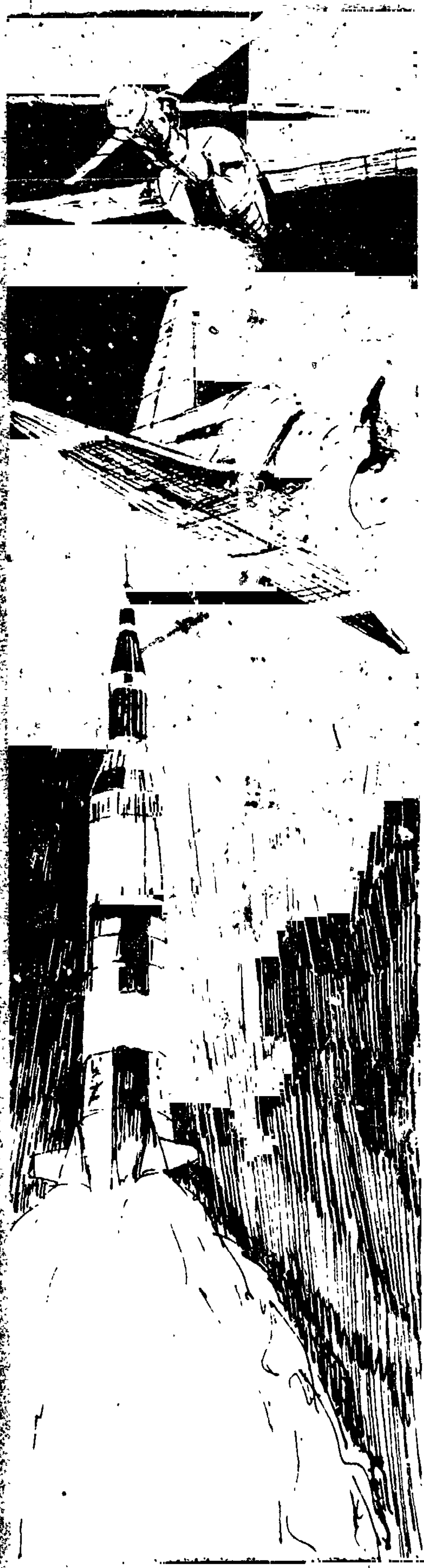

MAY 1974

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

(NASA-TM-X-70382) AN ILLUSTRATED CHRONOLOGY OF THE NASA MARSHALL CENTER AND MSFC PROGRAMS 1960-1973 (NASA) 438 p HC $9.00 CSCL 22C

AN ILLUSTRATED CHRONOLOGY OF THE NASA MARSHALL CENTER AND MSFC PROGRAMS

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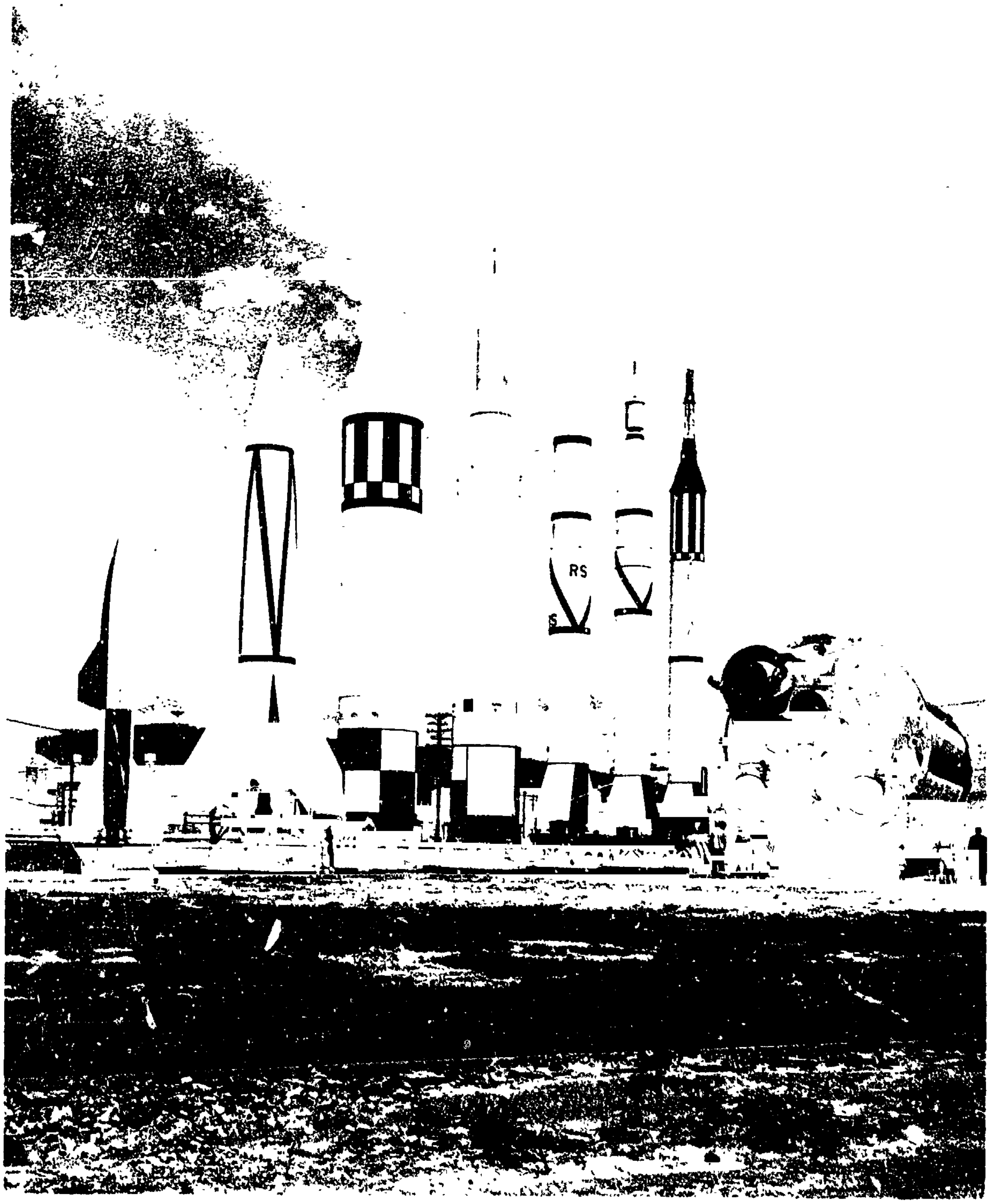
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

1960★1973



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May 1974

An Illustrated Chronology of the NASA Marshall Center and MSFC Programs 1960-1973

By

David S. Akens

Historical Staff
Management Services Office
George C. Marshall Space Flight Center
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Postscript

Although this chronology ends on June 30, 1973, it seems appropriate to add a few words about the Skylab program after that date and prior to chronology publication. On July 28, 1973, the Skylab II astronauts (SL-3, Second Manned Mission) went into space and, after a successful 59-day flight, returned safely to earth on September 25. Finally, the Skylab III (SL-4) astronauts, in the last flight mission in the Skylab program, rose from earth on November 16. The Skylab II astronauts successfully completed their mission and, after 84 days in space, returned safely to earth on February 8, 1974.

A final postscript concerns major changes at MSFC subsequent to its first 13 years. On March 5, 1974, NASA announced that Dr. Rocco Petrone would go to Washington to become NASA associate administrator, the agency's third highest ranking official. Replacing Dr. Petrone as MSFC director would be Dr. William R. Lucas, the MSFC deputy director. The official changeover from Petrone to Lucas was later reset for June 15, 1974. Concurrent with the announcement of these major personnel changes at MSFC, NASA also announced a major reorganization of MSFC to become effective May 30, 1974, paralleling an MSFC reduction-in-force that would be effective that date. The Center issued layoff notices to 397 persons and downgrading notices to 259. This new pared-down MSFC work force was considered a more efficient organization for carrying on the future MSFC roles.

DSA
May 31, 1974

INTRODUCTION

NASA's largest center, the Marshall Space Flight Center, played a major role in developing the largest technological program in the history of mankind. This *Illustrated Chronology of the NASA Marshall Center and MSFC Programs* highlights the Center's activities as well as the activities of its major programs from the Center's beginning in July 1960 to the end of its 13th year in June 1973. In addition to highlights during the Center's first 13 years, this volume also gives background information concerning events that were important in the Center's formation.

Contributing to the preparation of this volume were Mr. Erich Neubert of the Office of Director, MSFC; Mr. Don Lakey and Mrs. Betty Davis of the MSFC Historical Staff; and Mr. James R. Bishop of the MSFC Skylab Office.

The Appendices in the back of this book include summary charts showing MSFC's personnel strength at the end of its 1st year and at the end of its 13th year, as well as on its peak day of personnel strength, April 30, 1965. For those desiring clarification of terms in the text, there is a list of acronyms and abbreviations. Also included is a historical summary of MSFC's first 13 years.

NOTE

MSFC in this chronology stands for the Marshall Space Flight Center complex in Huntsville, Alabama. Michoud Assembly Facility (MAF) and Mississippi Test Facility (MTF) are part of the MSFC organization but physically are located in Louisiana and Mississippi, respectively. When an event in this chronology is cited as occurring at MSFC, the citation refers to the Huntsville complex. MAS and MTF are cited separately.

DSA
May 31, 1974

CONTENTS

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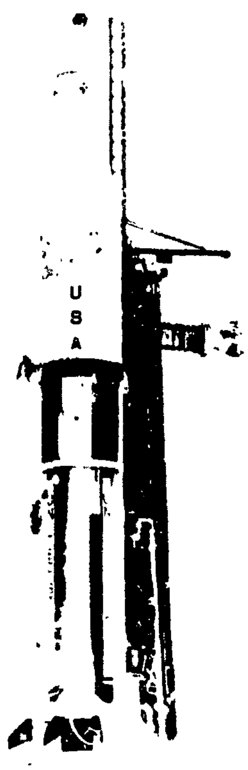
1957

In April the scientific organization directed by Dr. Wernher von Braun began studies which led to Saturn, America's first rocket developed for space investigation. The team at Redstone Arsenal, Alabama, hoped to design launch vehicles that could carry 20 000- to 40 000-pound payloads for orbital missions or 6000- to 12 000-pound payloads for escape missions. High-thrust booster stages were essential. In December the von Braun group, then working with the Army Ballistic Missile Agency (ABMA), proposed a program to the Department of Defense. At that time the United States was considering an integrated missile and space vehicle development program. Creation of a booster with 1 500 000 pounds of thrust was the aim of the proposed program [1].



Saturn IB

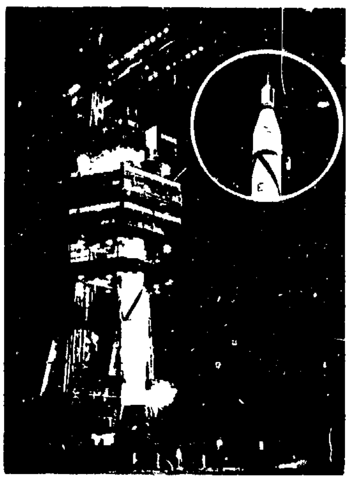
1958

On August 15 the Advanced Research Projects Agency (ARPA) formally initiated what was to become the Saturn project. The agency, a separately organized research and development arm of the Department of Defense, authorized ABMA to conduct a research and development program at Redstone Arsenal for a 1 500 000-pound thrust vehicle booster. A number of available rocket engines would be clustered. This design would be tested by a full-scale static firing by the end of 1959 [2].

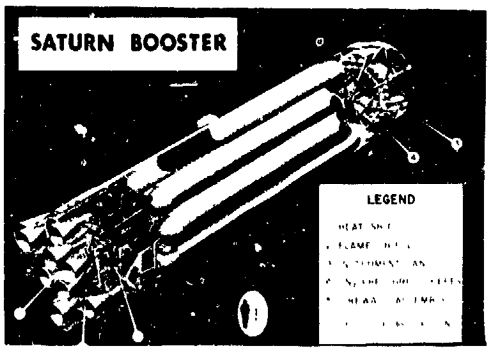
A contract was awarded Rocketdyne Division of North American Aviation on September 11 to uprate S-3D, the Thor-Jupiter engine. After redesign, simplification, and modification, the engine would be the H-1 [3].

In October ARPA expanded its program objectives. A multistage carrier vehicle capable of performing advanced space missions would be built. The vehicle was tentatively identified as Juno V. ARPA requested Redstone personnel to study a complete vehicle system so that upper-stage selection and development could begin and initiated a study of Atlantic Missile Range (AMR) launch facilities which could accommodate the launch vehicle [4]. Later, on December 11, ARPA authorized the Army Ordnance Missile Command (AOMC) to begin design, modification, and construction of a captive static test tower and facilities for use in the booster development program. AOMC was also to determine the design requirements for necessary launch facilities [5].

While the booster-vehicle program was being formulated and expanded, development work on the H-1 engine continued. The first full-power H-1 engine firing occurred in December at the Rocketdyne facility in Canoga Park, California [6].



Final preparation for launch of first U.S. satellite, January 31, 1958. Insert shows close-up of satellite atop the Jupiter C. This first U.S. satellite pioneered the U.S. space program that led to Saturn and beyond.



Proposed configuration of a clustered booster

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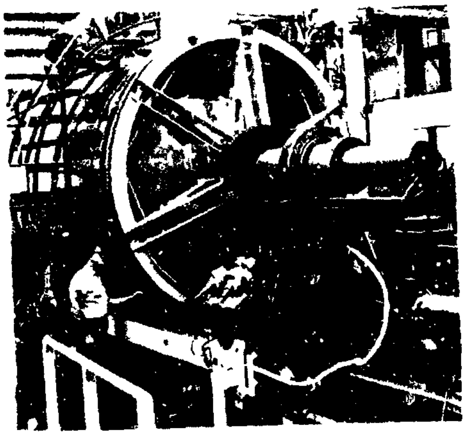
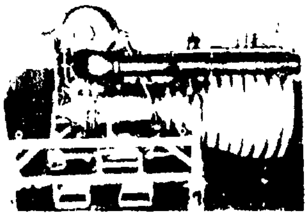
Thor-Jupiter engine



Booster tooling



Early H-1 engine

Dr. T. Keith Glennan on August 19, 1958, became the first administrator of NASA. He would serve until his replacement by James E. Webb on February 14, 1961.

1959

Concurrently with development of the H-1 engine, studies were conducted to determine the feasibility of a larger single-chamber rocket engine. On January 9 Rocketdyne agreed by contract to design, develop, and test such an engine, designated as the F-1. This engine, burning lox and RP-1, a kerosene-type fuel, would generate a very high thrust, approximately 1 500 000 pounds [7].

Construction of the ABMA static test stand for large boosters began January 10. Meanwhile, Army representatives of the ARPA board visited AMR to discuss selection of a site for large vehicle launch facilities at Cape Canaveral, Florida. By February a contract had been awarded for construction of the blockhouse at the site (Launch Complex 34). A design contract was also awarded for a movable structure which would be used to assemble and service the vehicle on the launch pedestal [8].

On January 27 the National Aeronautics and Space Administration (NASA) submitted to the President a report containing its recommendations for a National Space Vehicle Program: the development of a series of general purpose space-flight vehicles of increasing payload capability for successive periods of use, with the aim of achieving a high degree of reliability and reduced costs. Four types of vehicles, Atlas-Vega, Atlas-Centaur, Juno V, and Nova, were suggested and were discussed in terms of configuration, payload and mission capability, and development and operational time and cost.

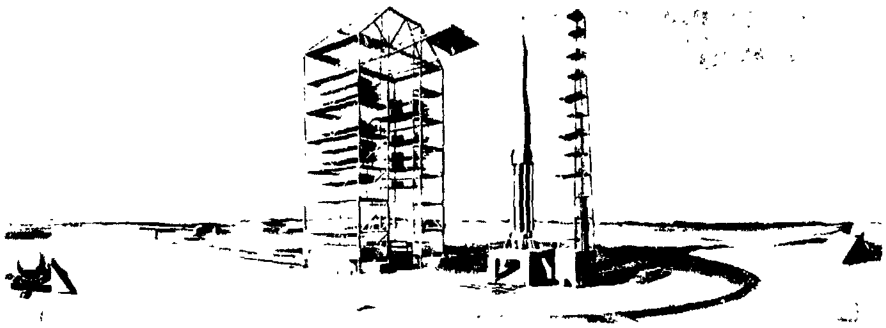
Concerning the Juno V, the third of the proposed National series, the report said, "A typical mission would involve sending a crew of men into orbit with enough facilities to sustain them for a long period of time and the necessary equipment to permit them to perform experiments and make observations. This vehicle may well become the basic vehicle for orbital supply missions, involving the transport of food and supplies to crews in orbit, the exchange of crew members, and the transport of additional fuel and equipment to the orbiting vehicle."

