 1.2 kW
  - **ORBIT** Synch. Equat.
  - **CONSTELLATION SIZE** 1
  - **LIFE/SERVICING PERIOD** 10/3 years
  - **TIME FRAME** 1990
  - **IOC COST** 90 M
- **PERFORMANCE**
  Ten times full-moon level illumination at night provided to area 180 nmi dia (no clouds). Full moon provided (heavy cloud cover).
- **BUILDING BLOCK REQUIREMENTS**
  - **TRANSPORTATION** Shuttle and tug and/or SEPS
  - **ON-ORBIT OPERATIONS** Automated or manual servicing unit
  - **SUBSYSTEMS** Attitude control; mirrors; structure
  - **TECHNOLOGY** Large reflector; pointing; stationkeeping master control
  - **OTHER** None

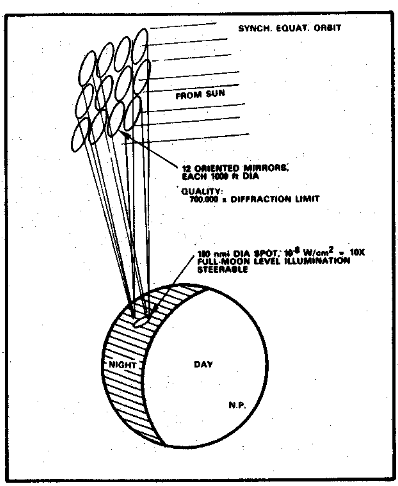


FIGURE 71

Mr. Ross. Here is a system (figs. 70 and 71) to light a city in case of an earthquake or other disaster, for round-the-clock working rescue personnel. This would provide by 1990, for $90 million, illumination equal to 10 full moons.

Mr. Frey. Once that's up there, could it stay?

Mr. Ross. Yes, it would be in synchronous equatorial orbit.

Mr. Frey. You just flip it where you need it?

Mr. Ross. Yes, by repositioning the mirrors which reflect light from the Sun.

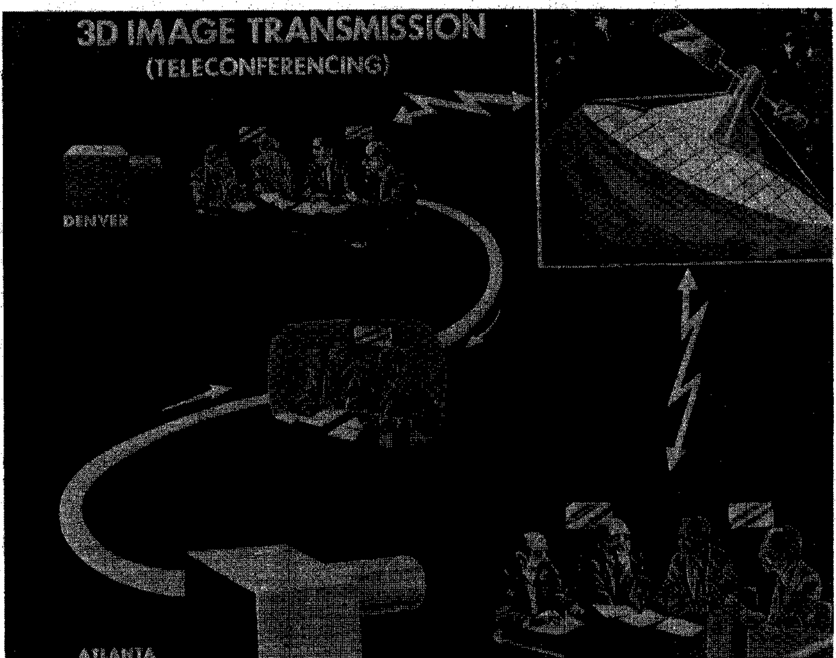
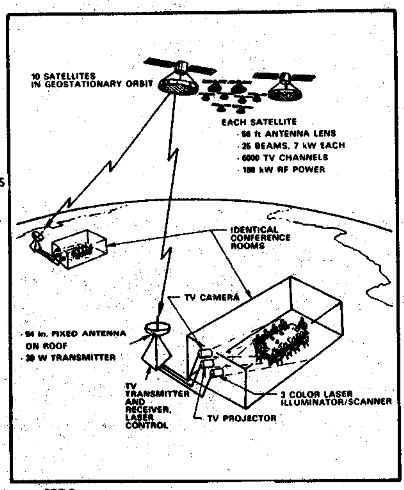


Figure 72

3-D HOLOGRAPHIC TELECONFERENCING (CC-11) E 7218R1



- **PURPOSE**
  To greatly reduce the need to travel for government and business conferences.

- **RATIONALE**
  Travel for conferences is costly, time consuming, and an inefficient way of conducting government or business.

- **CONCEPT DESCRIPTION**
  Identical conference rooms are fitted with a T. V. camera, T. V. projector, and laser illuminator. Resulting holograms produce images indistinguishable from live occupants.

- **CHARACTERISTICS**

• WEIGHT	15,000 lb
• SIZE	56 ft antenna
• RAW POWER	540 kW
• ORBIT	Geostationary
• CONSTELLATION SIZE	10 over U. S. A.
• LIFE/SERVICING PERIOD	10/3 Years
• TIME FRAME	1995
• IOC COST	1.3 B

- **PERFORMANCE**
  60,000 identical conference rooms interconnected simultaneously with 3D color holographic images, and stereo sound. Travel savings amortize investment in 1 yr. Revenues of 1.5B/year thereafter.

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle, Large Tug or Large SEPS
• ON-ORBIT OPERATIONS	Automated or manual assembly and servicing
• SUBSYSTEMS	Large multibeam antennas, processors
• TECHNOLOGY	30 GHz high power transmitters - LSI processors, 3-color lasers
• OTHER	

FIGURE 73

Here is one (figs. 72 and 73) I think that is really appealing. It uses holographic techniques to provide three-dimensional image transmission between cities via satellite. So, you could all be in Washington and we could be down here and we'd all see each other in 3-D sitting around a conference table.

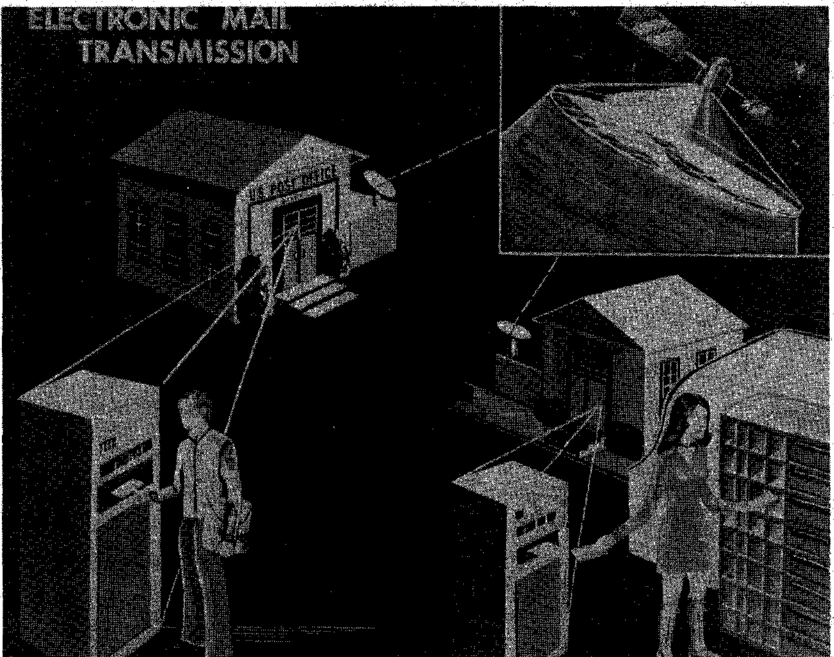
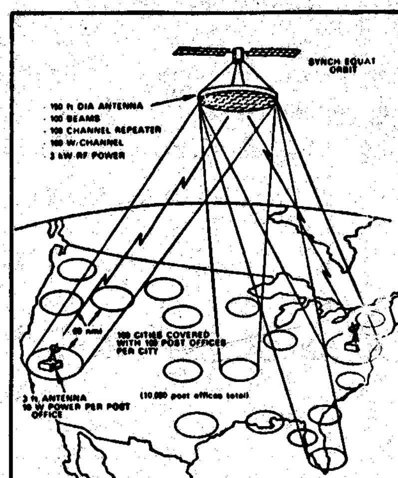


FIGURE 74

ELECTRONIC MAIL TRANSMISSION (CC-4)(U)



- **PURPOSE**

  To speed up delivery and lower costs of most mail.

- **RATIONALE**

  Delivery of physical letters is slow and needless in most cases when locally reproduced facsimile could do.

- **CONCEPT DESCRIPTION**

  Page readers and facsimile printers at each post office read, transmit, receive, and reproduce mail. Satellite acts as multichannel repeater.

- **CHARACTERISTICS**

• WEIGHT	8,500 lb
• SIZE	150 ft dia. antenna
• RAW POWER	10 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	1
• LIFE/SERVICING PERIOD	10/3 Years
• TIME FRAME	1990
• IOC COST	280 M

- **PERFORMANCE**

  Transmits facsimile at 10 pages (8 1/2 x 11") per second per post office; 100 post offices per city, 100 cities (10 billion pages per day)

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and tug and SEPS
• ON-ORBIT OPERATIONS	Automated Servicing Unit
• SUBSYSTEMS	Attitude control; antenna; processor
• TECHNOLOGY	Large multibeam antenna; multi-channel transponder; LSI processor; multiple-access techniques
• OTHER	None

FIGURE 75

Here is one (figs. 74 and 75) to help solve the mail system problems. This would provide mail transmission point to point, again using a satellite relay. Two-hundred-eighty million dollars would equip 10,000 post offices with receiving and transmitting stations so you can drop a letter in this terminal and send it through the post office over to a terminal here in an office building or in a home. That completes my presentation, and Joe Malaga will be next.

Mr. MALAGA. In order to make up some time, I will be very brief. Going ahead with getting this story across, although it doesn't have the same sophistication and acceptance that the more visible elements of the space programs have, the space program wouldn't exist down here if we didn't have effective program support operations. What I will try to do is put some values to the physical plant that Mr. Ross talked about as well as to the work force components that we have and give out some input on what the local work force situation looks like. Some values that I think you should remember, and be aware of, is that KSC is the largest NASA center (fig. 76).