The report was prepared by the Propulsion Staff of NASA, in consultation with ARPA of the Department of Defense [9].

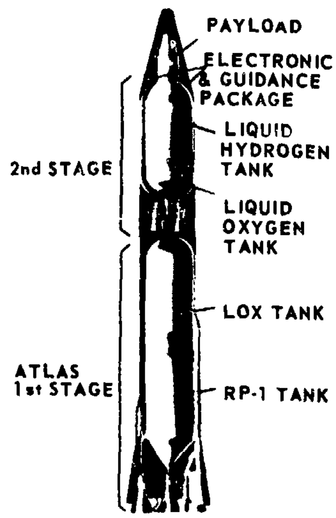
On February 3 an ARPA memorandum officially renamed the large launch vehicle project Saturn. ARPA representatives presented the proposed National Vehicle Program to the President and the National Aeronautics and Space Council on March 2. Included were the proposed Saturn B and C vehicle systems [10].

By April 28 the first production H-1 engine (H-1001) had been delivered on schedule to ABMA. ABMA's first firing test of this engine, later used in the first test booster, was performed successfully on May 26 [11].

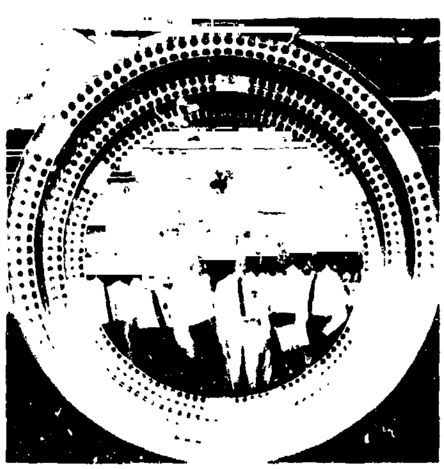
On July 5 construction of the Saturn blockhouse for Launch Complex 34 began at Cape Canaveral. On July 27 when the last Jupiter airframe was completed, Redstone Arsenal shops began retooling to support the Saturn project [12].



Preliminary concept of Launch Complex 34, Cape Canaveral



Atlas Centaur vehicle (Centaur second stage)



Seven astronauts with Dr. Wernher von Braun in the center, as seen through the frame of an ABMA missile. The picture was taken during the astronauts' visit to Redstone Arsenal in June 1959.

In September representatives of AOMC, NASA, and the Air Force presented Saturn, Nova, and Titan C systems to the Booster Evaluation Committee of the Office of the Secretary of Defense. On the basis of these presentations ARPA chose Saturn. ARPA then requested that Redstone scientists determine the Saturn configurations which could best carry NASA payloads [13].

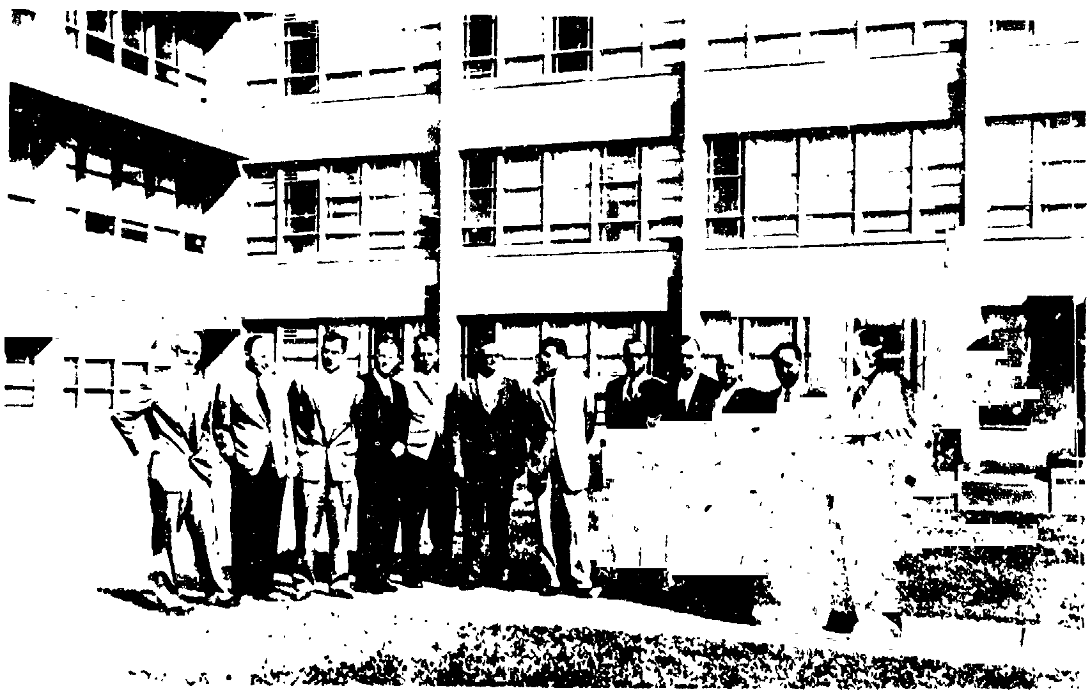
Because of its large size and weight, the Saturn booster could not be transported by air or land. Water transportation appeared most feasible, and ARPA, on October 23, authorized AOMC to proceed with engineering work for dock facilities. These would be located on the Tennessee River at the southern boundary of Redstone Arsenal. In December, AOMC was further authorized to construct the facilities and to build a barge to transport the booster to Cape Canaveral [14].

On November 18 NASA assumed technical direction of the Saturn project pending its formal transfer from ARPA. Administrative direction was retained by ARPA until March 16, 1960, when transfer of both administrative and technical direction would become effective [15].

On December 15 the Saturn Vehicle Evaluation Committee (the Silverstein Committee) reached a decision on Saturn upper-stage configurations. This committee, composed of representatives from NASA, ARPA, Department of Defense, and the Air Force, recommended a long-range development program for a Saturn vehicle with upper-stage engines burning liquid hydrogen and liquid oxygen. The initial vehicle, identified as C-1, was to be a stepping stone to a larger vehicle, the C-2. A building-block concept was proposed that would yield a variety of Saturn configurations, each using previously proven developments as far as possible. These recommendations were accepted by the NASA Administrator. On December 31 a 10-vehicle program was established [16]. The C-1 vehicle configuration included the S-I, S-IV, and S-V stages. The S-I stage would have eight H-1 engines. Fueled by lox/RP-1, the clustered engines were expected to produce a total of 1 500 000 pounds of thrust. The S-IV stage was envisioned as a four-engine liquid oxygen-liquid hydrogen fueled unit capable of producing a total of 80 000 pounds of thrust. The S-V stage would use two of the same engines as the S-IV stage and would provide an additional 40 000 pounds of thrust [17].

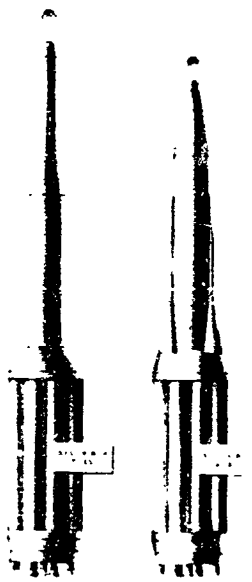
H-1 engine in alignment fixture

Model of blockhouse at Launch Complex 34

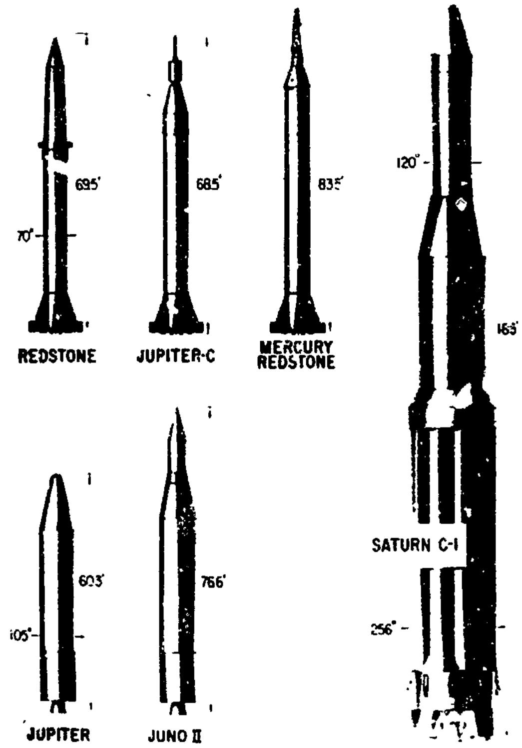


ABMA SCIENTISTS

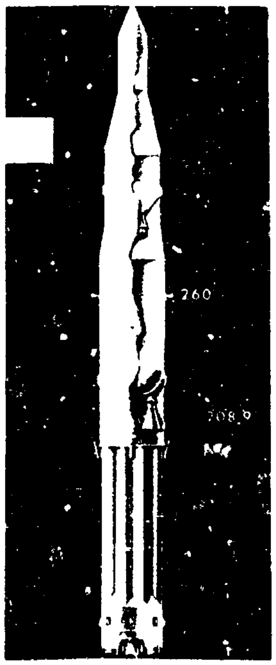
Top scientific specialists led the Army's space efforts at ABMA before transfer of the team to MSFC. From left to right: Dr Ernst Stuhlinger, Director-Research Projects Office. Dr. H. Hoelzer, Director-Computation Laboratory; K. L. Heimburg, Director-Test Laboratory, Dr E.D. Geissler, Director-Aeroballistics Laboratory, E.W. Neubert, Director-Systems Analysis & Reliability Laboratory; Dr. W. Haeussermann, Director Guidance and Control Laboratory; Dr. Wernher von Braun, Director-Development Operations Division, W.A. Mrazek, Director-Structures and Mechanics Laboratory Hans Hueter, Director-System Support Equipment Laboratory; Eberhard Rees, Deputy Director-Development Operations Division; Dr. Kurt Debus, Director-Missile Firing Laboratory; H.H. Maus, Director-Fabrication and Assembly Engineering Laboratory



Vehicles using Titan and Atlas Stages



C-1 and earlier vehicles



Proposed C-2

1960

The Saturn project was approved on January 18 as a program of the highest national priority (DX rating). A mockup of the Saturn booster was installed in the ABMA test stand on January 4 to check mating of the booster and stand and to test servicing methods. This mockup was removed from the test stand and the complete test booster, SA-T, was installed in its place during February 1960 [18].

During March the executive order transferring the Saturn program to NASA became effective [19]. Later in the month two of Saturn's eight first-stage engines passed an initial static firing test lasting 8 seconds. This test was identified as number SAT-01, the first live firing of the Saturn test booster (SA-T); it occurred on March 18 [20]. In a second test (SAT-02), on April 6, four engines were successfully static fired for 7 seconds. All eight engines of the test booster were successfully fired on April 29 in an 8-second test [21].

In April NASA awarded Douglas Aircraft Company a contract to develop the second stage for the Saturn rocket. Then in the following month NASA announced that Rocketdyne had been selected to develop the high-thrust J-2 engine. This engine, of the type defined by the Silverstein Committee in December 1959, would burn liquid hydrogen-liquid oxygen. It would be used in an advanced Saturn vehicle [22].

The first 10 Saturn flight vehicles would be numbered from SA-1 to SA-10. SA-10 would be the prototype of the operational Saturn. On May 26 assembly of the booster stage for the first Saturn flight vehicle began in Huntsville. On July 1 the Saturn program was formally transferred to the George C. Marshall Space Flight Center (MSFC) [23].

On July 1, 1960, formal transfer ceremonies at Huntsville, Alabama, officially opened NASA's George C. Marshall Space Flight Center [24].

On July 26 NASA signed a supplemental agreement with Douglas Aircraft Company covering the second stage. Douglas would design, develop, and fabricate the four-engine S-IV stage. Contracts were let on August 10 with Pratt & Whitney to develop and produce LR-119 engines; the Government would furnish these engines to the contractors responsible for building the S-IV and S-V stages of the C-1 vehicle. The LR-119, an uprated LR-115 engine, was expected to generate 17 500 pounds of thrust [25].

On August 14 construction began on the mobile service structure for Launch Complex 34 at Cape Canaveral [26].

On September 8 the facilities of the National Aeronautics and Space Administration at Huntsville, Alabama, were dedicated and designated as the George C. Marshall Space Flight Center. President Eisenhower, Mrs. George C. Marshall, NASA Administrator T. Keith Glennan, and many other national, state, and local dignitaries participated in the ceremony [27].

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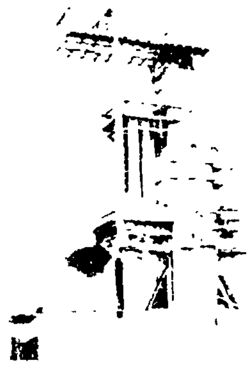
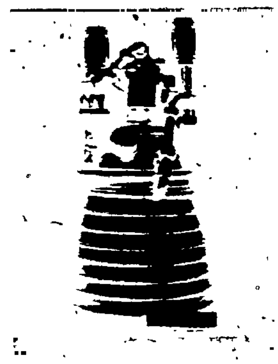
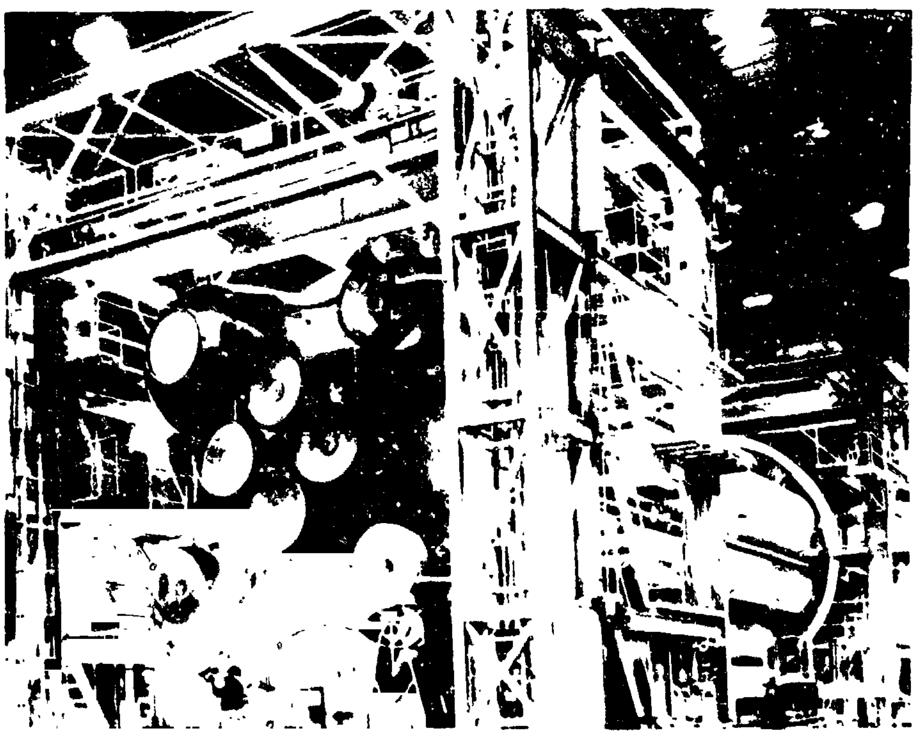


Booster static firing



Model of J-2 engine



Booster stage (S-I)

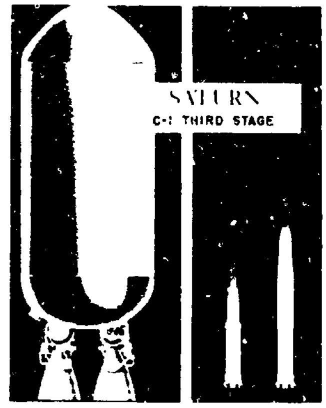
Initial configuration of the S-IV stage

On November 21 the first Mercury-Redstone (MR-1) failed to launch at Cape Canaveral because of improper separation of electrical connectors between the launching table and the vehicle [28].

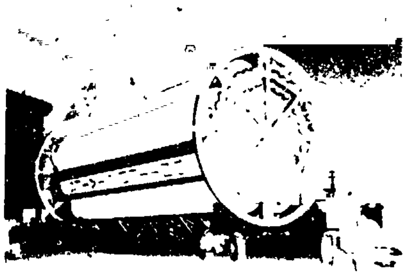
On December 19 at 11:15 a.m. EST, MSFC's Launch Operations Directorate launched Mercury-Redstone (MR-1A) at Cape Canaveral. The Mercury-Redstone booster launched the unmanned Mercury spacecraft 135 miles high and 235 miles down the Atlantic Missile Range. The 1-ton spacecraft landed by parachute and was recovered by helicopter. Thirty-two minutes after landing, the spacecraft was on the deck of the *USS Valley Forge*. The spacecraft was recovered in excellent condition [29].

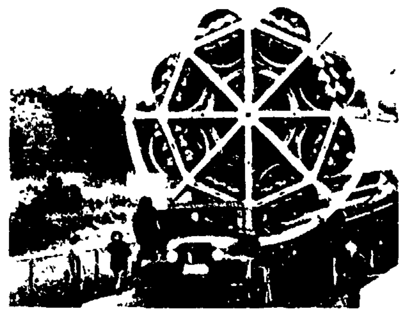
In December MSFC published the *Historical Origins of the George C. Marshall Space Flight Center*, highlighting events important in the Center's formation. This first MSFC history included background events such as the March 1945 formation in the Pentagon of Project Paperclip to recruit German missile scientists. Project Paperclip resulted in approximately 100 V-2 ballistic missiles being shipped from Germany to White Sands Proving Ground in the United States in August 1945. On September 20, 1945, MSFC's future director Wernher von Braun and six other key German rocket scientists arrived in the United States as a result of Project Paperclip. On December 10, 1945, 55 German specialists arrived at Fort Bliss, Texas, and White Sands Proving Ground, Texas, where they were joined by the first seven specialists headed by Wernher von Braun. The first V-2 rocket was static-fired at White Sands Proving Ground, March 15, 1946. On March 21, 1950, the U. S. Army Adjutant General ordered transfer of the missile personnel headed by Wernher von Braun from White Sands to Redstone Arsenal, Alabama. On April 1, 1950, the German missile personnel headed by Dr. von Braun were moved from White Sands Proving Ground to Redstone Arsenal, Alabama. On February 1, 1956, the Army activated the Army Ballistic Missile Agency (ABMA), which grew out of the Redstone Arsenal's Guided Missile Development Division. Russia inspired the U. S. to new space efforts when it launched Sputnik I, the first earth satellite, on October 4, 1957. The United States followed with Explorer I, the Free World's first earth satellite, orbited on January 31, 1958. The success of Explorer I whetted U. S. space appetite, and on April 2, 1959, NASA selected seven astronauts for project Mercury, after a series of the most rigorous physical and mental tests ever given to U. S. test pilots. On October 21, 1959, President Eisenhower announced his decision to transfer a portion of ABMA's personnel, facilities, and missions to NASA. The next month, on November 2, President Eisenhower announced his intention to transfer the Saturn project from the Army to NASA monitorship. On November 18, 1959, NASA assumed technical direction of the Saturn project pending its formal transfer from the Army. On January 14, 1960, President Eisenhower directed the transfer of ABMA's Development Operations Division and its space-related missions to NASA. The George C. Marshall Space Flight Center, NASA's Huntsville Facility, was so named by Executive Order of President Eisenhower on March 15, 1960. Formal transfer ceremonies at Huntsville officially opened NASA's George C. Marshall Space Flight Center, July 1, 1960 [30, 31].

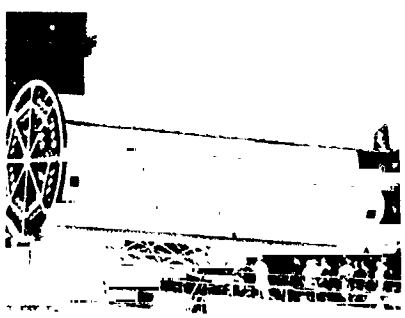
Second stage (S-IV)

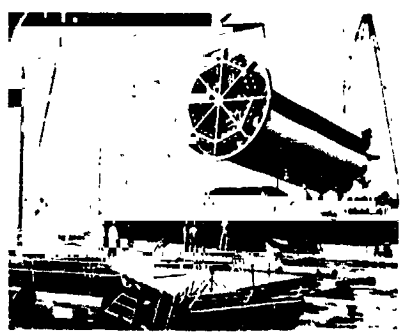


Third stage (S-V)



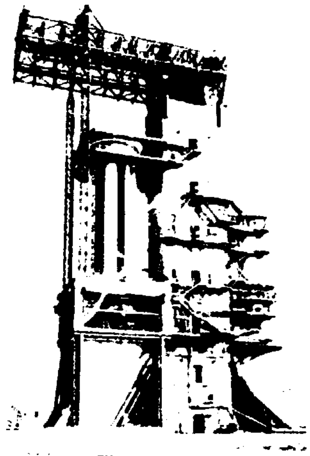






Moving Saturn test booster from assembly to test

NASA officials when MSFC was formed – Morris, Rees, von Braun, Glennan, and Ostrander.

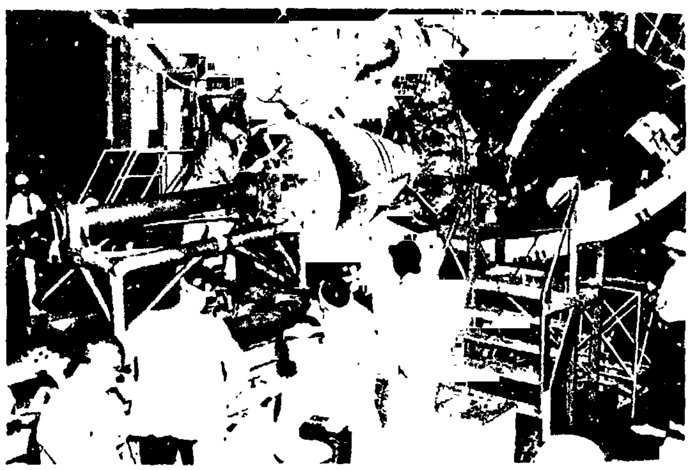


Booster in test stand

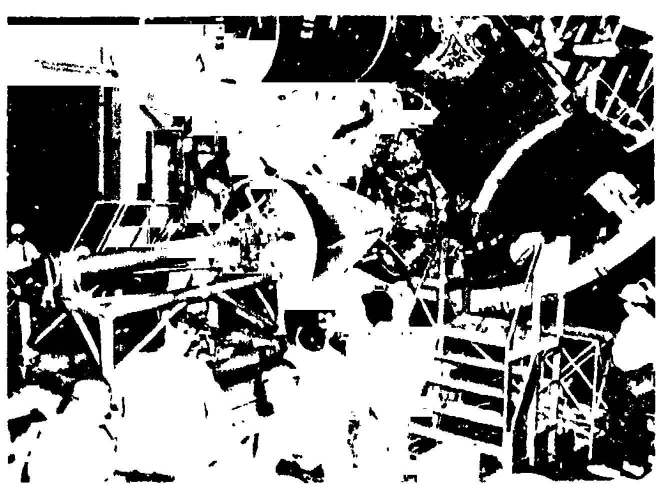
Assembly of main lox tank for SA-1 booster

Top scientific members of Dr. von Braun's early ABMA team, shown here with their wives but not with Dr. von Braun, transferred to MSFC upon formation of the Center.

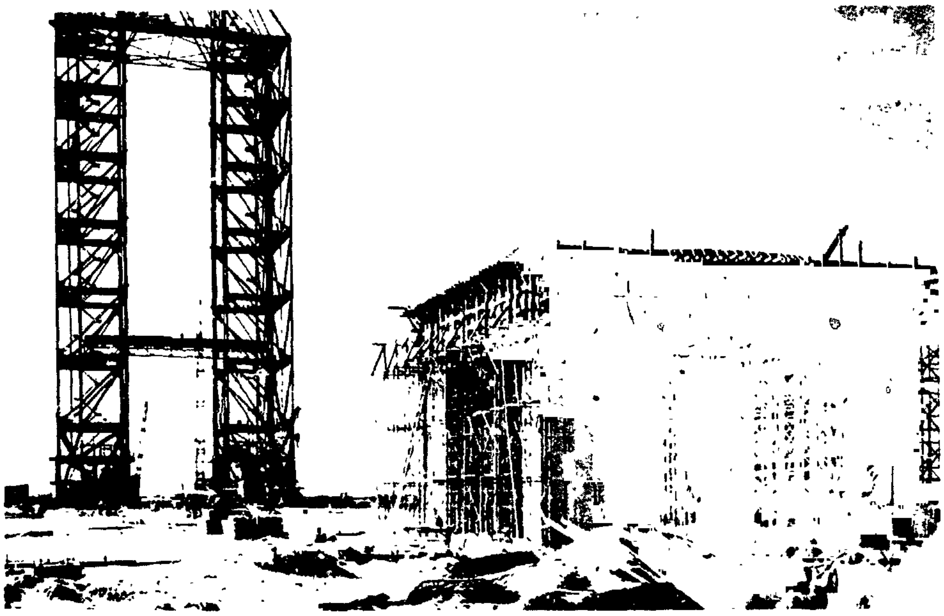
Assembly of tanks on SA-1 booster



Structural fabrication of SA-1 booster



Installation of engines on SA-1 booster

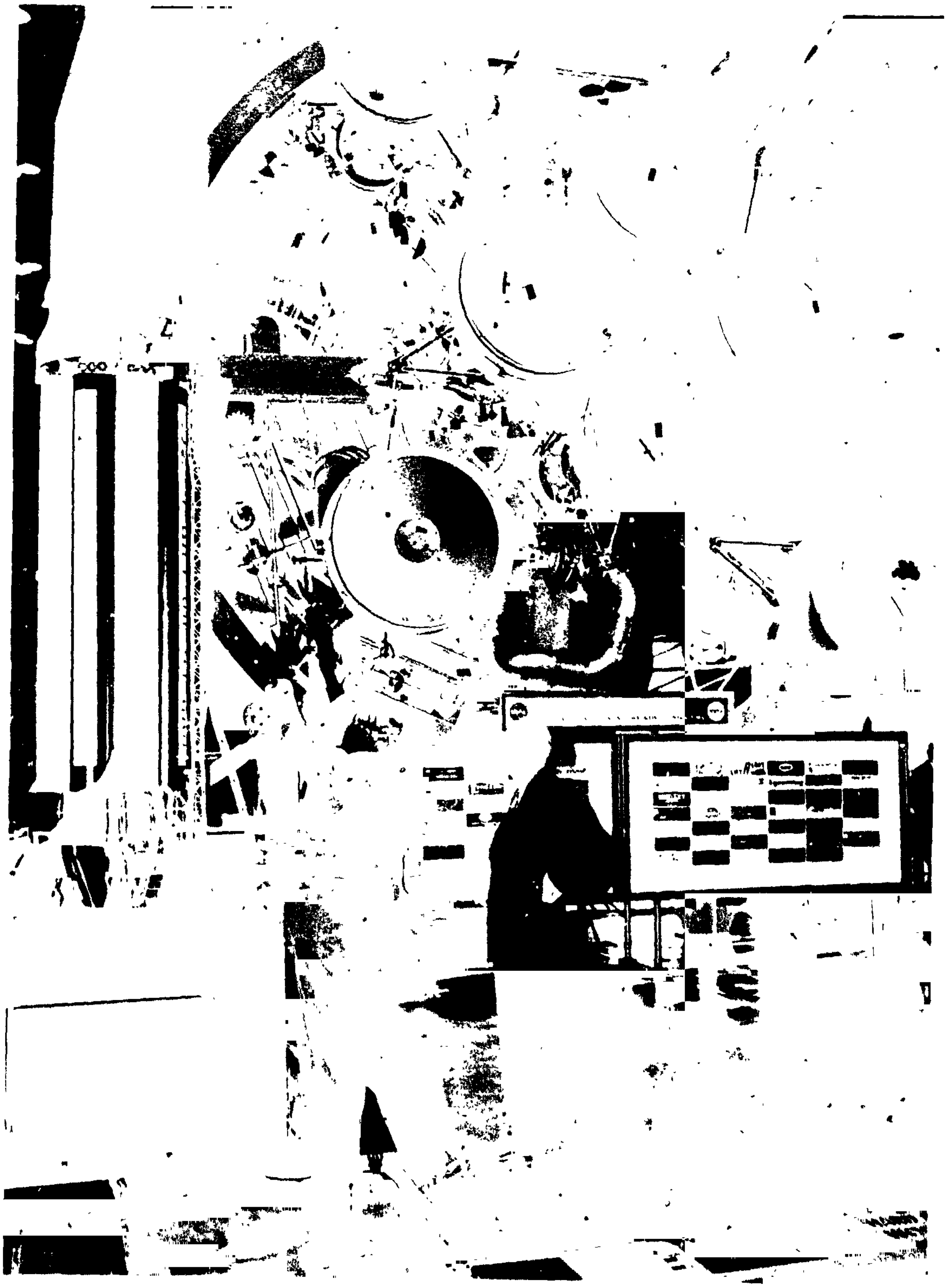


Construction of service tower and pedestal

MSFC's first director, Dr. Wernher von Braun

Dedication of George C. Marshall Space Flight Center, September 8, 1960 – Left to right: Dr. T. Keith Glennan, Administrator of NASA; Dr. Wernher von Braun, Director of MSFC; President Dwight D. Eisenhower; Mrs. George C. Marshall, Widow of the late General Marshall; and Major General August Schomburg, Commanding General, AOMC (far right). General Marshall's bust is in the forefront.

At Fabrication Plant on Arsenal a large crowd accompanies President Eisenhower on his September 8 visit.



President Eisenhower tours MSFC plant area, September 8, 1960

1961

On January 31 NASA conducted the Mercury-Redstone flight MR-2 mission at Cape Canaveral. A 37-pound male chimpanzee, Ham, rode in a regular Mercury spacecraft weighing 2400 pounds to an altitude of 155 miles and a distance of 420 miles. Because of premature lox depletion which activated an abort signal resulting in increased velocity, the spacecraft went 40 miles higher and 130 miles farther downrange than intended. Otherwise the flight was successful [32].

In January Convair Astronautics submitted a proposal for an S-V upper stage for the Saturn vehicle; however, later in the month Dr. von Braun proposed that the C-1 vehicle changed from a three-stage to a two-stage configuration in support of the Apollo program. NASA decided to delete requirements for the S-V stage on C-1 vehicles [33].

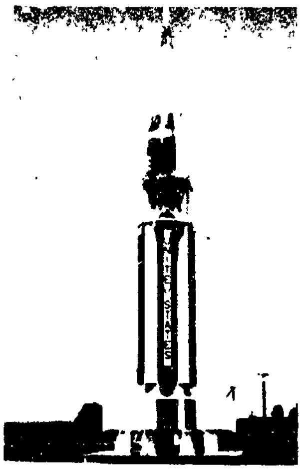
On April 10 NASA announced the Project Apollo objective of developing an orbiting laboratory for the study of effects of radiation and prolonged weightlessness, first with animals and later with a three-man crew. During April Douglas reported that air transport for the S-IV stage was feasible. (Douglas had been authorized in 1960 to study air transportation for S-IV stages.) This would greatly reduce the time which would be required if the stages were moved by water from California to MSFC at Huntsville, and thence to Cape Canaveral, Florida. The use of gliders, blimps, and other aircraft to carry the stages was also considered [34].

On April 17 the *Palaemon* began its first trial run to Cape Canaveral. The barge carried a water-ballasted tank simulating the size and weight of the S-I booster, plus a dummy S-V stage for the SA-1 [35].