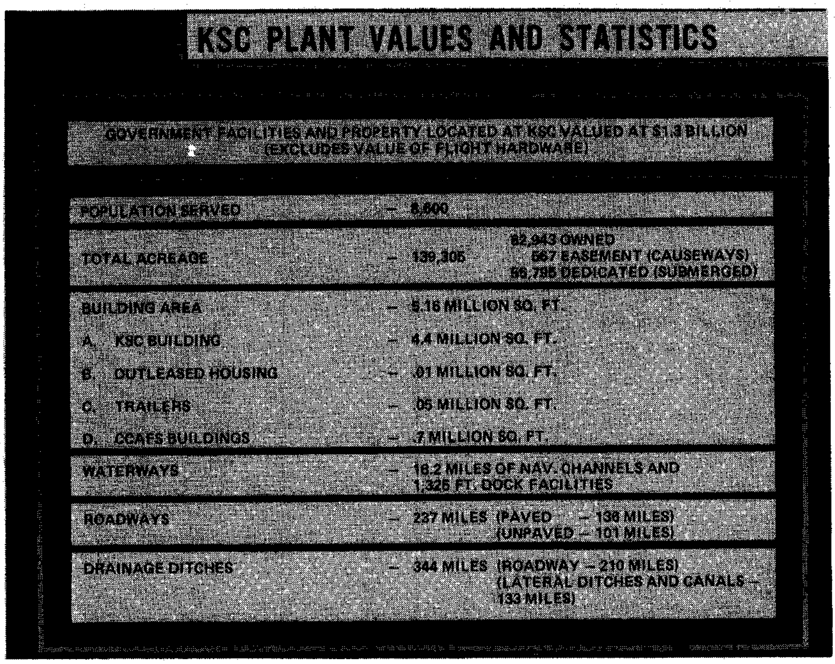


FIGURE 76

It has the most acreage, about 139,000 acres. It serves a population of approximately 8,600. The physical plant is at $1.3 billion, which, Mr. Frey, goes back to the point that you made of the fact that we are making use of this vast physical plant that was built at a substantial cost to the Government. In building areas we have over 5 million square feet; 4.4 million in buildings at KSC. Most of that, almost half, is in technical facilities; about a quarter is in office space;

another quarter in warehouse space and the balance of about 300,000 or 400,000 square feet in miscellaneous activities. We do have some out-leased housing, which is little more than a fishing camp up north of us and a couple of homes rented to people who work the orange groves, but that is a very small amount of building space. We have some trailers still located throughout the center but that's down to some 50,000 square feet. Across the river we have some 100,000 square feet mostly for our expendable launch vehicle operation. Now, Mr. Ross showed you on the KSC map the waterways and the dock facilities. We have some 18 miles of navigable channels, some of which we have to keep dredged. We needed them for the Apollo/Saturn program and we will need them for the Shuttle.

Mr. Fuqua. The Corps of Engineers does the dredging for you or do you do your own dredging?

Mr. Malaga. That was the item that Mr. Ross had in the budget, $2 million to dredge this channel. So the corps, I guess, Pete, does it. We will pay for it.

Mr. Minderman. The plan for this dredging is for the Corps of Engineers to contract for it. The original dredging was also done by the corps.

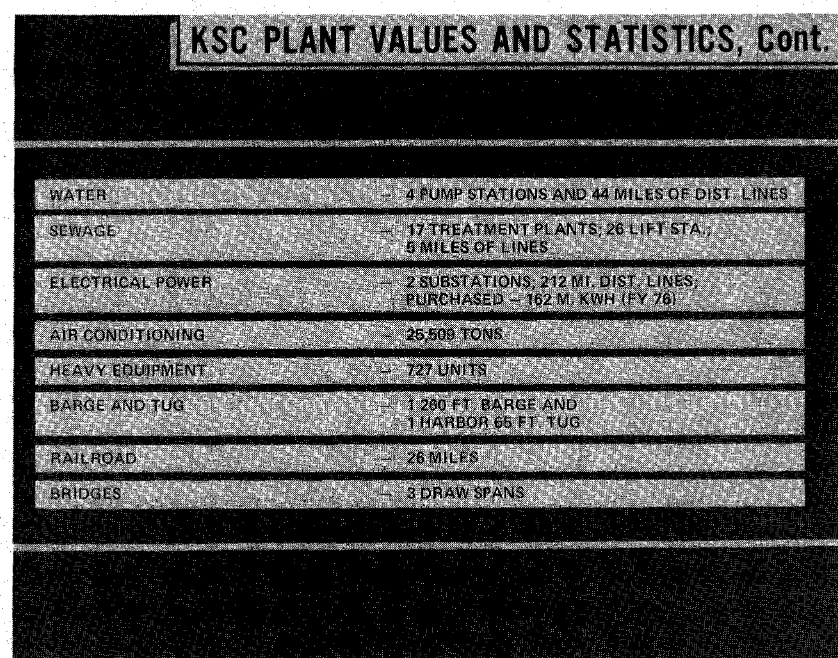


FIGURE 77

Mr. Malaga. We have some 225 miles of roadways which have to be maintained. We have 344 miles of drainage ditches to take care of the surface water problems. These have to be kept clear so that we don't get into additional problems. The maintenance consists of mowing operations and cleaning operations done inside the ditches themselves.

On the next chart (fig. 77) you can see some of the other major facilities we have. I draw your attention to the electrical power entry. We have two substations to distribute power within the center and we have over 25,000 tons of air-conditioning. We also have a lot of heavy equipment, mobile equipment, everywhere from a tractor to a 140 ton crane.

Mr. FREY. Is any of that stuff we are using now connected with solar energy or anything like that? These questions are getting asked more and more by various Members of the Congress as people come to testify. They always ask them if they have solar heating or solar cooling.

Mr. MINDERMAN. We have a couple of designs and projects right now to do some solar water heating for some of our smaller facilities.

Mr. FREY. Is that something we are trying very seriously? Obviously you are trying to get the solar energy center here. Maybe it's our fault for not pushing the budget process. Somehow or other these are natural places to develop this type of thing.

Mr. ROSS. The big energy load here comes from air-conditioning and so far there is not a cost effective solar powered air-conditioner. So that is why it is so important to get some of these solar research and development projects underway. To get an air-conditioning solar power system that is cost effective.

Mr. FREY. I think that NASA is really vulnerable on this in terms of possible criticism.

Mr. WINN. Did you submit a plan to ERDA?

Mr. ROSS. That's been done, Mr. Winn, primarily at the Lewis Research Center. They brought on line last year, a 100 kilowatt windmill, that certainly is in the R. & D. phase. They plan to come out with an RFP for contracts to be worked with 17 utility companies throughout the country to put in larger, about 200 and 1,500 kilowatt windmills. Again on a trial basis pretty much in the R. & D. phase.

Mr. WINN. There is money available isn't there? Through ERDA.

Mr. ROSS. We work all of our energy programs with ERDA because that's not a main line product of NASA.

Mr. FREY. You look over this stuff from the national resource we have here and the money poured into it; it's something maybe we ought to put a little more emphasis on.

Mr. ROSS. What we need is a cost effective system. You could do it now but it would be just something good to talk about. But it wouldn't be efficient. I think the cost tradeoff now for solar heating systems for a home has a 10- or 15-year payoff. That is why people are not rushing to put them in right now. Now, that doesn't say that the design of such a system——

Mr. WINN. Mike, I think you are missing his point. His point is that you should have something on the board, you should have some kind of a program lined out and a direction you would like to go to make a showing that you are capable of doing that with some of the last things that you had.

Mr. ROSS. OK, now that would be the budget that Mr. Minderman mentioned where we will have a couple of installations that use solar power to heat water.

Mr. FREY. Mike I think that isn't really enough that you tell the people that you're going to put a windmill somewhere.

Mr. Ross. You think that we ought to make more use of solar energy?

Mr. Frey. At least here in this area if you don't do it you've got to be working toward it.

Mr. Malaga. Mike Ross also mentioned the railroads in his presentation and he showed you where the railroad runs through KSC. We will be using the barge and tug in STS operations at KSC. We also have three drawbridges to maintain; two across the Indian River and one across the Banana River going over to the cape. The two on the Indian River cover the intercoastal waterway and are manned 24 hours a day. The one going over to the cape we man only on call. These are some of the major elements of our physical plant we have to worry about on a day-to-day basis. Here is a little bit of history which I

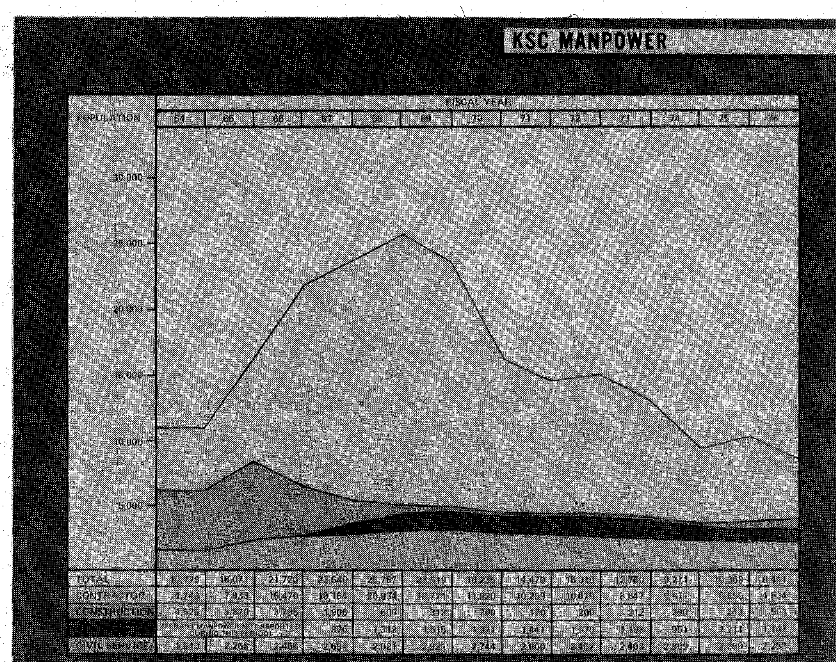
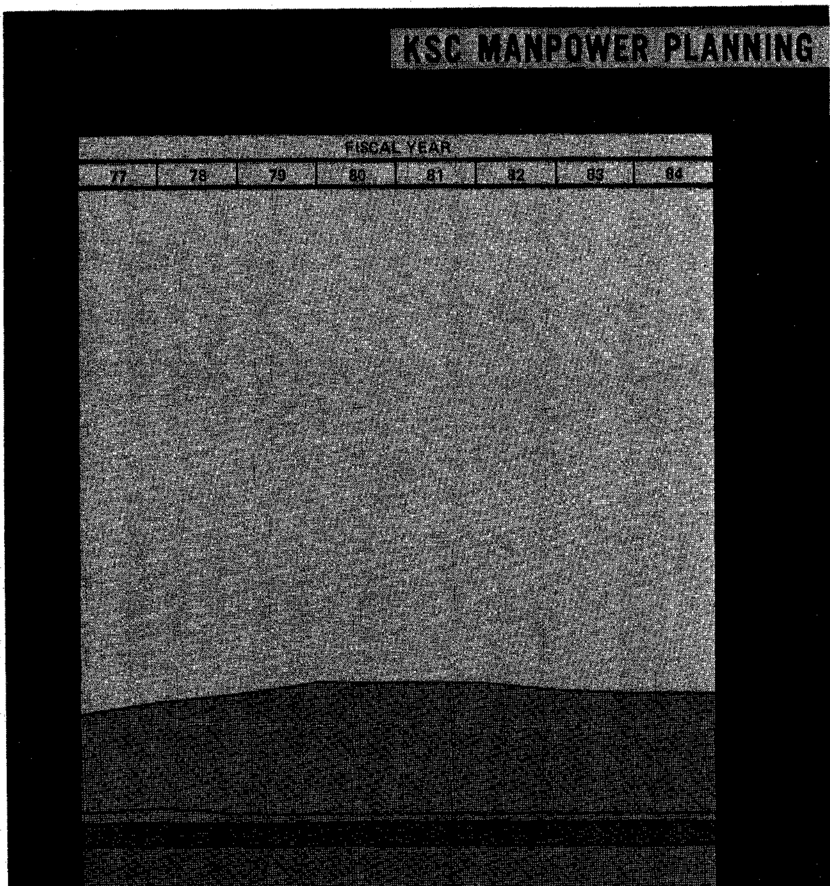


Figure 78



77	78	79	80	81	82	83	84
9,081	9,455	9,967	10,139	10,064	9,536	9,403	9,395
5,030	5,676	6,293	6,480	6,405	5,877	5,744	5,736
705	370	215	200	200	200	200	200
1,087	1,160	1,200	1,200	1,200	1,200	1,200	1,200
2,259	2,269	2,259	2,259	2,259	2,259	2,259	2,259

FIGURE 79

think might be interesting to you (figs. 78 and 79). The first thing of interest is the outside envelope of that total employment curve. You can see the buildup to the Apollo program in 1969, peaking out just under 26,000 and a very rapid buildup and even a more rapid decline once we landed on the Moon. There are two slight blips that you will see, one here in 1972, and in 1973 as we geared up again for the Skylab program; another decline and another slight buildup with ASTP; still another decline as we got ready for the site activation for the STS. Now another point, the civil service line you see down below, has stayed relatively constant. It built up to just under 3,000 during peak Apollo but this was a very conscious and deliberate decision that what we would do with civil service people is to have them responsible, technically and managerially for program control integration and in the final analysis the final decisions on mission success. We also must have a civil service staff for those functions which the Government cannot contract for. For example we can't contract for financial management, we can't contract for procurement, we can't contract personnel operations.