MSFC completed construction of its dynamic test tower on April 17, the same day that the *Palaemon* left for Florida. The dynamic tower would permit checkout of the mechanical mating of the C-1 vehicle and would aid in determining the vehicle's natural bending characteristics and the effect of simulated flight vibrations [36].

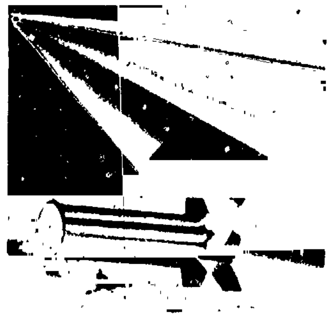
Mercury-Redstone MR-3 carried our nation's first astronaut into space at 9:34 a.m. EST on May 5, 1961. Astronaut Alan B. Shepard's parachute-cushioned spacecraft landed in the Atlantic Ocean 14.8 minutes later, at 9:49 a.m. This country's first astronaut had traveled 115 miles high and 302 miles to the south at a maximum speed of 5100 miles per hour [37].

In May NASA Headquarters accepted MSFC's proposal to incorporate design changes into the S-I stage of the C-1 vehicle. The changes would permit the C-1 to be used as a two- or three-stage vehicle possessing satisfactory safety requirements for the two-stage manned mission. This change eliminated the immediate need for an S-V stage with the C-1 except for special missions. Also during May MSFC began reexamination of the capabilities of the Saturn C-2 configuration to support lunar circumnavigation missions. Results of this examination indicated that a Saturn vehicle of even greater performance would be desirable [38].

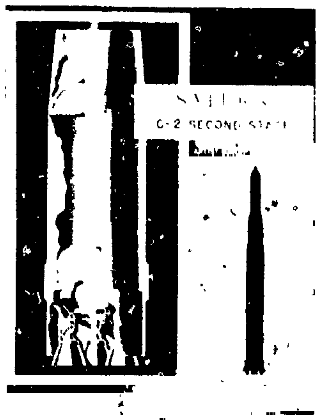


Proposed Saturn C-1 Apollo configuration

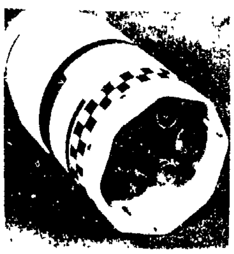
SA-1 checkout



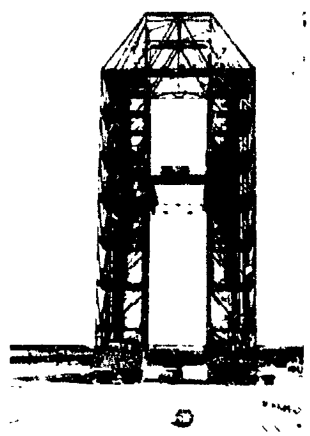
Saturn booster recovery



C-2 Second Stage concept

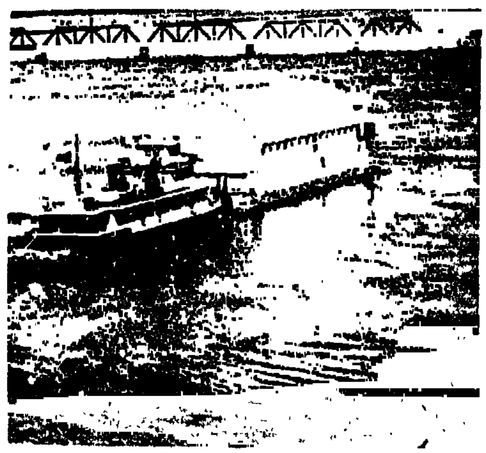


Six-engine configuration



Facilities construction at Launch Complex 34

Redesigned tail of the Saturn booster



The barge Palaemon was used to transport the Saturn between MSFC and the Cape

On June 2 a lock collapsed at the Wheeler Dam on the Tennessee River. All movement of river traffic was halted. Because the *Palaemon* was trapped in the upper river, MSFC decided to transport the booster in it over land to a point below the dam. There the stage would be reloaded on a barge to continue the trip to Cape Canaveral. To support this plan MSFC obtained a Navy barge which had been mothballed at Pensacola, Florida. Necessary modifications began so that the new barge, renamed the *Compromise*, could carry the S-I and dummy S-IV stages and dummy payload [39].

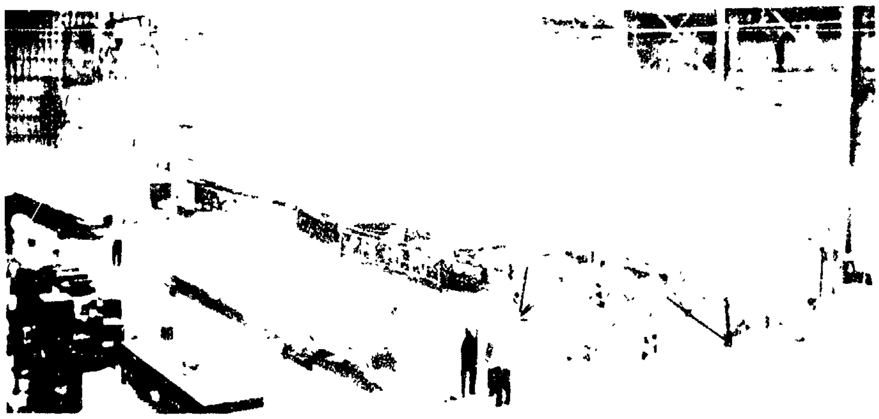
On June 5 Launch Complex 34 at Cape Canaveral was dedicated in a brief ceremony and turned over to NASA [40].

An estimated 45 000 to 50 000 "Space Day" visitors attended MSFC's first open house on July 1. Attending were such national figures as the NASA Administrator, James E Webb; the Director of NASA Launch Vehicle Programs, Maj. Gen. Don Ostrander; and numerous other national, state, and local dignitaries. Most of the visitors observed one of the four Saturn H-1 engine static firings during the day [41].

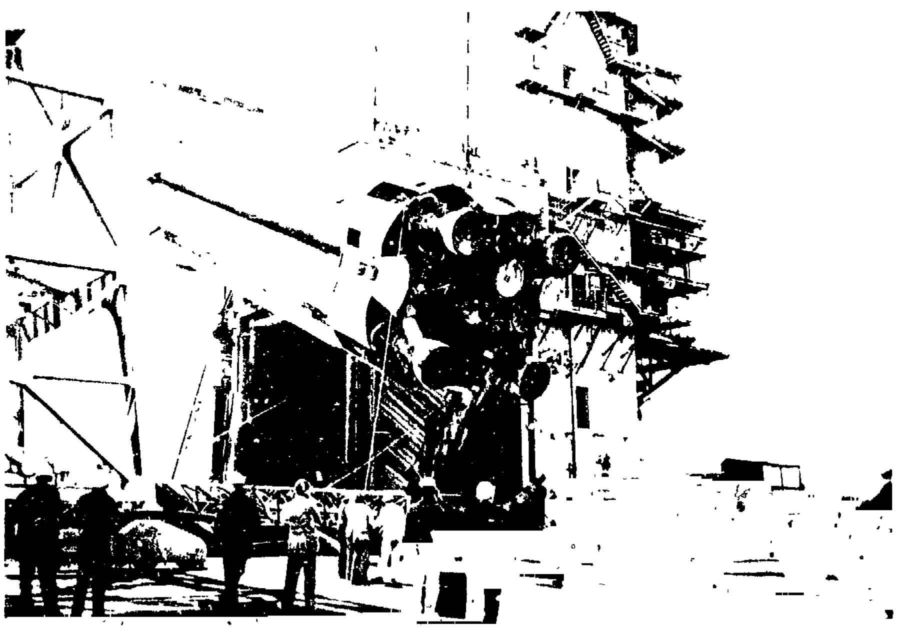
MR-4 (Liberty Bell 7) manned by Mercury Astronaut Virgil I. Grissom, made a successful 15-minute, 118-mile high, 303-mile long flight down the Atlantic Missile Range on July 21. After landing in the Atlantic, a premature blowout of the escape hatch flooded the capsule, making helicopter pickup of Grissom difficult. The capsule sank in 18 000 feet of water after a warning light indicated that the helicopter engine was overheating, and the capsule was cast loose. This was the second successful manned suborbital space flight [42].

MSFC awarded a contract to the Space Technology Laboratories, Inc., Los Angeles, California, during July, to investigate the relative merits and potential problems of assembling the giant Saturn boosters in horizontal and vertical positions. Other contracts awarded by the Center in July included qualification and reliability testing of Saturn ground support equipment, subsystems, and components; construction of a special assembly building at Cape Canaveral; and site development of the Center's new static test facility in Huntsville. Also in July NASA's Space Task Group invited 12 companies to submit proposals for the manned lunar Apollo spacecraft. Meanwhile, the Center contemplated a nuclear-powered Saturn upper stage and awarded contracts for a 6-month RIFT (reactor-in-flight test) design analysis to General Dynamics/Astronautics, Douglas Aircraft Company, Lockheed Aircraft Corporation, and the Martin Company [43].

Checkout of the SA-1 flight booster, started in June, was completed early in August [44]. The booster stage, the dummy S-IV stage, and the dummy payload body were shielded with protective covers and loaded on their respective transporters. The stages and payload body were then moved from the MSFC shops to the docking facilities on the Tennessee River and loaded aboard the *Palaemon*. On August 5 the barge began the first leg of the trip to Cape Canaveral. At Wheeler Dam the units were unloaded, transported to a dock below the dam, and placed on the second barge, the *Compromise*, to continue the 2200-mile trip to Florida [45].



First horizontal mating of the Saturn vehicle



Removal of the booster from the static test stand

Booster simulator being loaded aboard Palaemon

Unloading simulator at the Cape

On August 24 NASA designated Cape Canaveral as the base for all manned lunar flights and other space missions requiring advanced launch vehicles. NASA would secure an 80 000-acre tract of land, increasing its total area in the vicinity to 97 000 acres. The additional land was needed because of the tremendous vibration and noise expected with later launch vehicles [46].

On September 7 NASA selected the government-owned Michoud Ordnance Plant near New Orleans as the site for industrial production of the S-I stage. The plant would be operated by industry under the technical direction of MSFC. MSFC continued preparations for a conference to secure estimates from industry on production of the S-I stage. On September 11 NASA selected North American Aviation to develop and build the S-II stage for an advanced Saturn launch vehicle. The stage would be used in both manned and unmanned missions [47].

Death claimed Delmar M. Morris, MSFC Deputy Director for Administration, on September 9. He served as Acting Director of the Center until Dr. von Braun assumed the position of Director on July 1, 1960. Mr. Morris was responsible for a considerable amount of the work involved in transferring the Development Operations Division from the Army Ballistic Missile Agency to NASA [48].

Army Engineers awarded a contract on September 13 for the construction of Saturn Launch Complex 37 at Cape Canaveral. The complex would include a mobile steel tower, a blockhouse, and a cable tower on a 120-acre site at the north end of the Cape [49].

Dr. George N. Constan, acting manager for Michoud Operations, announced on October 20 that the official designation of the Saturn production plant in New Orleans was "The George C. Marshall Space Flight Center, Michoud Operations" [50].

On October 25 NASA selected a 13 550-acre site in Mississippi on which to build a facility for static testing advanced Saturn and Nova first stages, only 35 miles from the Michoud Plant where industry would manufacture the S-I and S-IC stages. NASA named this new location the Mississippi Test Facility. MSFC would operate the facility [51].

The world's largest known rocket, the Saturn first stage booster, was launched on October 27. It was 162 feet tall and weighed 460 tons at lift-off. The rocket attained a range of 214.7 miles from its launch pad at Cape Kennedy and an altitude of 84.8 miles. Its eight clustered engines had developed 1.3 million pounds of thrust at lift-off. on subsequent tests the thrust would be increased to 1.5 million pounds [52].

On November 3 NASA Headquarters directed the transfer of MSFC's electric propulsion program to Lewis Research Center where it would be consolidated into one electric propulsion program for NASA. The transfer would be completed within 3 months [53].

On November 6 MSFC directed North American to redesign the S-II stage to incorporate five J-2 engines, providing 1 million pounds of thrust [54].

Movement of dummy S-IV stage to checkout

James E. Webb on February 14, 1961, became the second administrator of NASA. He would retire on October 7, 1968.

Late in 1961 the expanding space program was evident at MSFC as elsewhere. In its lead story for November 8, the MSFC *Marshall Star* stated: "The Marshall Center has joined other elements of NASA in a nationwide drive to recruit new employees to carry out the nation's accelerating space and aeronautical research programs. A total of some 3,500 persons are to be hired by NASA between now and June 30, 1962. The majority, 2,000, will be scientific and engineering personnel. James E. Webb, NASA Administrator, announced the talent search Friday in Washington. The Marshall Center expects to hire some 750 additional persons during the fiscal year ending June 30. Present MSFC strength of about 5,750, plus the number of persons employed next spring, should approach 6,500" [55].

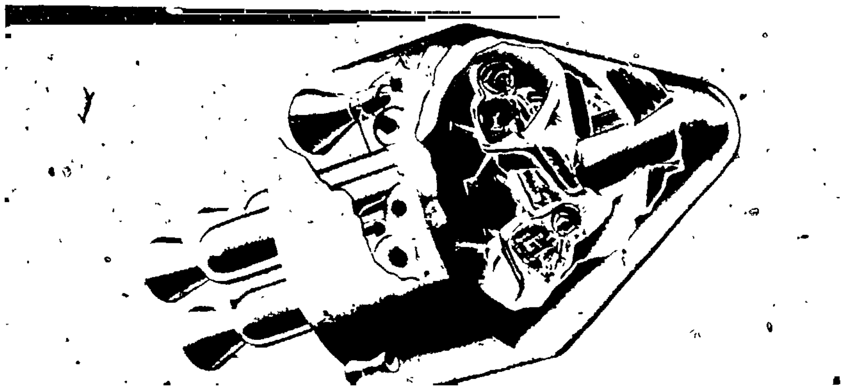
NASA announced on November 17 the selection of Chrysler Corporation to negotiate a contract to build, check out, and test 20 S-I boosters. These boosters would be manufactured at the Michoud Plant. The contract was signed in mid-January 1962 [56].

On November 19 the nation's first liquid hydrogen engine, the RL10, successfully completed its preliminary flight rating test. Producing 15 000 pounds thrust, the engine, designed and developed by Pratt & Whitney, performed about 30 percent better than engines using hydrocarbon fuels. Six such engines would power the Saturn S-IV stage [57].

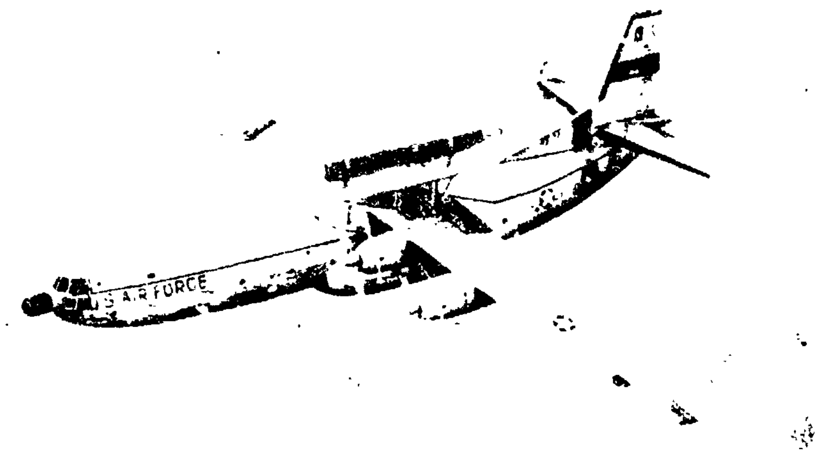
On December 5 Atomic Energy Commission (AEC)-NASA Space Nuclear Propulsion Office selected the Aetron Division of Aerojet-General Corporation's proposal as the basis for a Nerva engine test stand contract. The Nerva would be used in nuclear stages with a reactor derived from the Kiwi-B test series. Two days later a preproposal conference was held at Huntsville, Alabama, to select a prime contractor for the reactor-in-flight test (RIFT) stage launch vehicle. The RIFT vehicle, planned for use as an upper stage of a Saturn vehicle, would be powered by the Nerva nuclear engine [58].

On December 15 NASA selected the Boeing Company as a possible prime contractor for the first stage (S-IC) of the advanced Saturn vehicle. The S-IC, powered by five F-1 engines, would be 33 feet in diameter and about 140 feet tall. The manufacturing program at Michoud was to produce 24 flight stages and one ground test stage [59].

On December 28 the Mississippi Test Facility (MTF) was officially named Mississippi Test Operations (MTO) by Dr. Robert C. Seamans of NASA Headquarters [60].



Artist's concept of Apollo capsule



Air transport of S-IV stage

Route of the Palaemon to Cape Canaveral

Installing dummy S-I on Dynamic Test Tower

NASA Astronaut Alan B. Shepard, Jr. is shown in the Project Mercury spacecraft just prior to its being sealed. Shepard successfully completed a 302 mile suborbital flight, the first in the Project Mercury program.

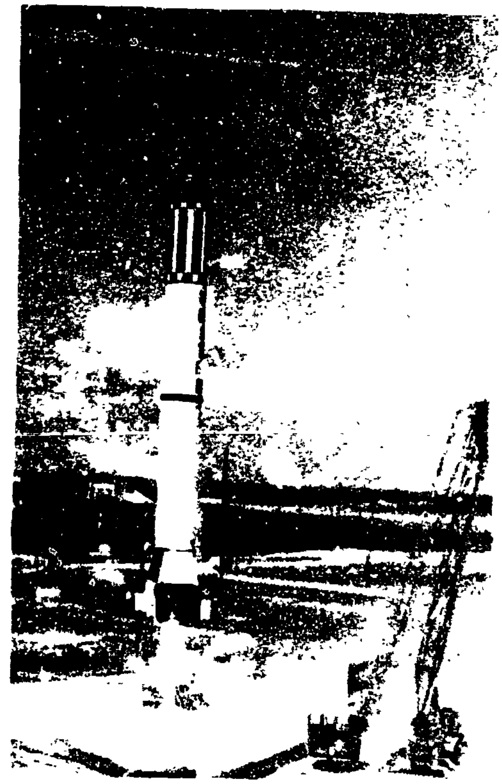
A helicopter lifts Shepard from water at the end of flight.

NASA Astronaut Alan B. Shepard strides across the deck of the U.S. Navy Carrier Champlain following an inspection of his spacecraft.

Astronauts D.K. Slayton (far left) and Virgil I. Grissom (far right) were on hand to greet Astronaut Alan B. Shepard at Grand Bahama Island. Just behind Shepard is Dr. Keith Lyndell.

Positioning flight booster in test stand

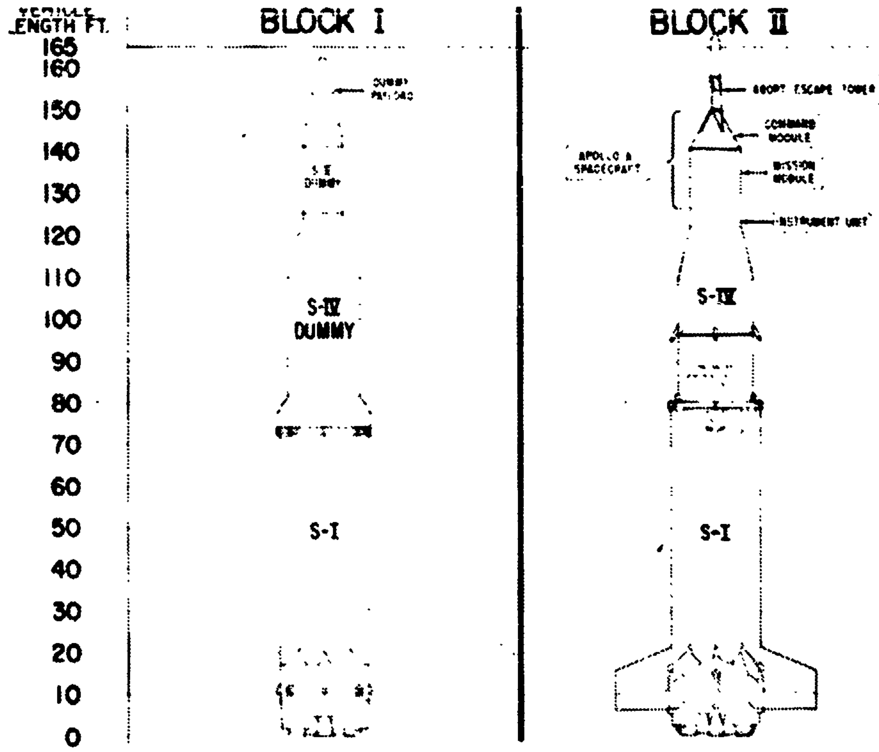
Dummy Saturn vehicle in dynamic test stand



Launch of MR-3 from Cape

Separation of upper stages from booster

Sacramento Test Facility

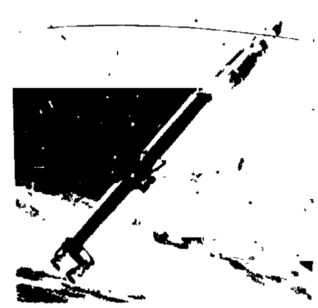


Configurations of Saturn flight vehicles

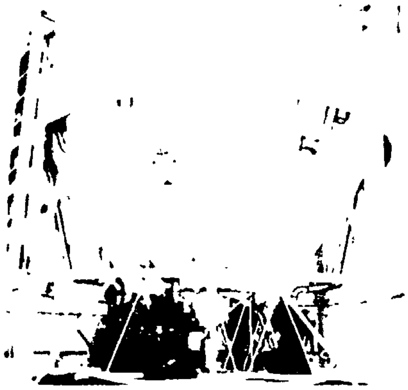
Testing of dummy S-IV stage

Instrument unit mockup

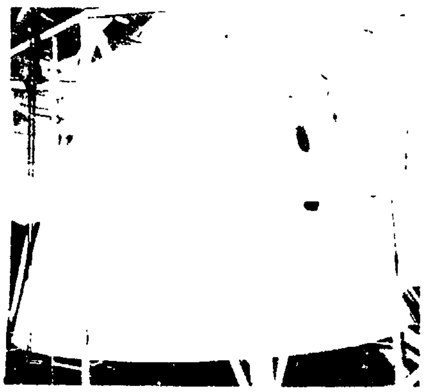
The barge Compromise



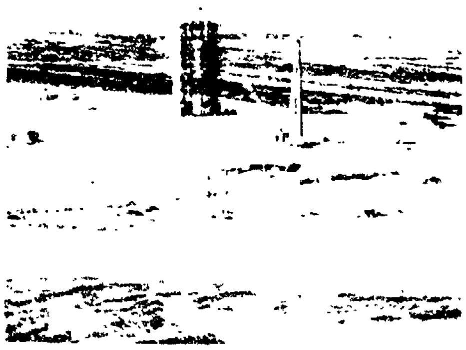
Proposed C-3/Apollo configuration



Tail area mockup



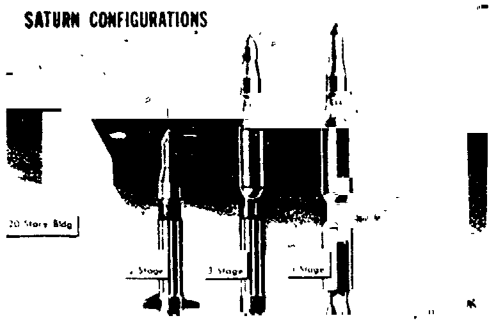
Forward interstage mockup



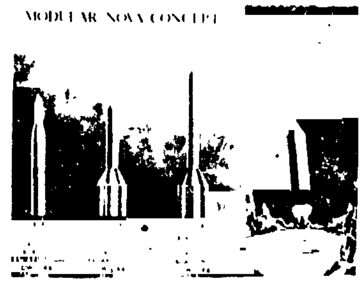
Launch Complex 34

Launch Complex 34, blockhouse interior

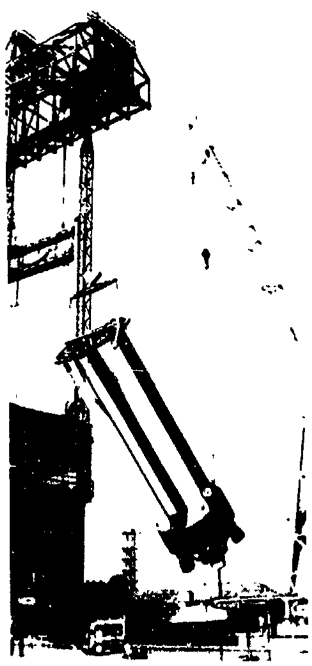
Booster movement around Wheeler Dam



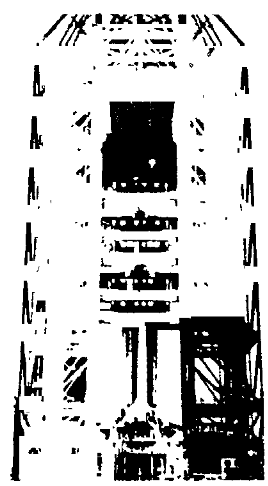
Comparison of Saturn



Possible Nova configurations



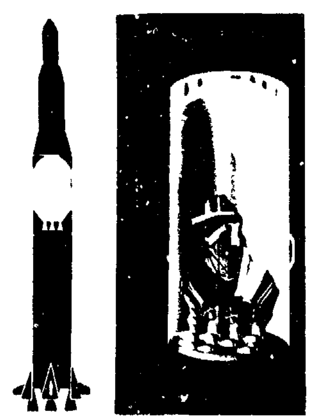
Installation of SA-T2 on static test stand



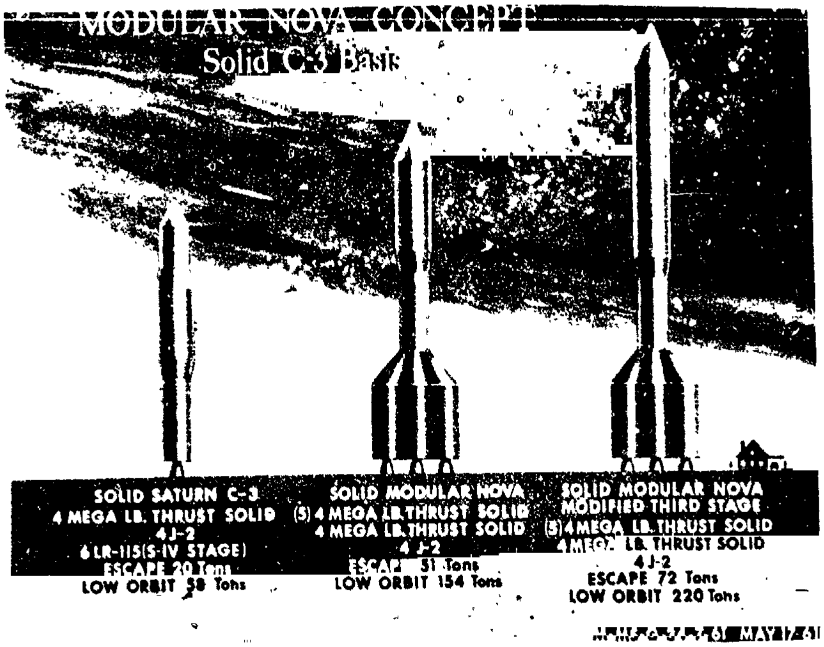
First Saturn assembled on launch pedestal

Static firing of SA-T2

Artist's concept of Apollo separation from second stage



S-II stage cutaway – artist's concept



Proposed solid propellant boosters for large space vehicles

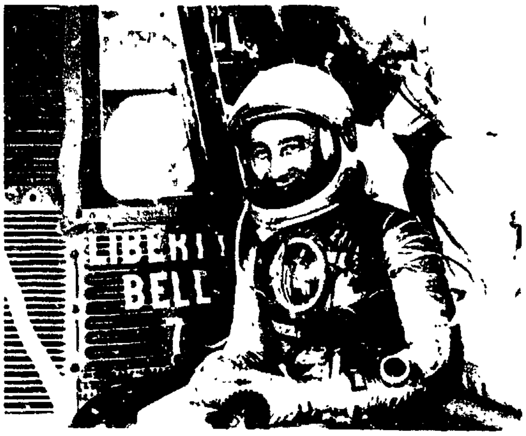
Welcoming Visitors at Anniversary Celebration -- Dr. Wernher von Braun, MSFC director, addressed visitors at the test area prior to a static firing on July 1, 1961. At left was Miss Carolyn Travis, attendant to Space Queen Linda Page, who stood behind Dr. von Braun. At right were Sandra Baerg, Space Queen attendant; James E. Webb NASA administrator, who also welcomed the visitors; and Maj. Gen. Don Ostrander, director of Office of Launch Vehicle Programs at NASA Headquarters.

On MSFC's first anniversary, July 1, 1961, there were 27 top officials. Upper row, left to right: Bart J. Slattery, Jr., Public Information Office; Jerry C. McCall, Assistant to the Director; Erich W. Neubert, Associate Deputy Director, Research and Development; Eberhard F. M. Rees, Deputy Director, Research and Development; Wernher von Braun, Director; Delmar M. Morris, Deputy Director, Administration; Harry Gorman, Associate Deputy Director, Administration; Chauncey W. Huth, Operations Analysis Office; William E. Guilian, Chief Counsel. Second Row: Oswald H. Lange, Saturn Systems Office, Hans Hueter, Light and Medium Vehicles Office; Werner G. Tiller, Weapon Systems Office; Heinz H. Koelle, Future Projects Office; George N. Constan, Technical Program Coordination Office; David H. Newby, Technical Services Office; Victor C. Sorensen, Management Services Office; Claude E. Stockton, Financial Management Office; Wilbur S. Davis, Procurement and Contract Office. Third Row: Ernst D. Geissler, Aeroballistics Division; Helmut Hoelzer, Computation Division; Hans H. Maus, Fabrication and Assembly Engineering Division; Walter Haeussermann, Guidance and Control Division; Kurt H. Debus, Launch Operations Directorate; Ernst Stuhlinger, Research Projects Division; William A. Mrazek, Structures and Mechanics Division; Dieter Grau, Quality Division; Karl L. Heimburg, Test Division.

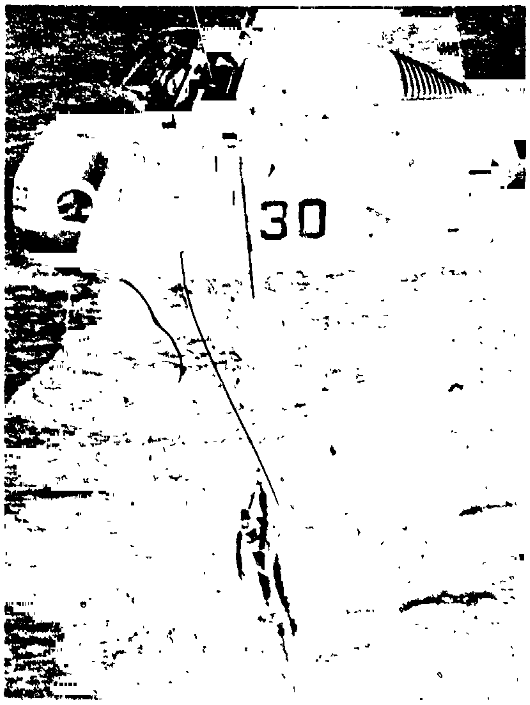
Payload movement around Wheeler Dam

Booster movement to docking facility

Astronaut Gus Grissom prior to America's second manned flight into space

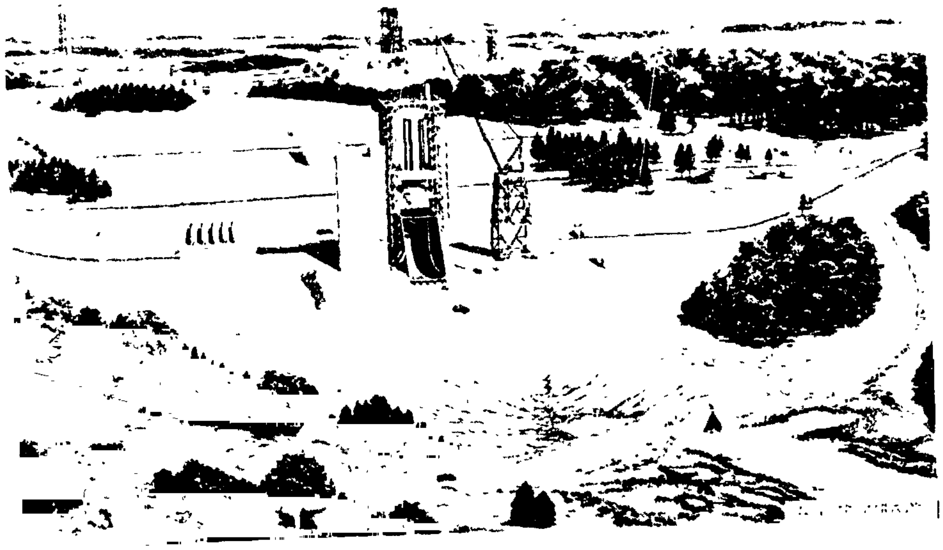


Astronaut Grissom prepares to enter Liberty Bell 7 spacecraft.