Mr. WINN. I'm sorry I didn't hear you. You can't contract for what kind of management?

Mr. MALAGA. Financial management and personnel operations. What we did was to rely on industry to really do the detailed design, the fabrication, the construction, the development, the installation and the maintenance and operation of the facilities here. The Government had the hard-core cadre and industry did the major part of the work. You can see what happened as the program grew and then declined, the outline pretty much demonstrates that. Another thing Mr. Ross mentioned, the timelines on Apollo and the Shuttle. We are talking about 3 months to process Apollo for launch going down to 160 hours to process Shuttle for launch. Now these are planning values but assuming that we do achieve 160 hour turnaround time for the Orbiter, then those values are essentially what we think we will see and that's just under 10,000 people. Included in this is a very, very rough estimate of tenants that we think, based on past experience, might approximate 1,200. I think with all the potential uses of the Shuttle, that estimate of tenants is understated. I think that there will be a lot more people down here working on payloads, working on experiments, but for planning purposes and because we must provide base support to the on-site population, we have put in the figure of 1,200 people.

Mr. FUQUA. What makes you think that?

Mr. MALAGA. This is just my personal opinion. I think that we are just beginning to really appreciate what the Shuttle is going to do and the uses we put it to and the number of people that are going to be working on it. Every day we are seeing more and more private enterprise interest in supporting experiments, grants, the whole bit. Now, if you compare that value of 1,200 to the days when we were essentially doing expendable launch vehicle operations; building up for Apollo here, and again for ASTP, it's not very far from that. But we're talking about 40 launches a year. And I think we will probably see a substantial increase in that value. I don't know who shares this view, but I personally feel that way.

Mr. FUQUA. Well, we talk about 40 launches but I sure haven't seen them yet. And I am concerned about that.

Mr. ROSS. We have not talked at all about the mission model and what the payloads are for this. Have you had a briefing on that yet?

Mr. FUQUA. Not recently.

Mr. FREY. I have a question, too, about the morale. A lot of people say the Civil Service comes through this super. They're doing my job and that they have taken it away from me. This guy really doesn't know how to do it and I tell him how to do it and he's sitting there because he doesn't have anything else to do. They're riding a good thing. How's that problem?

Mr. FUQUA. That's what you're supposed to straighten out.

Mr. FREY. Yes; that's why I'm looking for an answer.

Mr. MALAGA. Mr. Frey, let me make two comments. One, the civil service complement did not grow in proportion to the total growth nor did it come down in the same proportion. The big increase took place in industry and obviously when a program is matured, the biggest reduction has to take place there. Second, it is my observation that people who don't have a piece of hardware to kick around and really wrap their arms around, get concerned about who's doing what to whom and I think that situation will clarify. There is no real movement from a contractor operation to a civil service-type operation, quite the contrary. We're making a fundamental change here in current industry/Government relationships. What we're attempting to do with portions of the two contracts which are being completed right now—the CISS contract and the GSO contract—is to give the fundamental responsibility for getting the job done to industry and having him, using his ingenuity, his imagination, tell us the best way to do it. Now, it's not a large step but it's a step in that direction. And I'm sure that you're aware of the pressures that we suffer to keep the civil service staff from growing. And if I showed you the requirements line estimated by this gentleman who has to worry about launching and turning that Shuttle around and this gentleman who has to worry about getting the site activated you would see the hard constraints we're working under.

Mr. KAPRYAN. I think that if you were to make a significant reduction in civil servants there would have to be a philosophical change in the way we do business. Now, that doesn't mean that it can't happen but having been involved in the manned space flight program since its inception, I've seen it evolve into a check and balance system where the contractors and the civil service engineers work together. You've got two sets of eyes and brains that work problems, I personally feel that this system has contributed to a large degree to the success that we have had.

We can say "get the Civil Service the heck out of here" and you can just have a couple of administrators to sign the paychecks for the contractors. You can do it, but that's not our philosophy.

Mr. FREY. I was really asking Kappy, too, because I've lived with this from the beginning too. Just where are things in your opinion in terms of the morale. For instance, today, how many jobs do we have?

Mr. MALAGA. Civil Service?

Mr. FREY. Both.

Mr. ROSS. Altogether about 8,500.

Mr. MALAGA. 8,500 or 8,600 people, on site, including tenants, who would sort of suffer the kinds of emotions that you are talking about.

Mr. FREY. So roughly you are looking at, I assume that is the new fiscal year kind of thing, 1,500 jobs or so over the next 2 or 3 years.

Mr. ROSS. There will be a significant change in the mix of people here. The construction work force will phase down. The flight hardware contractors will build up.

Mr. FREY. When you're looking at those numbers, they are misleading because those numbers also include the construction things.

Mr. ROSS. You can say construction but this group will begin to phase down.

Mr. MALAGA. But this includes the element contractors as well as the support contractors. And this mix begins to change but it does grow and peak as we get this place ready. It grows until we get the site activated, get development testing under way and then when we finally get to a steady State operation with the 160-hour turn around time, at around 9,400 or 9,500 people.

Mr. FREY. So we're going to have the stability here that we have lacked for years.

Mr. MINDERMAN. We have passed the depth of the valley and we're starting up the curve.

Mr. MALAGA. We think we have passed them.

Mr. MINDERMAN. Unless something happens to the budget, we don't know about.

Mr. ROSS. Now we think that one of the most important things to do is be quite open on what we see in the future, with the community people. And we've always done that but they don't always listen to you but they tend to listen through rose-colored glasses, to mix a metaphor.

Mr. FREY. Either dark gray ones or rose-colored.

Mr. ROSS. Of course many of the complaints that we hear come from the employees of one contractor complaining that the contract is being recompeted, which we're required to do, or is being meshed with another contract or that we've consolidated the contract with the Air Force to provide joint services.

Mr. FREY. Some of those problems are compounded because the Eastern Test Range is being treated one way and at the Western Test Range they've extended some of their contracts for 2 years without competition. Right?

Mr. MALAGA. But, we've extended some here.

Mr. FREY. When?

Mr. ROSS. Where we can justify it we have extended. For example the support contract operated by Bendix was extended as long as the flight hardware contractors were here because the Bendix mission was so close to the launch contractor's mission, in some areas they were hardly distinguishable and it wasn't reasonable to consider bringing on an entirely new crew to run the launch or to do the job that Bendix had.

Mr. FREY. It's the same problem with natural gas—you allocate what you don't have. In one case gas, in another case jobs.

Mr. ROSS. I expect that you would see some more complaints if we proposed to consolidate more contracts with the Air Force. We have several now and they are very cost effective to operate, particularly where support equipment is involved. Then both agencies don't have to have duplicate equipment.

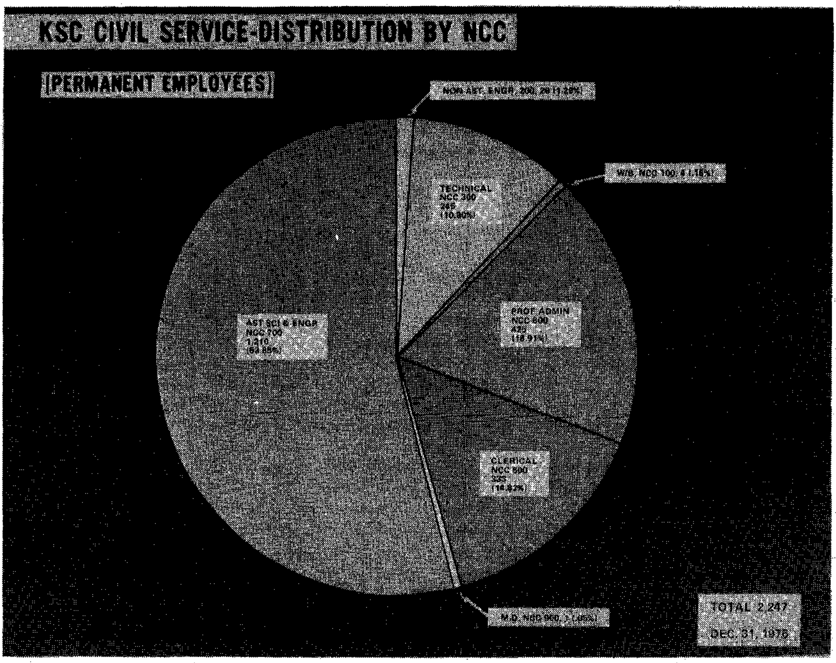


FIGURE 80

COMPARISON OF KSC MINORITY EMPLOYEES
(PERMANENT)
VS
TOTAL KSC WORK FORCE

DATE	NUMBER OF EMPLOYEES	NUMBER OF MIN. EMPLOYEES	% OF WORK FORCE
12-31-74	2300	83	3.6
12-31-76	2247	121	5.4
NET	-53	+38	+1.8

(- DECREASE)
(+ INCREASE)

FIGURE 81

Mr. MALAGA. Let me make one other point on the civil service component. The total component is dominated by scientific, technical and administrative professionals. (Figure 80.) You can see that our scientists and engineers comprise almost 54 percent, and professional administrators almost 19 percent. That exceeds 70 percent and is roughly comparable to what you would see at Marshall, Johnson and Goddard, the development centers. We do have a few wage board people who worry about our airplanes that we operate down here. We do have a doctor who heads our medical activities and we do have some plant engineering and maintenance people who worry about the physical plant but who are non-AST engineers. One other point. As you know NASA in general has been very concerned about improving the representation within its work force of minorities and females. There has been a lot of work in the past few years. (Figure 81.) Although KSC is near the bottom end of the spectrum as to how many minorities we have, we also have been very busy. From December of 1974 to December 1976 we have increased the percentage of minorities in the total work force from 3.6 percent to 5.4 percent. That's an increase of 45.8 percent. The significant thing is that it's the greatest increase, even though we perhaps had a greater distance to travel, of any NASA center and it is roughly three times what the agency has done in the same time period. So we are working this problem very actively.

Mr. FUQUA. But you've lost 53.

Mr. MALAGA. We have lost 53 people in total but at the same time we've gained 38 minority employees.

Mr. ROSS. We've lost 53 employees but increased 38 minority employees.

Mr. MALAGA. So even though the work force was coming down we were increasing the ratio. And it's getting very difficult. The competition is very keen. There are only so many minority people in the candidate pools. And you can't compomise quality.

Mr. FUQUA. What kinds of jobs are these?

Mr. MALAGA. These are all professionals here. I'm sorry, these are professionals and clerical.

Mr. ROSS. What percentage of our professionals are minorities? It's smaller than the 5.4 percent. Most of our minority employees come from our co-op program which is very productive. Our biggest problem in hiring minorities is in the nonprofessional area, because we must hire from a register, and there is such a high unemployment rate in Brevard County that the register is filled. In fact, the register has been closed to new entrants for several months. So, there is much competition for jobs.

Mr. MALAGA. We are meeting our objectives in hiring professional minorities and females. We have been falling short in the nonprofessional areas for exactly the reasons Mike just mentioned. But the biggest portion of those values is the professionals.

Mr. ROSS. This past year about 40 percent of our new professional employees were minorities and women, and 23 percent of our nonprofessional new employees were minorities.