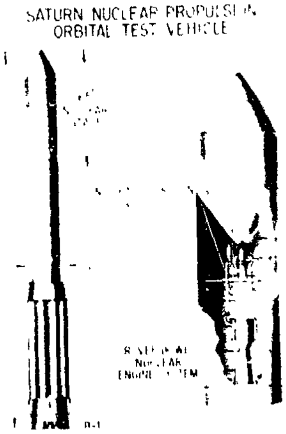


Astronaut Gus Grissom being rescued after splashdown of Liberty Bell 7.

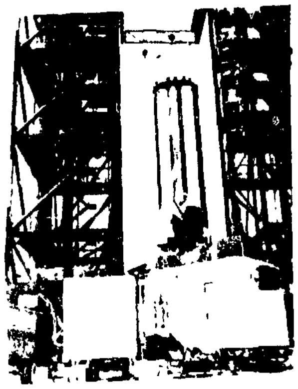
Navy doctors aboard USS Randolph check Astronaut Grissom following his trip into space July 21, 1961.



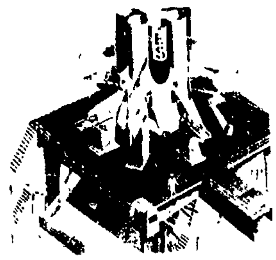
Concept of new static test facility, MSFC



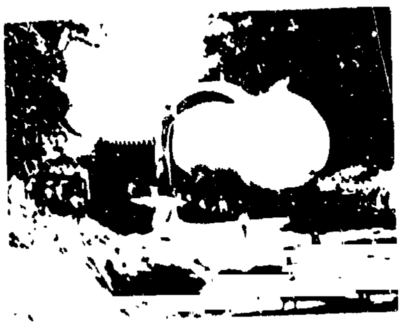
Concept of Saturn with nuclear powered stage



First Saturn booster erection at Cape Canaveral

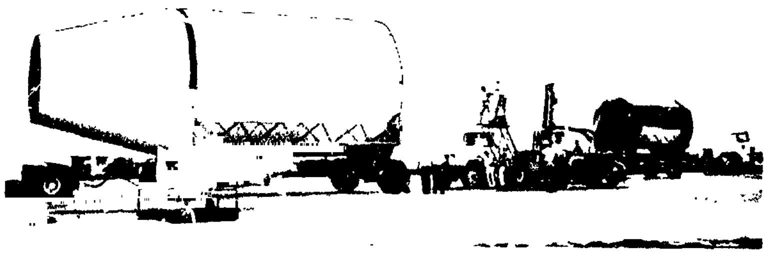


Artist's concept of launch pedestal for Launch Complex 37



Booster movement around Wheeler Dam

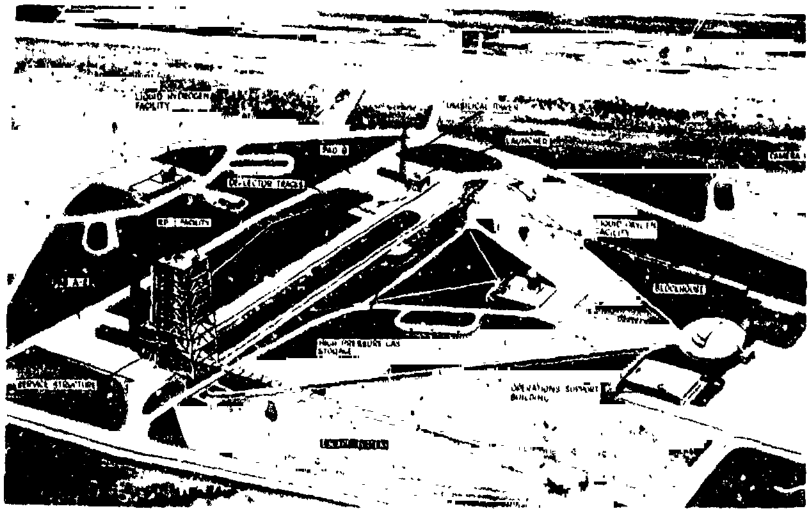
S-I and S-IV stages aboard the Compromise



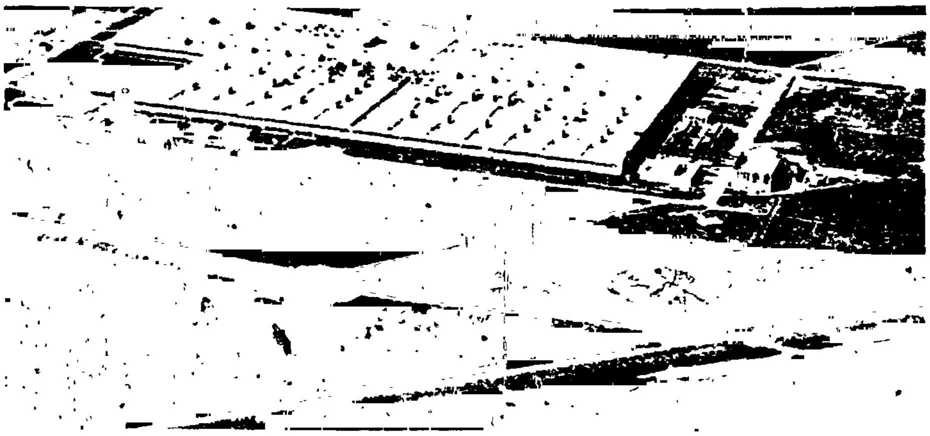
Unloading Compromise in Florida

S-IV erection at Cape Canaveral

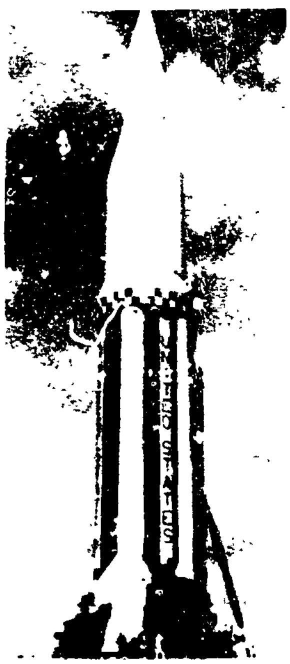
Payload body erection into service structure



Saturn Launch Complex – artist's concept

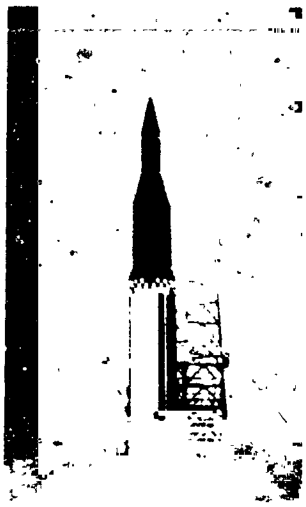


Michoud plant at New Orleans



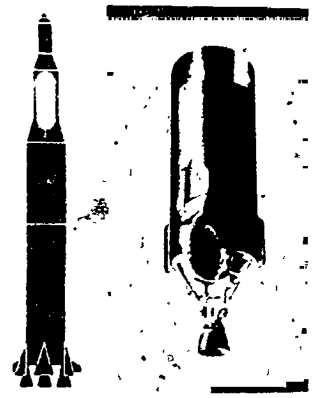
Saturn SA-1 flight vehicle on launch pedestal

First launch of the Saturn vehicle October 27, 1961. The flight lasted about 8 minutes 3.6 seconds. Saturn reached a velocity of 3607 mph.

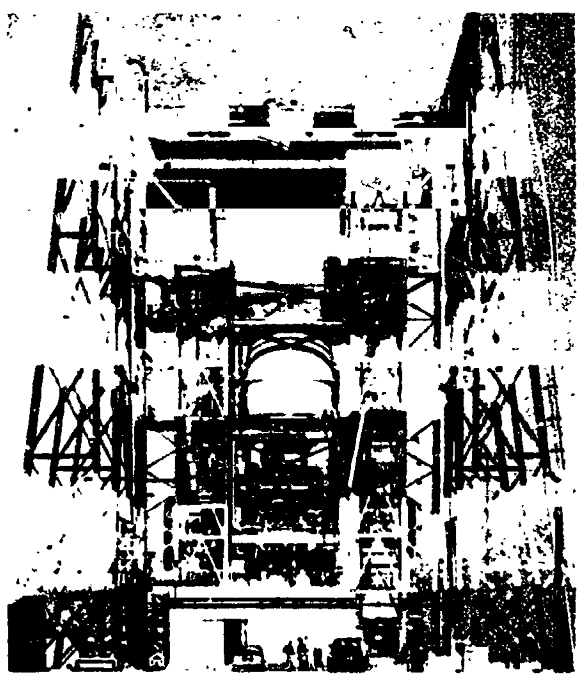


Launch of Saturn SA-1 flight vehicle

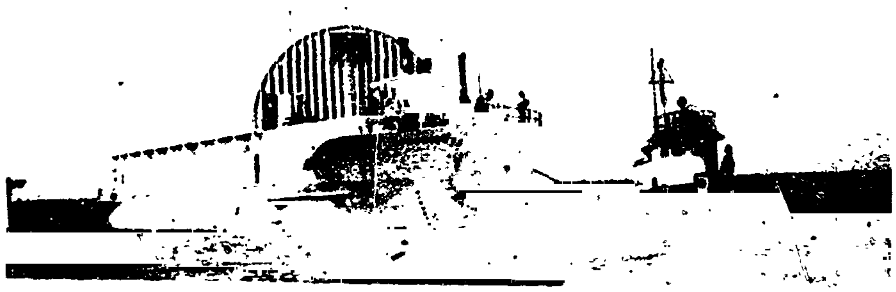
S-IC stage artist's concept



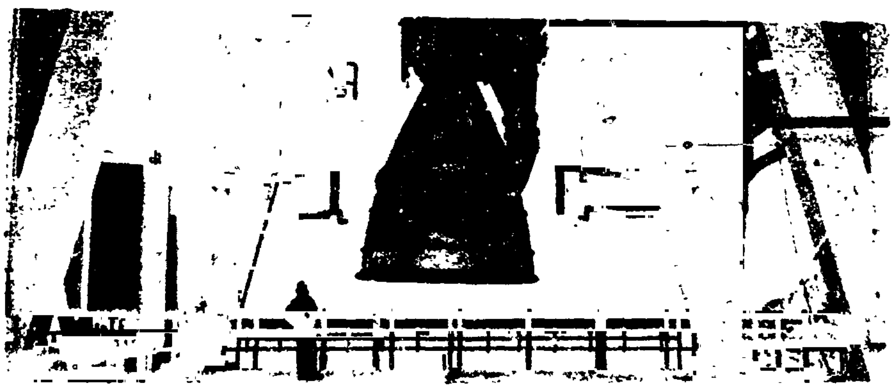
S-II stage
cutaway artist's concept



S-IV tankage at Sacramento Test Facility



Barge Promise



F-1 engine and test stand

1962

On January 25 NASA approved development of the three-stage Saturn C-5 vehicle under the direction of MSFC. The vehicle would support manned circumlunar flights and manned landings by earth or lunar orbit rendezvous method. The C-5 was expected to be capable of placing 120 tons in low earth orbit or sending 45 tons to the vicinity of the moon [61].

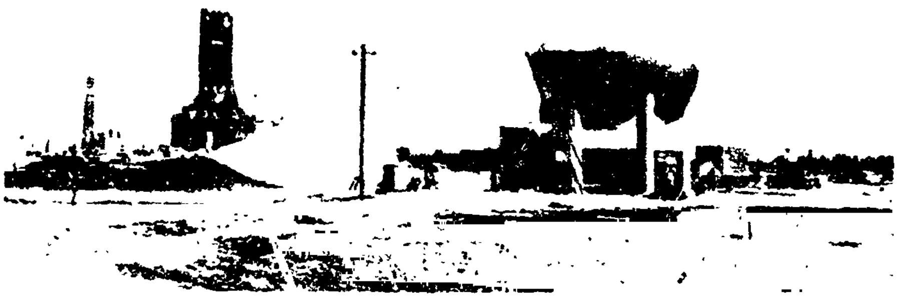
On February 9 a preliminary contract was awarded the Space and Information Systems Division (S&ID) of North American Aviation to design, develop, and fabricate the S-II stage of the C-5 vehicle. MSFC signed a preliminary S-IC development contract with Boeing Company on February 14 [62].

After several days of frustrating delays, John Glenn, destined to become the first American in orbit, entered Friendship 7 on February 20. There he waited an additional 3 hours and 44 minutes before the Friendship 7 lift-off. But then in one blaze of fire and smoke it all became worthwhile as crowds at the Cape yelled "Go, Man Go" and similar yells were shouted at radio and television sets throughout the land. "Keep it A. O. K.–Go, Man Go" and similar space words were soon to become familiar jargon through the world. Astronaut Glenn was forced to manually control the spacecraft during the second and third orbits because of troubles with the automatic pilot, but after three orbits Friendship 7 reentered as scheduled and parachuted into the Atlantic east of the Bahamas. Glenn had ridden 81 000 miles in 4 hours and 56 minutes. Retrieved by the destroyer *Noa*, Glenn remained inside the capsule until aboard ship where he emerged "feeling fine." It was estimated that over 60 million Americans had witnessed the launch via live TV coverage. The Voice of America carried live overseas broadcasts, the U.S. Senate recessed before the spacecraft landed, and the U.S. Post Office placed Project Mercury postage stamps on sale the same day [63, 64].

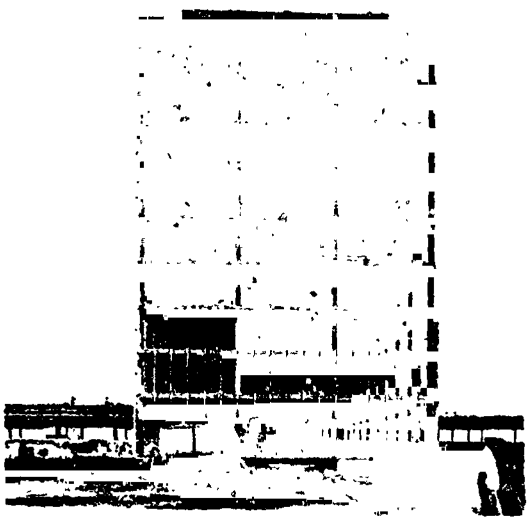
On March 7 NASA established the NASA Launch Operations Center at Cape Canaveral, with Dr. Kurt H. Debus as Director. Reporting to the Director of Manned Space Flight at NASA Headquarters, the new Center would serve all NASA projects launched from Cape Canaveral, absorbing Marshall Space Flight Center's Launch Operations Directorate [65].

On March 19 the Seal Beach, California, site was reconfirmed as the location of the S-II stage major manufacturing and assembly activities. Testing of prototype stages would be performed at Santa Susana, California. Stage acceptance testing would be conducted at the Mississippi Test Operations [66].