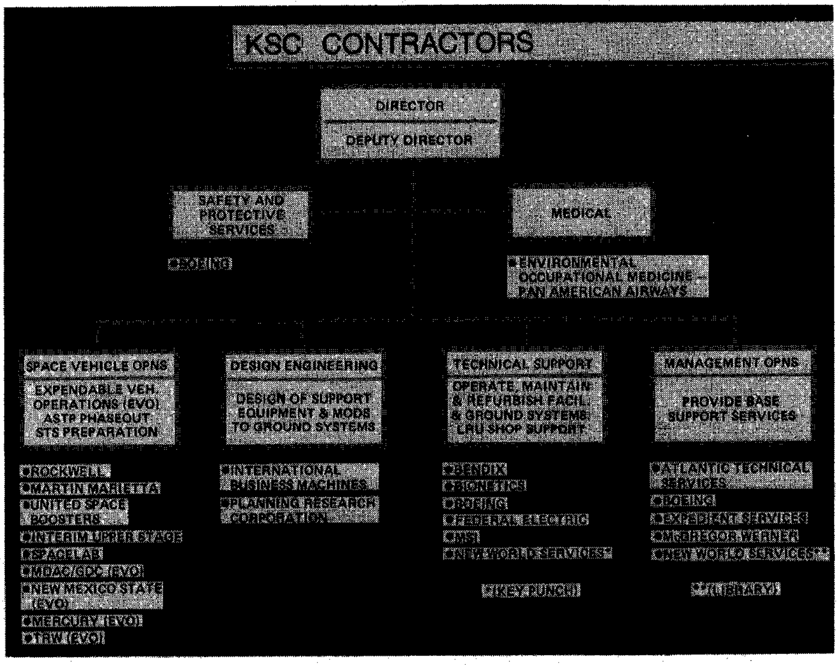


FIGURE 82

Mr. MALAGA. You remember the organizational chart that Mr. Ross showed at the outset. I have taken here (figure 82) the major organizations through which we acquire services from contractors. On the right hand side, we have management operations which I sort of worry about. It provides the classical base support type services which I'll explain in just a minute. If you add to that the medical piece which is the environmental and occupational medicine program, our safety and protective services, then you have completed the base support kind of functions at KSC. We have technical support that Mr. Minderman worries about. It is probably one of the most difficult to understand because we have this great physical plant. We expend large amounts of money and use a large number of people doing exactly what it says here. But it is not very visible to people who don't come down and look at things that need modifying and refurbishing. Remember we are building only two major new facilities for the Shuttle program. Everything else we're modifying, refurbishing and in the meantime doing necessary maintenance and operations in anticipation of the Shuttle operations. But I see little difference in technical support or program support which is primarily funded by DTMO which for some reason does not leave a very good taste in some peoples' mouths but it's just as important as what we do in design engineering where we get all of our ground support equipment designed and purchased and facilities modified and the stage or element contractors that Mr. Kapryan worries about, to actually get things checked out and flying.

Mr. FUQUA. Who is United Space Boosters?

Mr. KAPRYAN. They won the booster assembly contract and are part of the United Technology Corp. (UTC).

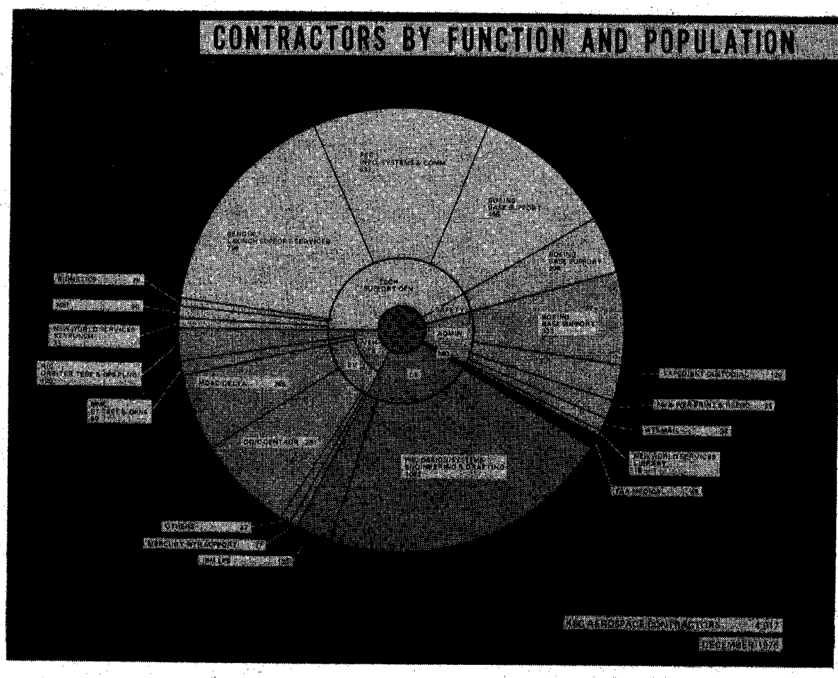
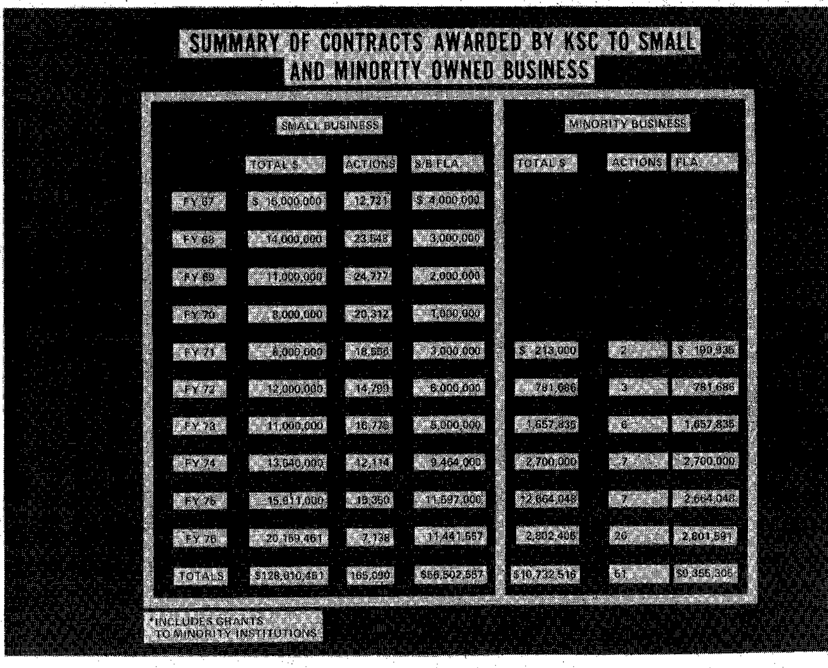


FIGURE 83

Mr. MALAGA. Now this chart (figure 83) looks busy but what it really does is takes the organizations that I just mentioned and then describes the services. For example, management operations includes the supply and transportation functions, and documentation functions which are currently in the Boeing contract. The custodial function, printing and reproduction, the mail function and library are all in the Directorate of Administration. This small piece represents the medical function. A good portion of the Boeing contract, labeled Support for the Directorate of Technical Support here, is the plant engineering and maintenance and that's what we are combining into the ground support operations contract which is being competed. It lines up organizationally and you also get some efficiencies by having a better utilization of skills. FEC, the current contractor in communications and information systems is also being competed and we are well on the way with reviewing that. Bionetics takes care of calibrations. MSI (Management Services) takes care of chemical cleaning. Next in the circle, the space vehicle element stage contractors do the things that we mentioned earlier. I think that if you look at the contractors displayed this way and not to forget PRC, which does design engineering and drafting, and IBM on the LPS software, the heavy involvement and wide variety of activities carried out by contractors is more important. You can better understand what's here locally and what's happening out on the site but a lot of work goes off base where we get design services, certain things fabricated, which are part of construction packages and also procure ground support equipment. So you will find a whole list of contractors throughout the activity.

Mr. FUQUA. Are any of those minority contractors?



SUMMARY OF CONTRACTS AWARDED BY KSC TO SMALL AND MINORITY OWNED BUSINESS

	SMALL BUSINESS			MINORITY BUSINESS		
	TOTAL $	ACTIONS	S/B FLA.	TOTAL $	ACTIONS	FLA.
FY 67	$ 16,000,000	12,721	$ 4,000,000			
FY 68	14,000,000	23,548	3,000,000			
FY 69	11,000,000	24,777	2,000,000			
FY 70	8,000,000	20,312	1,000,000			
FY 71	6,000,000	18,556	3,000,000	$ 213,000	2	$ 190,935
FY 72	12,000,000	14,799	6,000,000	781,686	3	781,686
FY 73	11,000,000	16,779	5,000,000	1,657,835	6	1,657,835
FY 74	13,640,000	12,114	9,464,000	2,700,000	7	2,700,000
FY 75	15,911,000	15,350	11,597,000	*2,664,048	7	2,664,048
FY 76	20,169,461	7,138	11,441,557	2,802,406	26	2,801,591
TOTALS	$128,810,461	165,090	$56,502,557	$10,732,516	61	$9,355,305

*INCLUDES GRANTS TO MINORITY INSTITUTIONS

FIGURE 84

Mr. MALAGA. Yes, sir, I'll show you that right now (fig. 84). Let me start with small business. In fiscal year 1976 we did about $20 million worth of business with small business enterprise in total. Over half of that was in Florida. That is somewhere around 12 or 13 percent of our total business, which is above the agency average for small business. The 8A set-asides for 1976 were 2.8 percent—that's also slightly above the agency average. In fact, we were the leading center up until last year. In our current fiscal year plans for 8A set-asides we are planning a level of activity comparable to what we did in 1976.

Mr. FREY. In some areas are they picking you to death? Maybe you don't feel that way, but in some areas of the small business, are they picking different parts of contracts out and pulling them out and saying, OK, now that's small business and this is small business?

Mr. MALAGA. We look very hard at the total procurement plans to find out what we can really put out for small business.

Mr. ROSS. To answer your question, Mr. Frey, the SBA doesn't do that, we do. We propose breakouts from a large contract and then go to the SBA.

Mr. MALAGA. We don't find the contractors. We find the items to procure, and then we go to SBA.

Mr. ROSS. There are some contracts we have proposed be let to minority firms, but SBA was not able to locate a firm capable of doing the business. Some of the work we now contract to minority firms includes janitorial work, keypunch operations, and operation of our library.

Mr. MALAGA. We're about to have the roads and grounds contract let to a minority firm. This will be a new contract.

Mr. ROSS. Many of the small facility jobs and the rehabilitation and modification contracts are let to minority owned firms. Restriping and sealing the parking lots, roadways and as Mr. Malaga said, small roads and grounds contracts. The main problem we have is finding the firms qualified to do the work who are also qualified as minority-owned firms.

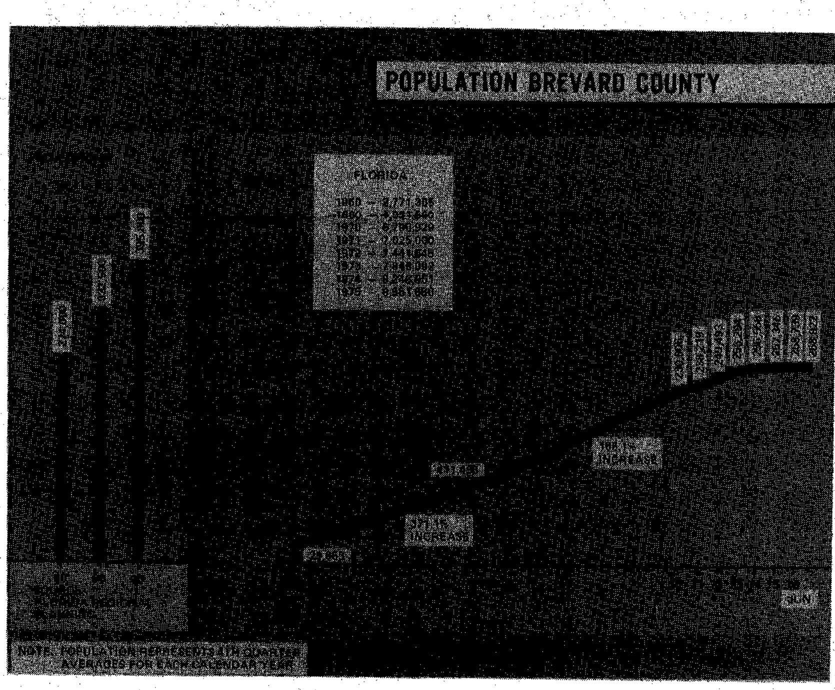


FIGURE 85

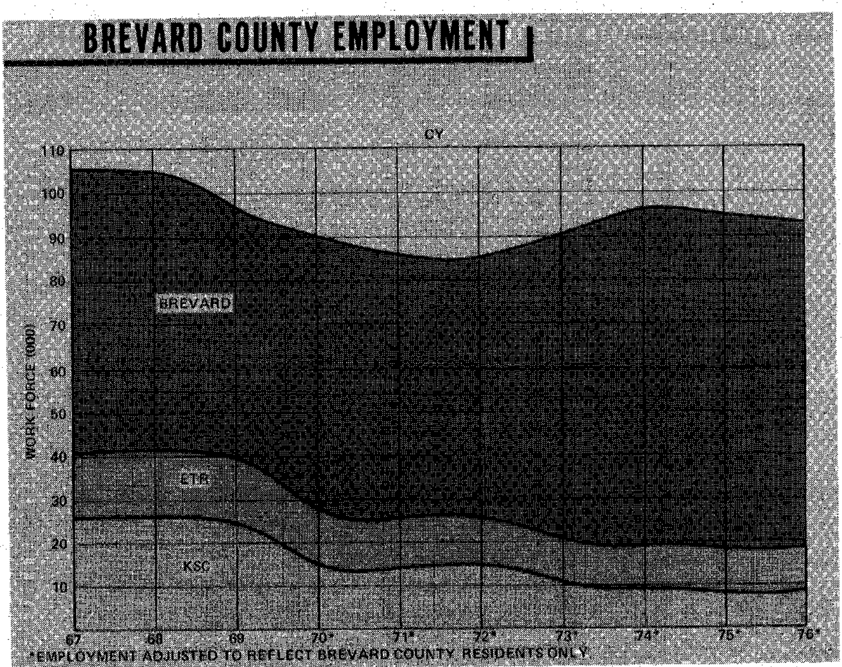


FIGURE 86

Mr. MALAGA. I have called back the chart you saw earlier on the profile of total employment on site at KSC (fig. 78), to show how that matches the growth of Brevard County (fig. 85). You see from the early 1960's to the 1970's that the population of Brevard County doubled. And it continues to grow even though you can see a drop in total employment (fig. 86). Two-thirds of the people came off the rolls of KSC from 1967. I can't go retrospectively any further, because we just can't get the data. We had just over 100,000 in the work force. You see back in those days that the combination of ETR and KSC comprised some 40 percent of that total local work force. This portion has since declined due to program adjustments to just under 20 percent and will stay substantially at this level even though we have this slight peak ahead of us. The work force has dipped from 1969 to 1970 and subsequently, primarily because these data were purged of those people coming from other counties, so that it is not quite comparable. But now what we are looking at from 1970 on is truly Brevard County. We grew in 1974. We had a slight decline indicated here in 1975 and 1976, yet the total population statistics show a continuing slight increase.

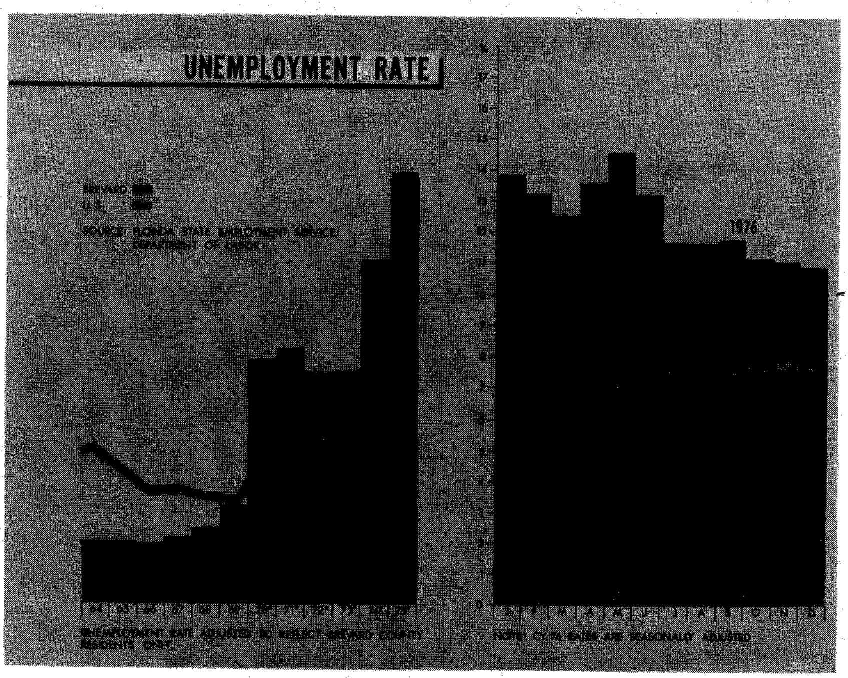


FIGURE 87

In terms of unemployment (fig. 87), as you know, things were pretty good as we built up for Apollo. The red line indicates the national trend in unemployment. Read the percentages here. And Brevard was much, much below that because we had the intense buildup to get the site ready. Post Apollo saw the crossover and Brevard suddenly exceeds by far the national average which actually in 1975 was over 14 percent. Looking at this past year, which began just under 14 percent, we've had some ups and downs as the tourist trade has changed. Now, as of December 31 we understand that we are something like 10.9 percent unemployed. So that has come down considerably. That's our situation in terms of the local workforce. If there are no questions, that concludes my presentation, Mr. Chairman.

FIELD HEARINGS

SATURDAY, FEBRUARY 5, 1977

U.S. House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Michoud Assembly Facility, New Orleans, La.

STATEMENT OF ROBERT C. LITTLEFIELD, MANAGER, MICHOUD ASSEMBLY FACILITY

Mr. Littlefield. Good morning, gentlemen, welcome to New Orleans and the Michoud Assembly Facility. Mr. Chairman, I had prepared a short statement explaining the facility operation but in the interest of time I suggest that we skip most of it since much of the information is the same as my report to you last year.

Chairman Fuqua. It will be placed in the record.

Mr. Littlefield. I would, however, like to make a few very brief comments with respect to our overall facility operation which I think is generally going rather well. We have cut out some frills, eliminated some functions—and learned that we can operate effectively in this plant with about 100 less people maintaining the facility, than we had toward the end of the Saturn program. It has also become very clear to me in the year I've been here that the greater utilization the Government can make of this facility, the better off we are on the space program.

MICHOUD ASSEMBLY FACILITY

MAJOR CONCERNS

- **FACILITY UTILIZATION**
- **UTILITY COSTS**

Figure 1

(Fig. 1.) At the present time, about 25 percent of our capacity is filled with tenants. These are the same organizations I mentioned last year and they, through reimbursements flowing from other Government agencies to NASA, pay for approximately 25 percent of our costs. We still have around a 20-percent idle capacity. Actually it's presently about 15 percent, but Bell and the Navy, since they lost the large Surface Effects Ship contract here, are really going down in a hurry. So, I'm concerned about how we utilize the facility because I think it is very much to our advantage to fill it up as best we can. The other thing that continues to plague me is our soaring utilities costs—I believe this might have been mentioned in earlier testimony—as one of the examples of our rising costs.

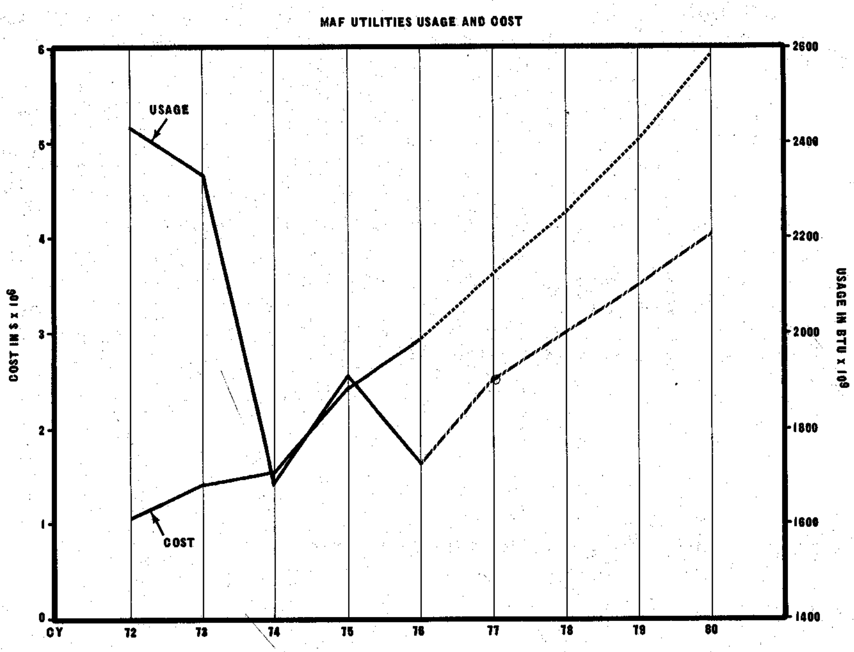


FIGURE 2

(Fig. 2.) We have had and continue to have a very effective utilities conservation program here, but there is no question that as we build up to rate on the external tank, our power usage is going to grow correspondingly and the rates are going to go up too. We have reached the point to where utilities amount to about 31 percent of our total cost of operating the facility right now. So, that continues to bother us but we are continuing to try to keep these costs down. I really don't think I need say anything further right now and unless there are questions, I would like to introduce Mr. George Smith, vice president and director of Martin Marietta for the external tank program.

Congressman WINN. Bob, last year, I thought you were in the process of negotiating a special rate structure with the power and light company?

Mr. LITTLEFIELD. I have talked to the New Orleans Public Service Inc. on a number of occasions. We are in the industrial category and we really do get an appreciable break. The thing that has concerned me recently rather than the rate, is that I was trying to convince them that we should be in a special category insofar as natural gas curtailment was concerned. The rate situation that we have is as good as we can expect. I have been talking extensively with them for the last 2 weeks as to whether we can expect any natural gas interruptions. We have on board, 1 million gallons of fuel. We can convert our boilers to fuel oil and run this plant for a month—it will cost us a little more, but we can do it. So, I am not too worried about a short curtailment, but I get very confused input from them about when it is going to happen, if at all. Their advice ranges from it might happen in a week to it may not hit us till next summer.

Congressman WINN. I thought I remembered your comments on the utility costs from last year.