About 60 key officials of the nation's space program, including Astronauts John Glenn and Alan Shephard, met at MSFC on April 16 for a talk on the manned lunar exploration program. Directors of three NASA centers charged with carrying out the project held a joint technical planning and review session concerning the program. Dr. Wernher von Braun was host to Dr. Robert Gilruth, Director of the Manned Spacecraft Center, and to Dr. Kurt Debus, Director of the Launch Operations Center, as well as to Astronauts Glenn and Shephard [67].



SA-2 erected on launch pedestal



Central Laboratory and Office Building – Builders expected to complete this $4 000 000 MSFC building early in 1963.

Astronaut John H. Glenn, Jr., Dr. William Douglas, Astronaut's Flight Surgeon, and Joe Schmitt, Equipment Specialist, leaving crew quarters prior to MA-6 launch.

NASA Headquarters announced on April 18 that the highest national priority (DX) had been approved for the Apollo, Saturn C-1, and Saturn C-5. The priority included all stages, engines, facilities, and related construction for production, test, research, launch, and instrumentation [68].

NASA launched the second Saturn flight vehicle, the SA-2, from Cape Canaveral on April 25. As with the SA-1, the vehicle was launched without a technical hold during the 10-hour countdown. This vehicle had a secondary mission. After first stage shutoff at 65 miles altitude, the water-filled upper stages were exploded, dumping 95 tons of water in the upper atmosphere. The massive ice cloud produced rose to a height of 90 miles. The experiment, called Project High Water, was performed to investigate the effects on the ionosphere of the sudden release of such a great volume of water. This experiment did not interfere with the major goal of the flight which was achieved when the first-stage engines burned out 116 seconds after launch. Every phase of the flight was considered successful [69-72].

In mid-April reconstruction of the Wheeler Dam Lock on the Tennessee River was completed; transportation of Saturn flight stages could be made without land detour [73].

On May 26 Rocketdyne successfully conducted the first full-thrust, long-duration F-1 engine test [74].

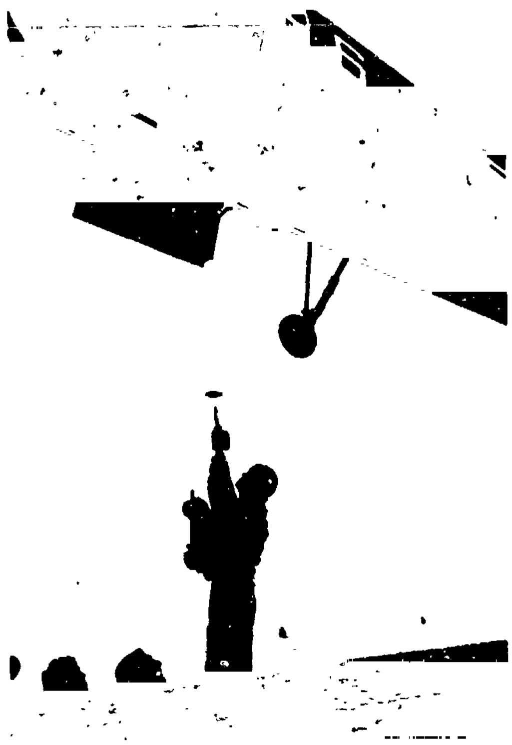
In mid-May MSFC directed Douglas to produce a 260-inch-diameter S-IVB stage. The increase of 40 inches over the initially planned diameter permitted development of a more optimum size stage. Also during May the Center decided to increase S-II stage length from 75 feet to 81.5 feet and decrease the S-IC stage length from 141 feet to 138 feet [75].

On June 5 MSFC contracted to modify the Saturn C-1 booster static test stand at MSFC. The stand, originally built to test the Redstone and Jupiter missiles and later modified for Saturn testing, would provide test positions for two C-1 first stages [76].

More than 25 000 MSFC employees and relatives visited the MSFC Space Museum during "Family Day." The occasion was the second birthday of MSFC [77].

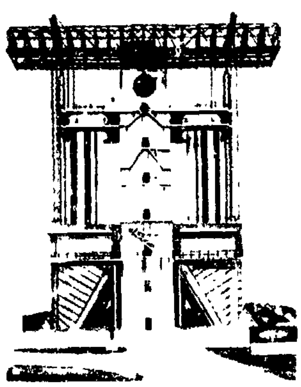
During June bids were requested for construction of a static test stand to captive fire the Saturn C-5 booster The stand, to be located at MSFC, would provide handling equipment and thrust restraint for boosters up to 178 feet in length, 48 feet in diameter, and with thrust of up to 7.5 million pounds. Including a crane at the top, the tower would stand 405 feet high, more than twice as tall as the current Saturn C-1 booster test stand [78].

As of Independence Day, July 4, a total of 1239 technical, administrative, and support personnel were employed at the MSFC Michoud Operations. Fifty-four percent of the employees had been hired from the New Orleans area [79].



Project Mercury Astronaut John H. Glenn, Jr., is picked up by a Navy helicopter and hoisted aboard for the trip to the carrier USS RANDOLPH from the destroyer USS NOA. Glenn was retrieved by the NOA, when his spacecraft was hoisted by a crane and lifted to the decks of the NOA, just 21 minutes after landing in the Atlantic near Grand Turk Island, following his historic three-orbit flight around the earth on February 20, 1962.

Astronaut, John Glenn speaks at a "Welcome Home" celebration and parade.



C-1 first stage test stand

Saturn C-IB vehicle

Launch of Saturn SA-2 flight vehicle

A new Saturn vehicle was needed. NASA announced on July 11 that a new, two-stage Saturn-class vehicle would be developed for manned earth orbital missions with full-scale Apollo spacecraft [80]. The Saturn would be known as the Saturn C-1B. Simultaneously, NASA announced selection of lunar orbit rendezvous as the method of performing the manned lunar landing. This lunar rendezvous mode would require the use of only one Saturn C-5 vehicle to inject the spacecraft into an earth-lunar trajectory. The entire Apollo spacecraft would not land on the moon after its separation from the launch vehicle's third stage. Rather, one unit of the spacecraft, a lunar excursion module, or "bug," would land and later rejoin the rest of the orbiting Apollo [81].

On July 21 NASA Headquarters announced construction plans for Launch Complex 39, Saturn C-5 launch facilities, at Cape Canaveral. The 350-foot-high vehicle would be erected and checked out vertically in a special 48-story assembly building. Following checkout, a 2500-ton crawler vehicle would move the Saturn C-5 to its launch pad [82].

In July NASA announced that a computer center would be established at Slidell, Louisiana, to service the Michoud Operations. The center, to be one of the nation's largest, would perform engineering calculations necessary in the development, building, and static testing of the Saturn C-1 and C-5 boosters [83].

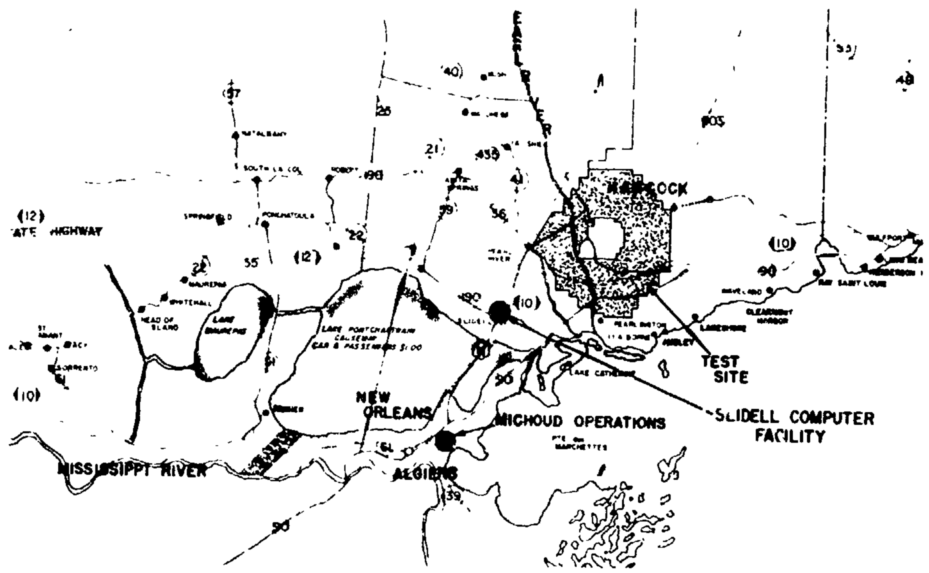
To test C-5 strength, MSFC awarded a design contract in July for a 360-foot-high dynamics test tower at MSFC. The Saturn C-5 launch vehicle would be suspended in the tower and vibrated by mechanical and electrical means. This simulation of free-flight conditions would determine the vehicle's natural bending modes [84].

On August 6 NASA and Chrysler Corporation signed a contract for production of 21 C-1 boosters, to be delivered between late 1964 and early 1966. The stages would be produced by Chrysler at the Michoud Plant near New Orleans. On the same date NASA announced that the Boeing Company had received a supplementary contract from MSFC for work leading to design, development, fabrication, and test of the C-5 booster [85].

A C-5 second stage contract for design, development, fabrication, and testing of the S-IVB stages was awarded Douglas on August 8. The contract called for 11 of the stages: five for ground tests (two of which would be used later as inert flight stages) and six for powered flight. Next, provision was made for C-5 guidance and control. On August 13 MSFC selected the C-5 instrument unit design. The cylindrical unit would measure 260 inches in diameter and stand 36 inches high. All vehicle guidance and control equipment would be mounted on panels fastened within this structure [86].

On August 15 NASA awarded Rocketdyne Division a two-year contract to continue H-1 engine research and development. The first Saturn booster engines would also be used in Saturn IB boosters. Meanwhile, the C-1 second stage progress continued [87].

President John F. Kennedy and Vice-President Lyndon B. Johnson, with an official party of key government officials, including NASA Administrator James E. Webb, visited the Center for a look at Saturn progress on September 11, 1962 [88].



Regional map showing Mississippi Test Operations

Launch Complex 37 under construction

President Kennedy visits MSFC.

On September 15 Michoud technicians installed a 42-foot boring mill, the largest known, for use in C-5 production [89]. Also in mid-September, MSFC provided Douglas a 90-day program authorization to investigate minimum changes necessary to adapt C-5 second stages to C-IB. Douglas would also study attachment of the S-IVB stages to the C-1 booster, as well as separation during flight [90].

Early in September ground breaking ceremonies were held at Seal Beach, California, where assembly and test facilities for the second (S-II) stage of Saturn C-5 would be located. The S-II facility would be constructed by the Navy and operated by North American Aviation's S&ID [91].

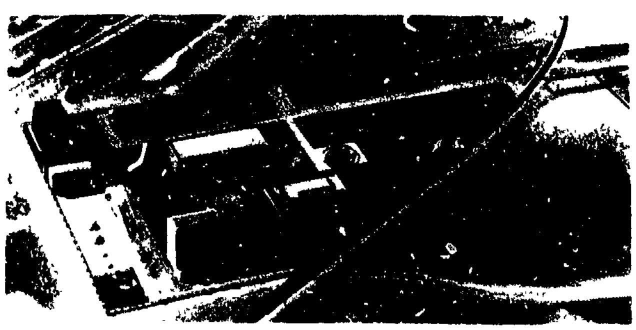
During September preliminary plans were completed for development of the Mississippi Test Operations facility. First phase of the three-phase program included building two test stands each for static firing the S-IC and S-II stages and about 20 service and support buildings. Improvement of approximately 15 miles of river channel and construction of a canal within the test facility would permit transportation of stages from Michoud to Mississippi Test Operations test stands [92].

MSFC awarded a Saturn C-5 contract on October 5 for construction in Huntsville of a combined S-IC stage vertical assembly building and hydrostatic test tower [93, 94].

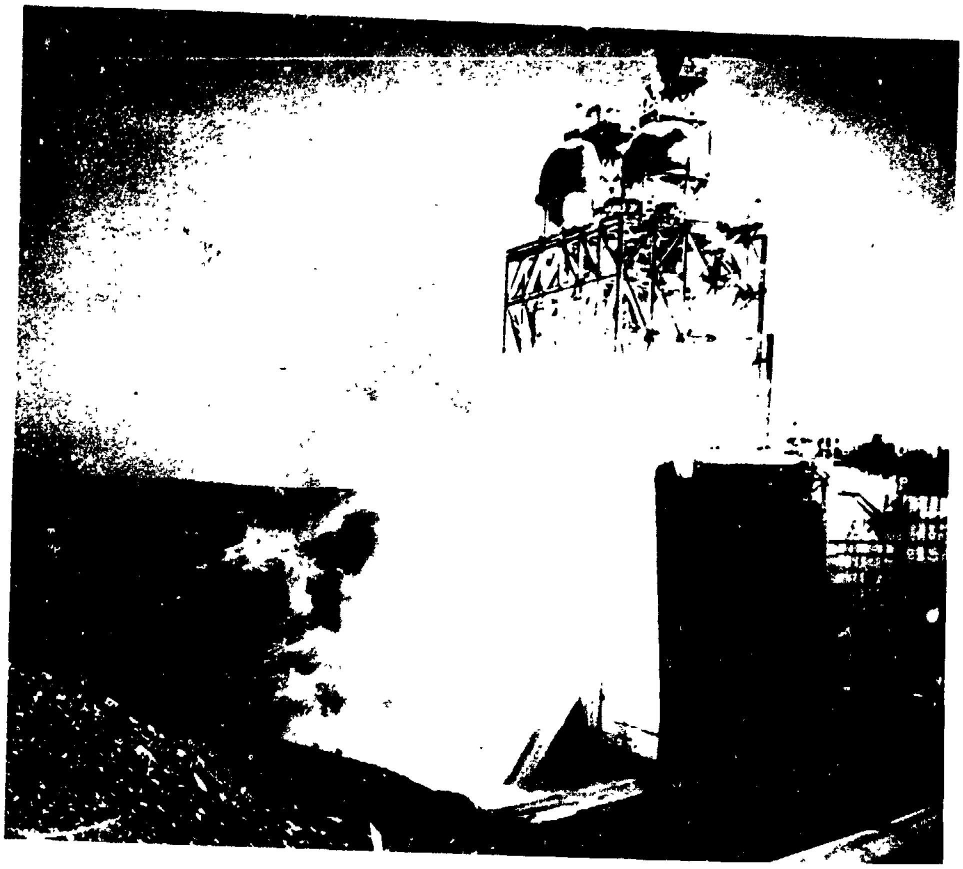
The third Saturn flew on November 16. SA-3 was successfully launched from Cape Canaveral, carrying a full propellant load of 750 000 pounds. It rose to a height of about 104 miles; flight range was 131 statute miles. Inboard engine cutoff occurred as planned after 141 seconds of flight; outboard engine cutoff came 8 seconds later. Project High Water was performed as a secondary mission on SA-3 as on SA-2 [95-97].

The first documented report to suggest use of an S-IVB stage as a laboratory in space was published by Douglas Aircraft Company in November. Meanwhile, at MSFC similar ideas were generating, though not yet to the extent of being published as a report [98, 99].

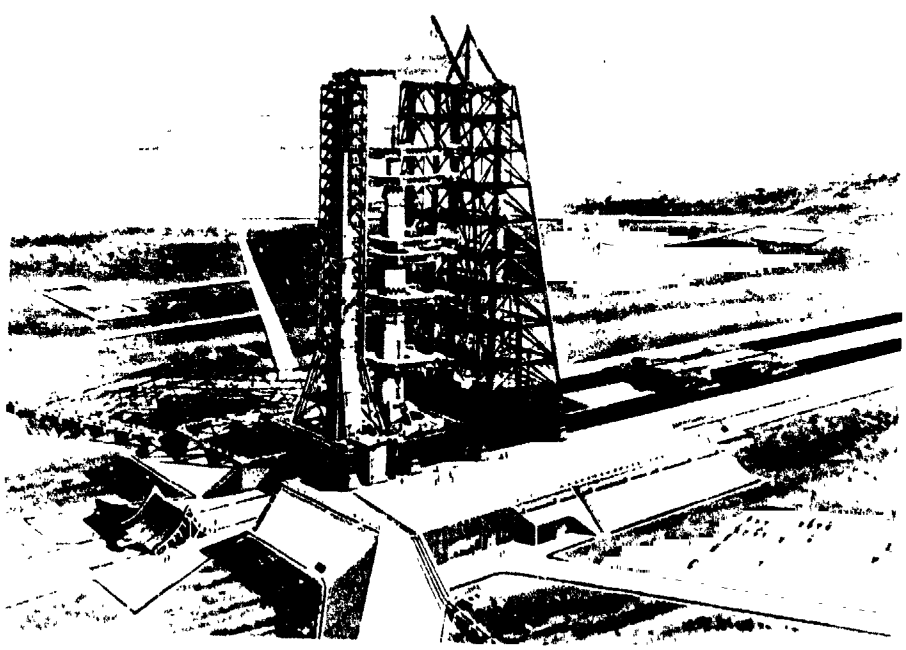
MSFC Director Wernher von Braun announced on December 14 that Captain William C. Fortune had been appointed manager of the Mississippi Test Operations [100].