[The prepared statement of Mr. Littlefield follows:]

VISIT OF

HOUSE SPACE SCIENCE AND APPLICATIONS SUBCOMMITTEE

TO

MICHOUD

FEBRUARY 5, 1977

PRESENTATION BY
ROBERT C. LITTLEFIELD, MANAGER, MAF
TO
HOUSE SPACE SCIENCE AND APPLICATIONS SUBCOMMITTEE

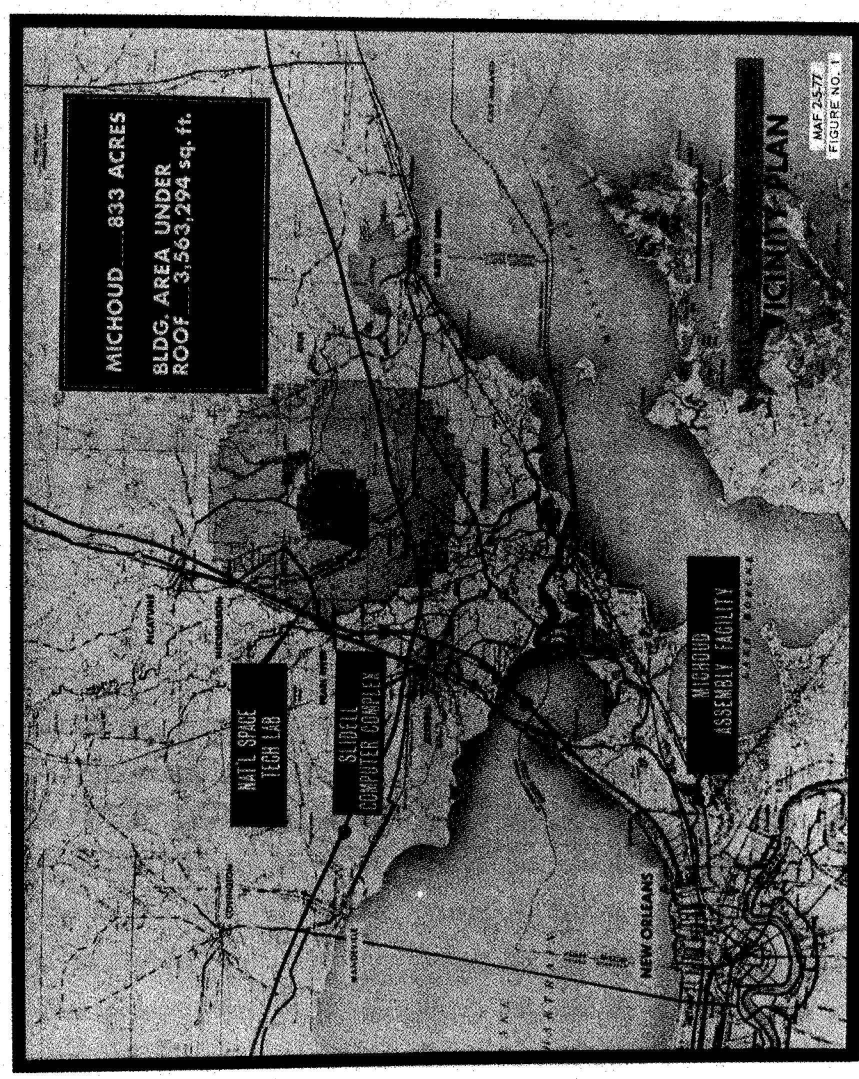
FEBRUARY 5, 1977

Gentlemen, it is a pleasure to welcome you to New Orleans and to the Michoud Assembly Facility.

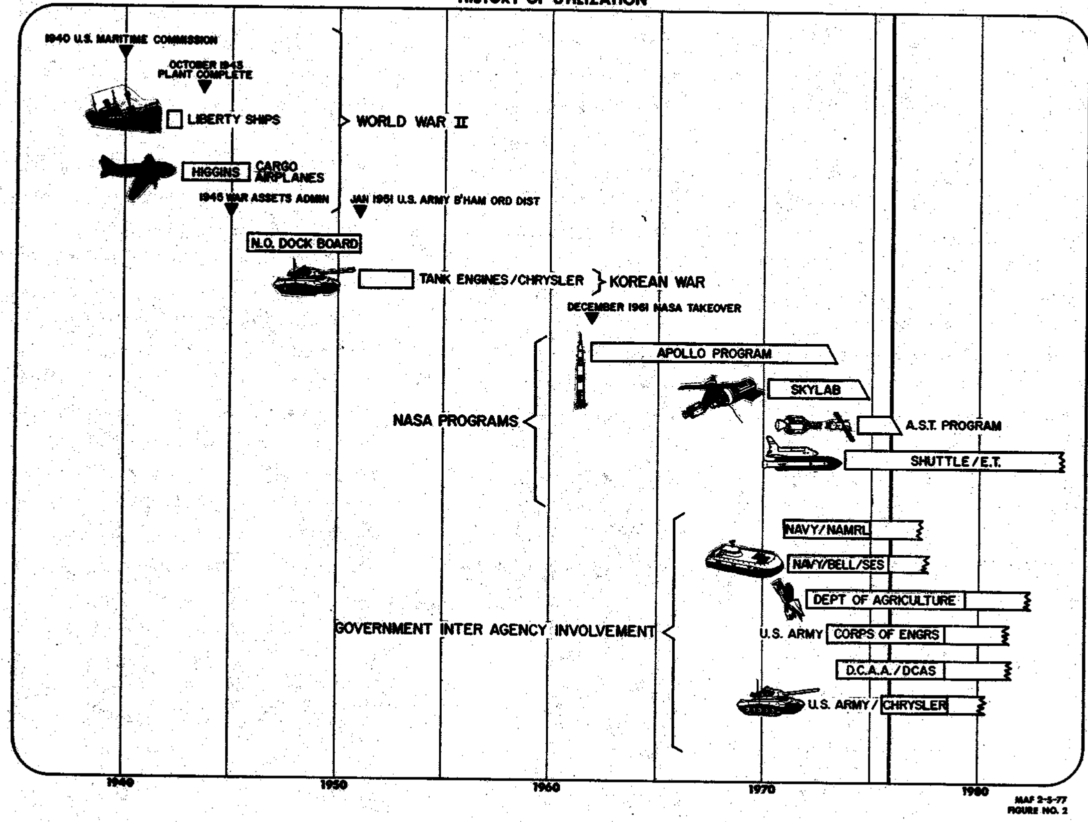
With your permission, Mr. Chairman, I would like to make a few brief remarks about the overall facility operation before we begin the review of the External Tank program.

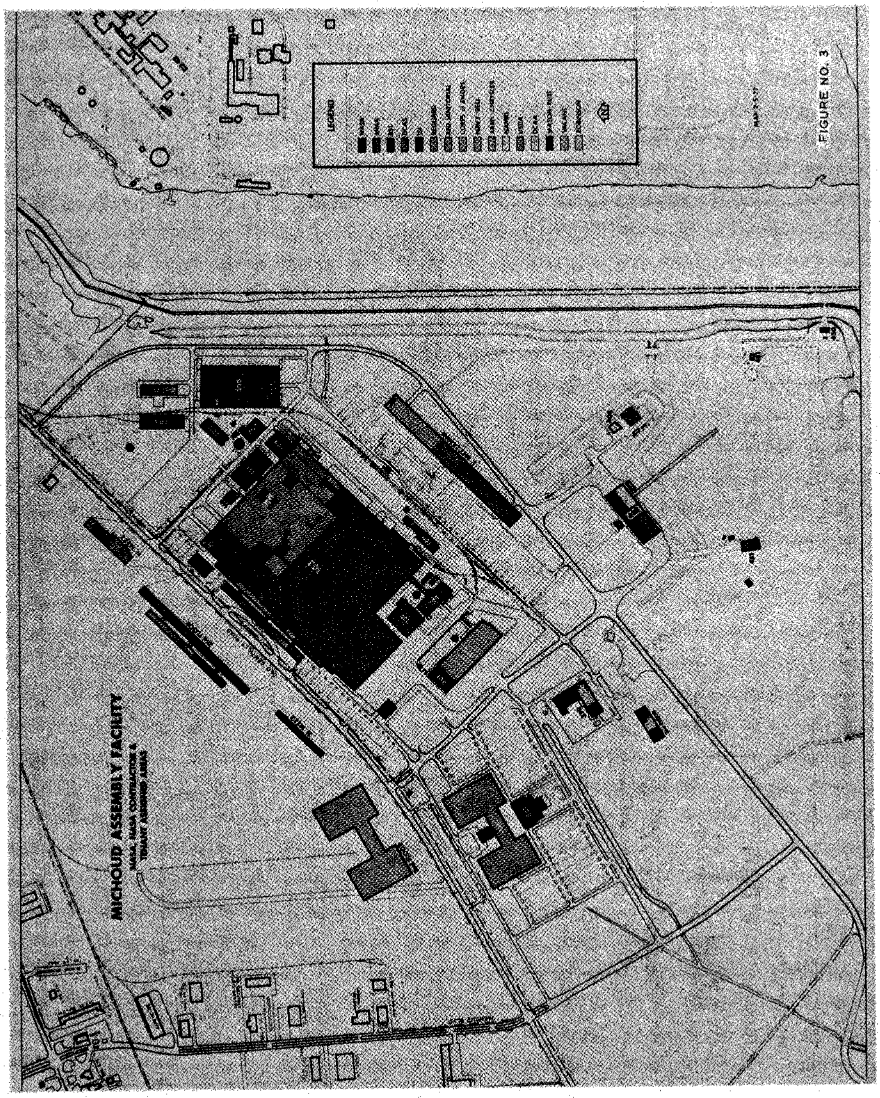
(Figure 1) First, to orient you with respect to our location, Michoud is in the eastern part of the city of New Orleans approximately 15 miles from the central business district. The Slidell Computer Center is 24 miles northeast of Michoud in Slidell, La., and the National Space Technology Laboratories is approximately 44 miles away in the same direction in the State of Mississippi. Both the Michoud Assembly Facility and the Slidell Computer Center are part of the Marshall Space Flight Center and most of our shuttle propulsion testing for which MSFC is responsible will be accomplished at the National Space Technology Laboratories. There are 833 acres of land and slightly over 3.5 million sq. ft. under roof at MAF. One important aspect of our geographical location is that the Michoud Assembly Facility is situated on the Mississippi Gulf Outlet. All External Tanks will be shipped from this site by barge as were the earlier Saturn stages. We hope to show you our barges and port a little later if time permits.

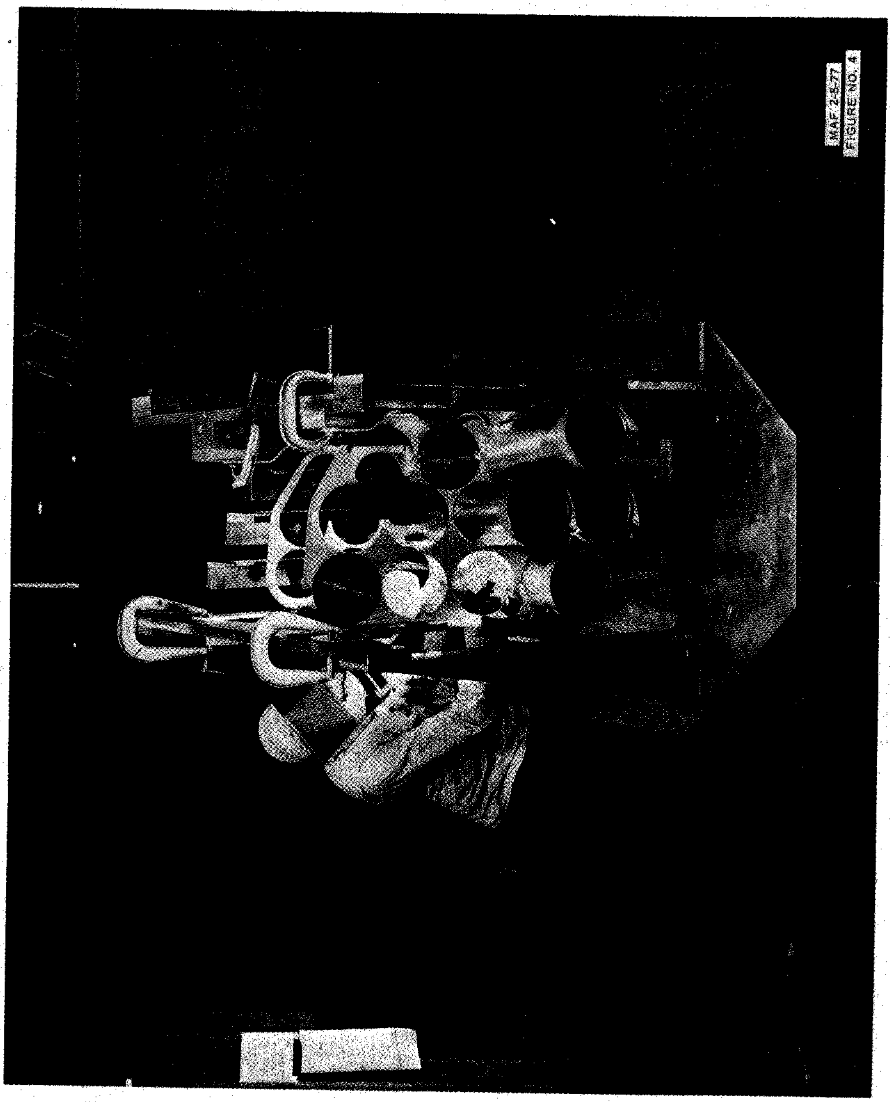
(Figure 2) Construction on Michoud began in 1940 with the intent of producing liberty ships at the facility. The plant was essentially completed in September 1943 but the intended use was changed from ship construction to the fabrication of wooden cargo airplanes. Two such aircraft were completed prior to the end of World War II. The facility was phased down and remained essentially inactive in a defense plant reserve status until the Korean war when Chrysler Corporation used part of the facility to assemble and test tank engines for the U. S. Army. NASA assumed ownership of the facility in late 1961 and the first stages of the Saturn IB and Saturn V vehicles were assembled at Michoud. The stages were used during the Apollo, Skylab and ASTP programs. In 1970 Michoud was baselined as the site for the assembly of the External Tank on the Shuttle program. In addition to the NASA program we have a number of tenant activities at Michoud whose presence here is based on formal agreements between NASA and other government agencies. An essential part of these agreements is that the tenants share in the costs of operating the facility.

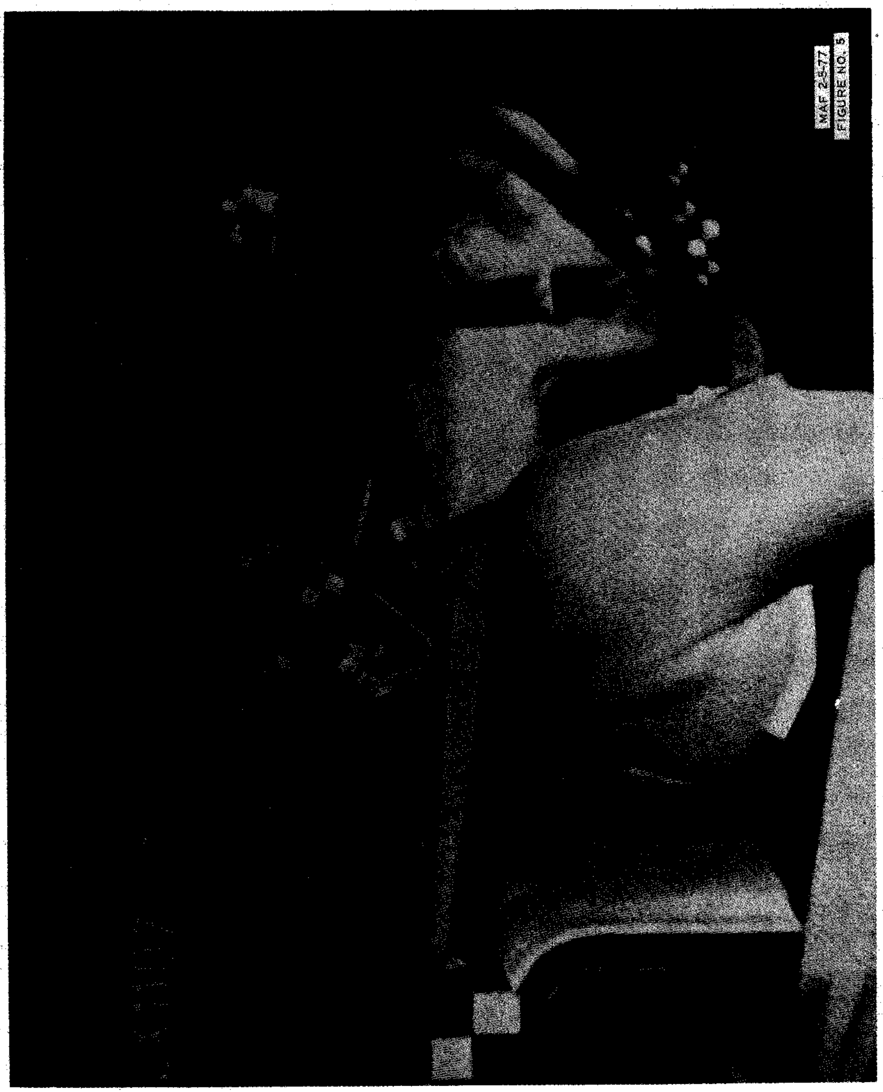

MICHOUD.....833 ACRES
BLDG. AREA UNDER
ROOF.....3,563,294 sq. ft.
NAT'L SPACE
TECH LAB
SLIDELL
COMPUTER COMPLEX
MICHOUD
ASSEMBLY FACILITY
NEW ORLEANS
VICINITY PLAN
MAF 2-5-77
FIGURE NO. 1

MICHOUD ASSEMBLY FACILITY
HISTORY OF UTILIZATION




MICHOUD ASSEMBLY FACILITY
LEGEND
FIGURE NO. 3


MAF 2-5-77
FIGURE NO. 4


MAF 2-5-77
FIGURE NO. 5

(Figure 3) The purple area on this chart represents that space utilized by the Martin Marietta Corporation on the ET project. It is worth noting that on the ET project we added only one new building at MAF, the pneumatic test facility, Building 451. We hope to show you this on the tour, time permitting. Mr. George E. Smith of Martin Marietta is going to review the ET project in some detail in a moment so I will move on to the other operations here.

When the total space requirements for the ET project at Michoud were fully understood, it was apparent that our requirements utilized only approximately one-half of the total facility capability. At that time there were a few tenants already on board and we began to attempt to attract other government operations to the facility since it was evident that greater utilization would be to NASA's advantage and would tend to offset the cost of overall facility operation. This arrangement also results in a mutual benefit for these tenants. At this time tenants occupy approximately 25 percent of our total area and contribute approximately 25 percent of the funds required to operate the facility.

Present tenant operations at Michoud include the Chrysler Corporation represented by the orange area in Building 103 (Figure 4) whose principal effort is supplying component parts on the M60 A1 Tank program and pneumatic consoles for the Kennedy Space Center for the Shuttle program.

The yellow area in Building 420 represents the space devoted to the Naval Aerospace Medical Research Laboratory (Figure 5) for performing impact acceleration and vibration tests on both primates and humans. They have requested additional space at Michoud for the installation of a motion simulator.

The light green area principally in Building 350 is the Department of Agriculture who are our largest tenant. Their operations at Michoud (Figure 6) include the National Finance Center (Figure 7) and the New Orleans Computer Center.

The blue area represents space presently occupied by the Bell Aerospace Corporation. (Figure 8) Their major current program is the JEFF-B Amphibious Assault Landing Craft. Bell and the Navy are in the process of a major retrenchment at Michoud as a result of the loss of the award of the large surface effects ship contract. At the present time it appears that their operation at Michoud will shrink to a relatively small office requirement in Building 350 by late spring of this year.

Other organizations with operations at Michoud are the Defense Contract Administration Services, who perform quality assurance and

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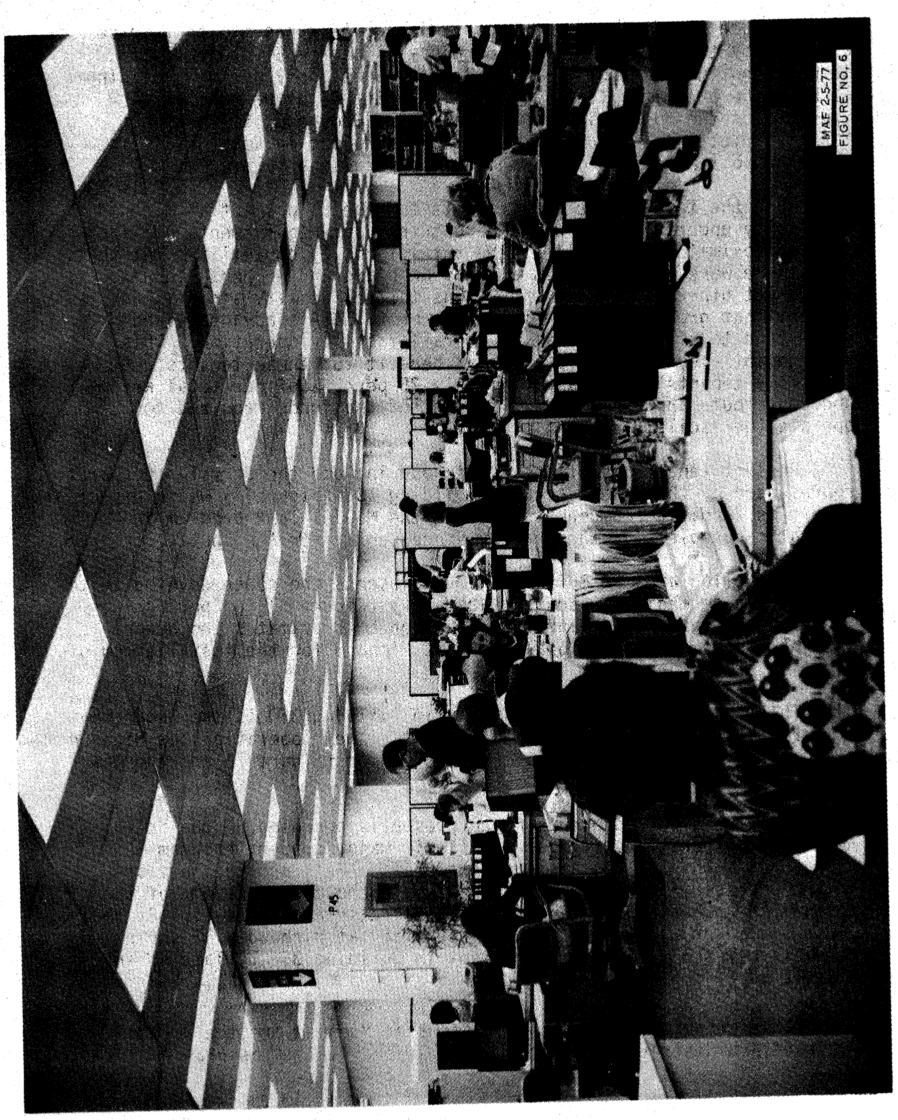
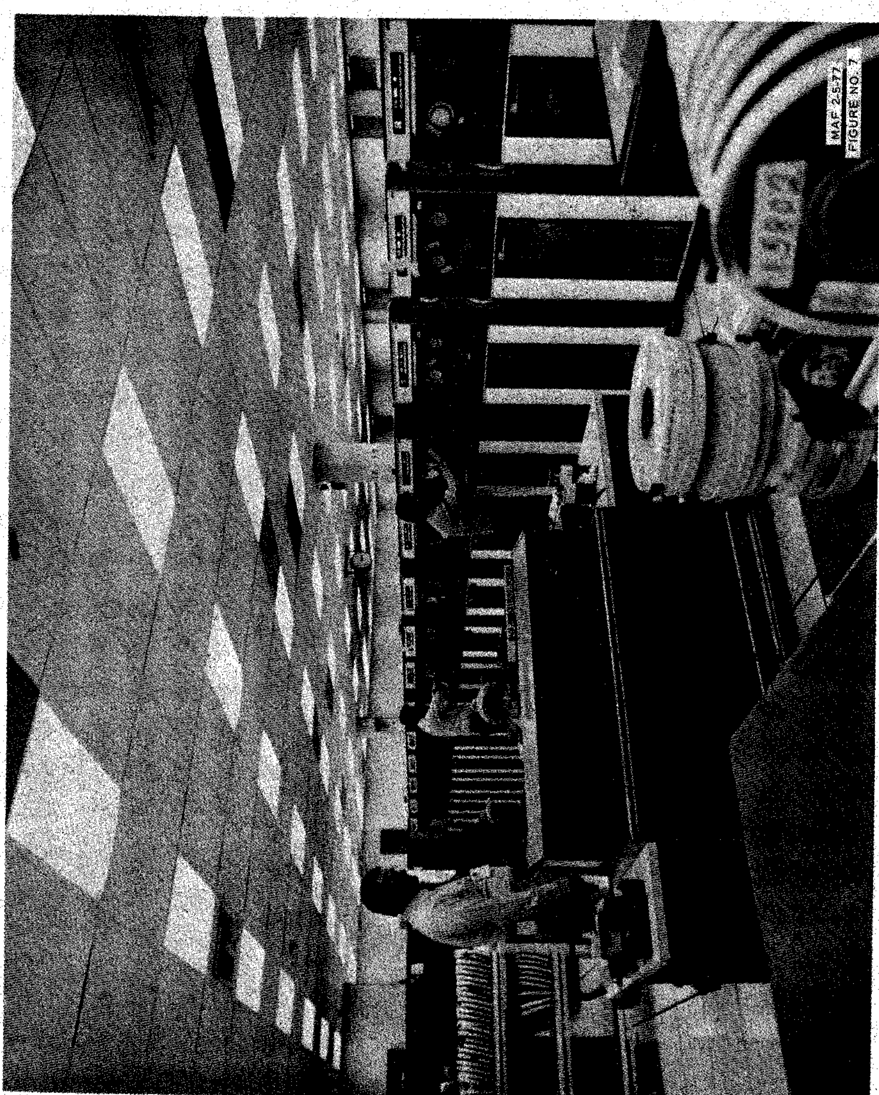
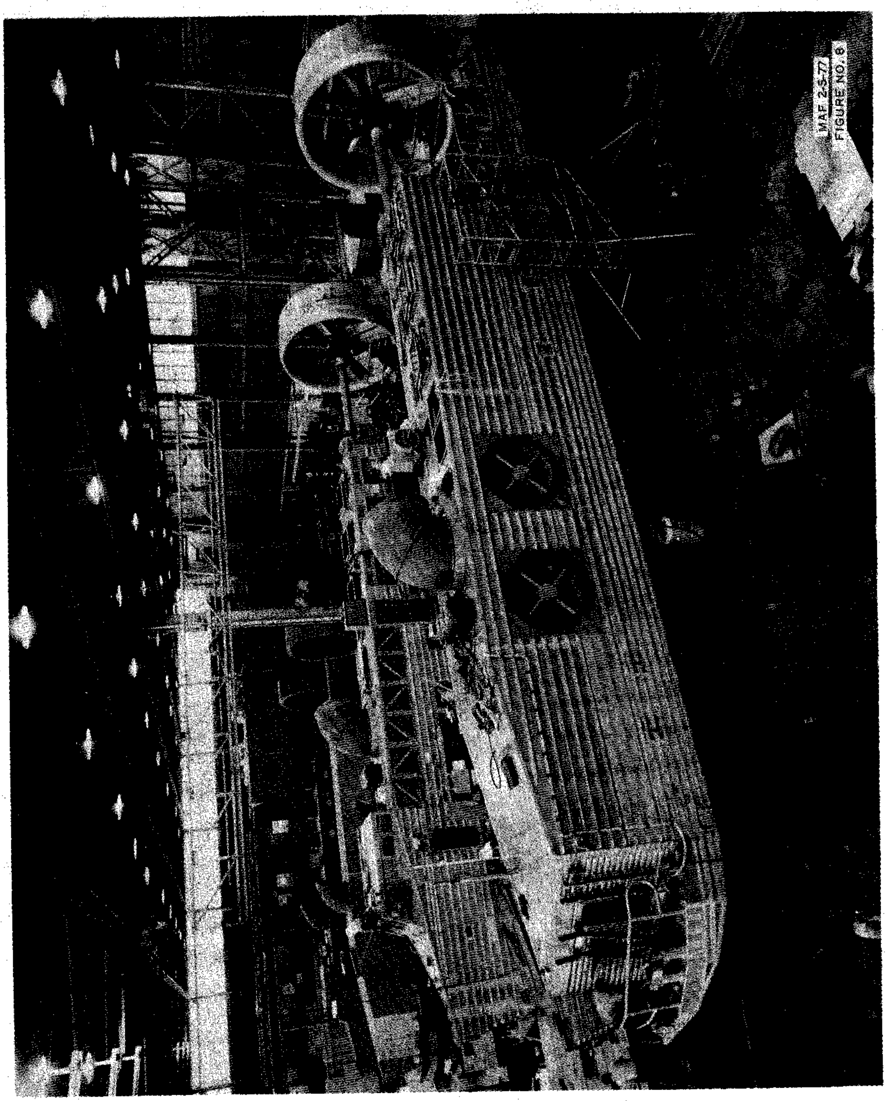

MAF 2-5-77
FIGURE NO. 6


MAF 2-5-77
FIGURE NO. 7


MAF 2-3-77
FIGURE NO. 8

MICHOUD ASSEMBLY FACILITY

PERSONNEL STRENGTH AS OF 2-1-77

MARTIN MARIETTA AEROSPACE		1437
SUBCONTRACTORS		116
BOEING SERVICES INTERNATIONAL		208
SUBCONTRACTOR		21
NASA		36
SPACE DIV., ROCKWELL INT'L		1
DCAS		44
RED JANITORIAL		49
REGUARD		32
ROBINSON		33
	SUB-TOTAL	1977
TENANT AGENCIES:		
NAVY/BELL AEROSPACE (209) SUPSHIPS NRLNS (7)		216
ARMY/CHRYSLER CORP		173
NAVAL AEROSPACE MED. RESEARCH LAB.		73
U. S. DEPT. OF AGRICULTURE		1032
DCAA		20
CORPS OF ENGINEERS		50
DCAS		22
	SUB-TOTAL	1586
	TOTAL	3563

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FIGURE NO. 9

MICHOUD ASSEMBLY FACILITY

MAJOR CONCERNS

- FACILITY UTILIZATION
- UTILITY COSTS

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FIGURE NO. 10

MAF UTILITIES USAGE AND COST

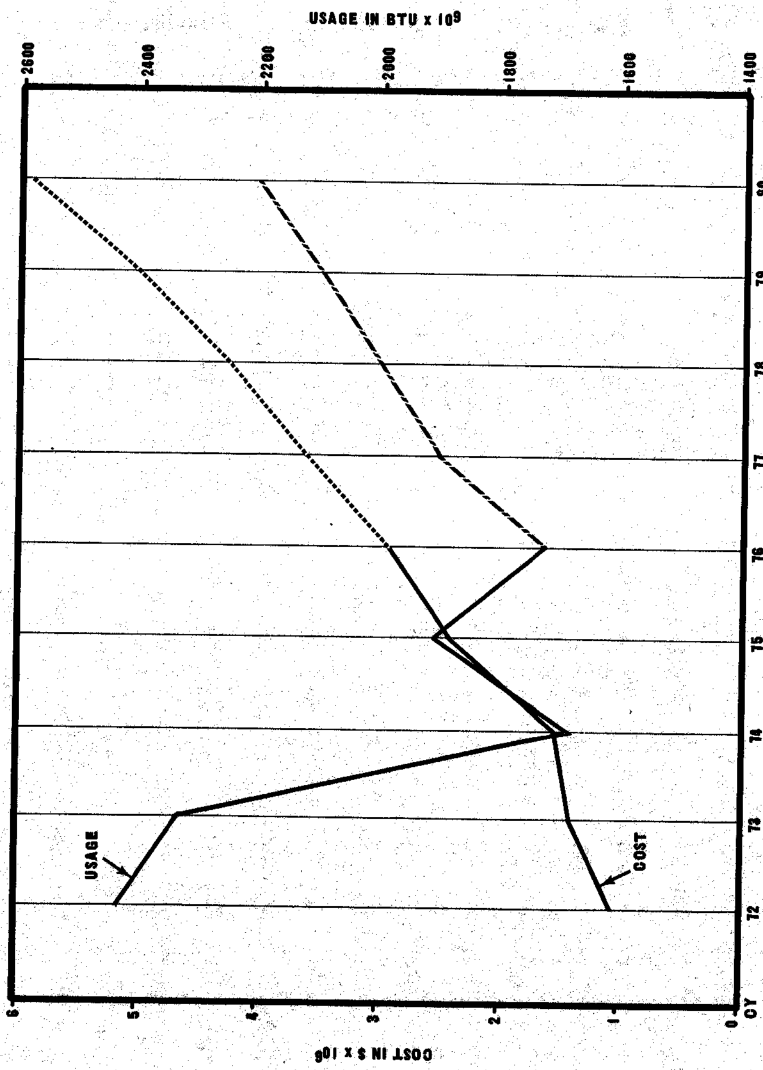

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FIGURE NO. 11

contract administration for NASA and DOD in addition to having their area office at Michoud; the Defense Contract Audit Agency who perform contract audit functions for NASA and DOD; and the Corps of Engineers who conduct inspection and contract administration on civil works projects, levees and flood control systems in southeast Louisiana.

The grey area on the chart is unoccupied and represents over 15 percent of our total capacity. We are continuing to attempt to attract additional tenants to Michoud and at the same time are considering several retrenchment options which would close a number of the outlying buildings and concentrate our NASA effort in fewer buildings.

(Figure 9) The present total personnel employed at MAF is 3,563. This is a drop of 216 from my report to you of last year. This reduction principally is a result of the phase down of Bell's operation. I would like to point out that we presently have three 8a, (Red Janitorial, Reguard, and Robinson Printing) Minority Small Business, contracts at Michoud the value of which represents 28 percent of the total value of our facility operating contracts.

(Figure 10) I would like to also point out what I feel are two of our major concerns with respect to the operation of the facility. The first point refers to our continuing effort to make maximum utilization of this site. As I previously mentioned it is definitely to NASA's advantage, and I believe to the advantage of other government agencies, to make maximum utilization of this facility. At MAF we are demonstrating that different government activities can work effectively together in a single government owned facility and by doing so can save overall government dollars while still meeting our commitments in the Space program. The second point is the continuing escalation in our utility costs. (Figure 11) At the present time utilities amount to 31 percent of our total operating cost. We have and will continue a very energetic and effective utility conservation program but are still faced with the prospect of ever increasing costs as we move into the production phase of the External Tank program.

Overall, I believe the facility is being operated in a reasonably good cost effective manner. We have cut out some frills, eliminated some functions and found that we can do the work with about 100 less people than was the situation toward the end of the Saturn program.

That completes my presentation, Mr. Chairman, and if there are no questions, I would like at this time to introduce Mr. George Smith, the Vice President and Director of the Martin Marietta Corporation for the External Tank program.