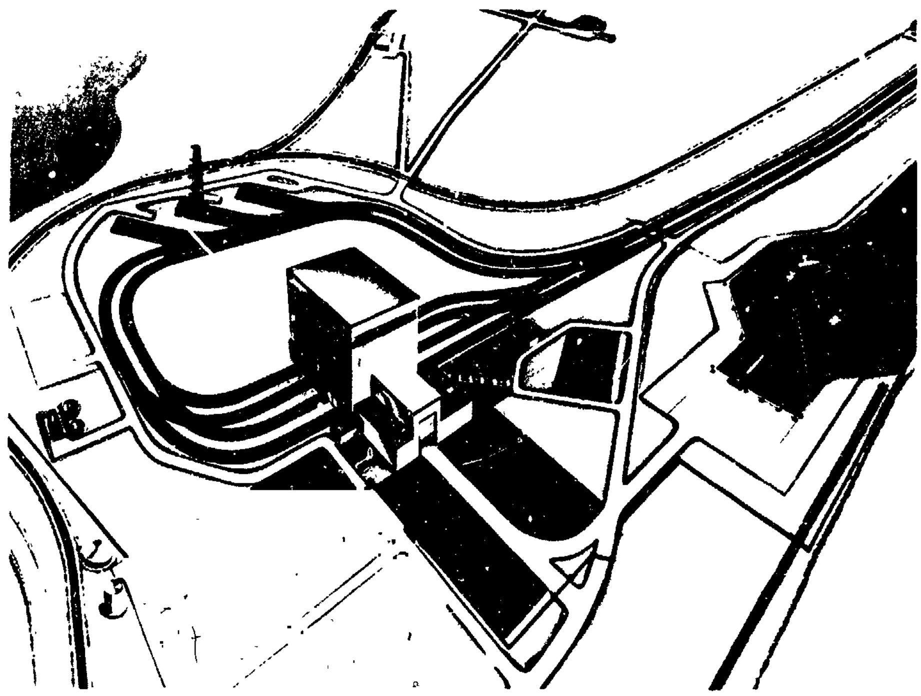
S-II stage assembly and test facility



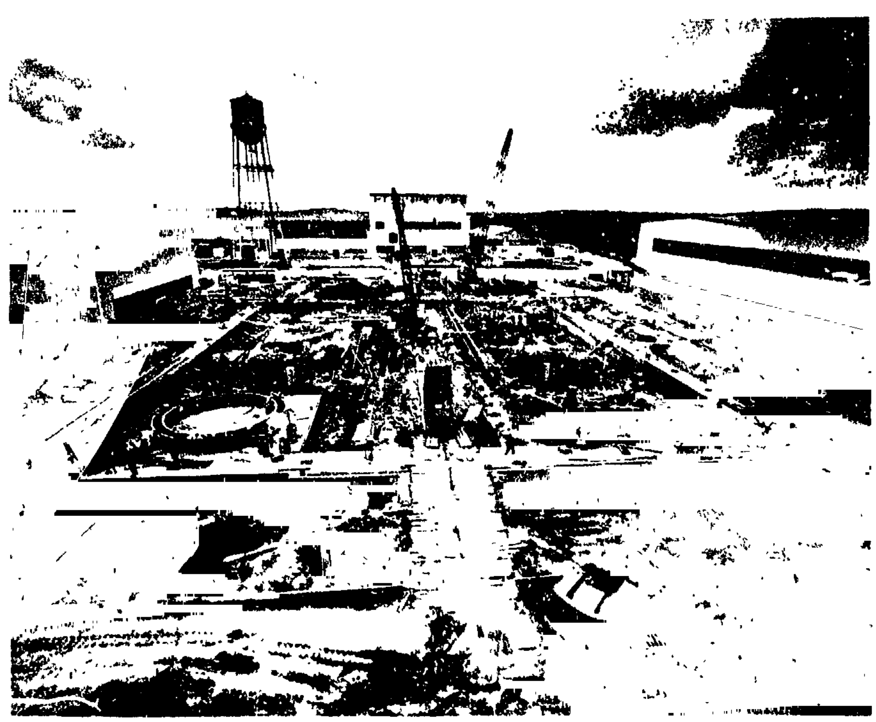
Static firing of F-1 engine



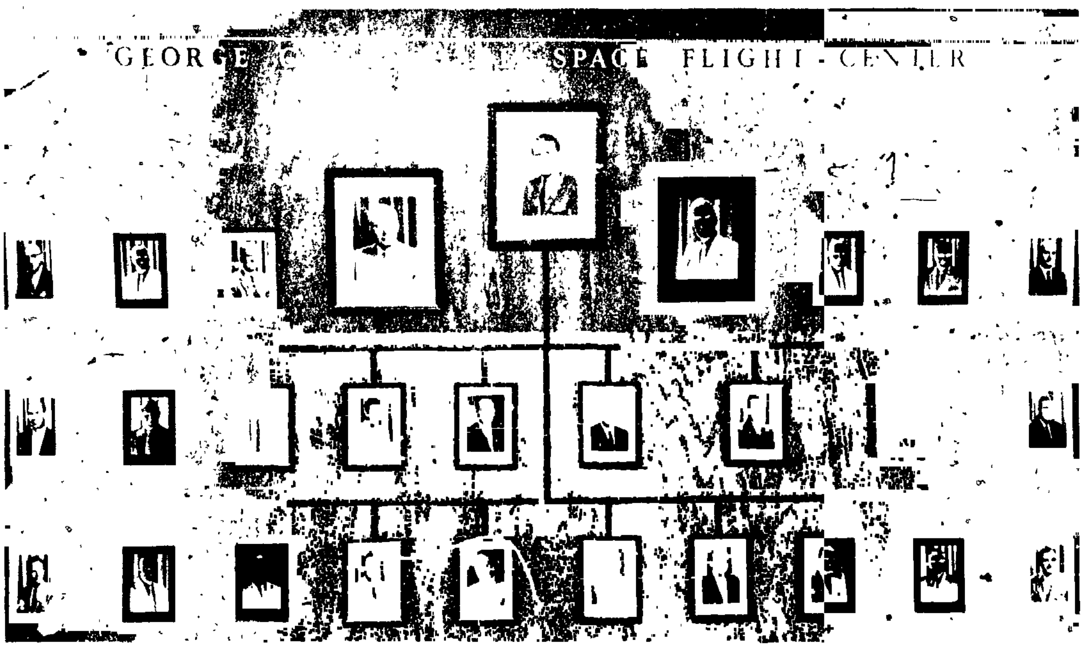
Saturn C-5 launch pad – artist's concept



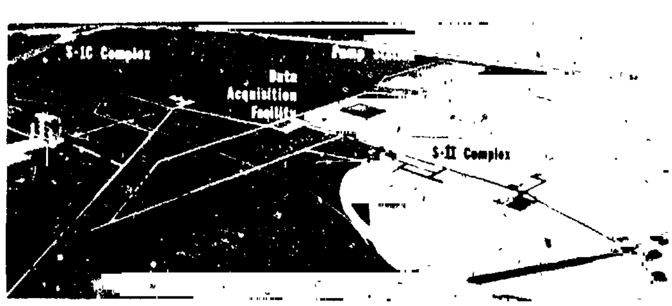
Launch Complex 39 – artist's concept



Pictured here in the spring of 1963 is construction of the Vertical Assembly and Hydrostatic Test Facility at MSFC's Michoud Operations. The foundation is 215 by 195 feet, an indication of the size of the structure that would stand 214 feet high.

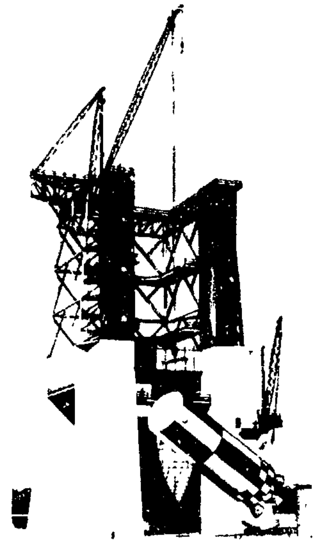


At the close of MSFC's second year, June 30, 1962, there were 27 top officials. Upper row, left to right: Bart J. Slattery, Jr., Public Information Office; Jerry C. McCall, Assistant to the Director; Erich W. Neubert, Associate Deputy Director, Research and Development; Eberhard F. M. Rees, Deputy Director, Research and Development; Wernher von Braun, Director; Harry H. Gorman, Deputy Director, Administration; David H. Newby, Associate Deputy Director, Administration; Hans H. Maus, Central Planning Office; William E. Guilian, Chief Counsel. Second row: Oswald H. Lange, Saturn Systems Office; Hans Heuter, Light and Medium Vehicles Office; Heinz H. Koelle, Future Projects Office; James T. Shepherd, Facilities Engineering Office; Davis E. Foxworthy, Support Services Office; Victor C. Sorensen, Management Services Office; Theodore U. Hardeman, Financial Management Office; Wilbur S. Davis, Procurement and Contracts Office. Third row: Ernst D. Geissler, Aeroballistics Division; Helmut Hoelzer, Computation Division; Werner R. Kuers Manufacturing Engineering Division; Walter Haeussermann, Astrionics Division; Kurt H. Debus, Launch Operations Directorate; Ernst Stuhlinger, Research Projects Division; William A. Mrazek, Propulsion and Vehicle Engineering Division; George N. Constan, Michoud Operations; Dieter Grau, Quality Assurance Division; Karl L. Heimburg, Test Division.

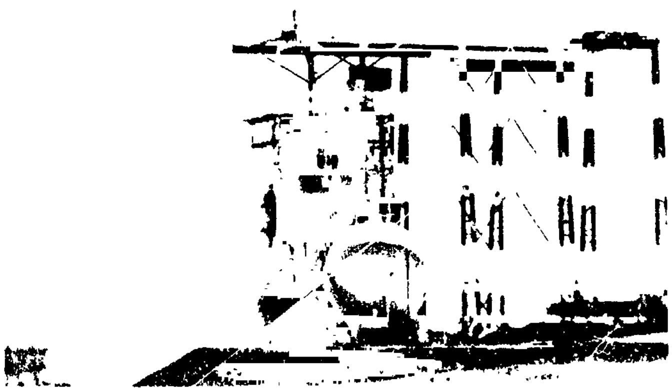


Mississippi Test Facility

NASA Computer Center, Slidell, Louisiana



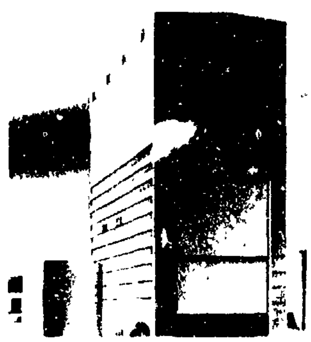
S-IC static test stand - artist's concept



S-IV battleship static firing

SA-5 configuration

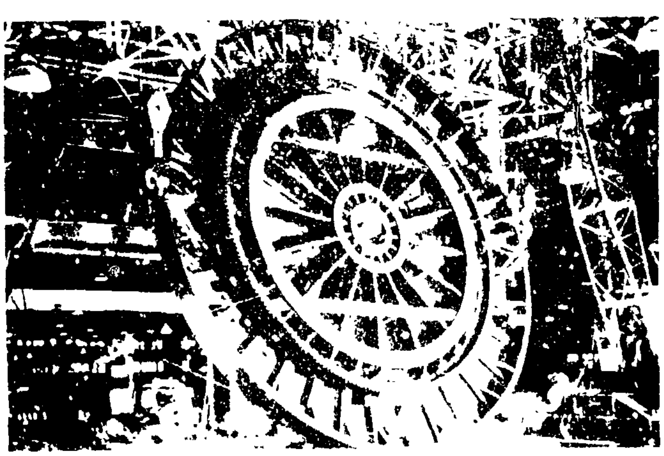
J-2 test facility



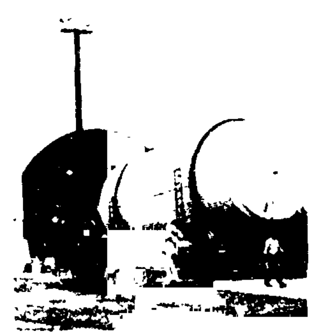
S-IC stage facility

President Kennedy and MSFC Director Wernher von Braun tour manufacturing and test facilities during the visit of the Presidential party to MSFC on September 11. A Saturn briefing and a static firing of a Saturn C-1 booster were features of the tour.

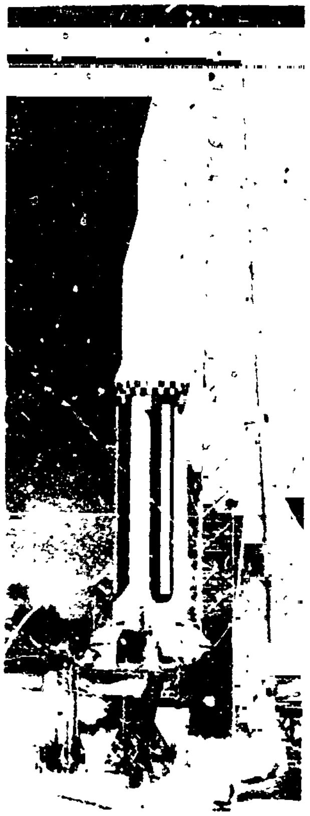
During their September 11 visit to MSFC, President Kennedy and Vice President Lyndon B. Johnson viewed the Saturn C-1 vehicle in the Manufacturing Engineering Division. The President and Vice President are shown with Dr. Wernher von Braun, MSFC Director



Installation of 42-foot boring mill

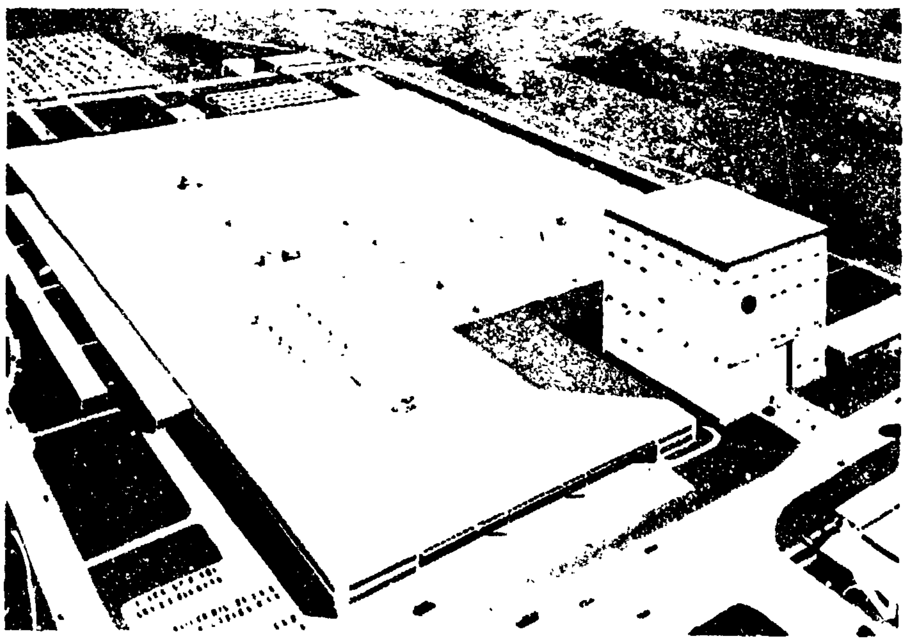


Unloading S-IV stage at MSFC

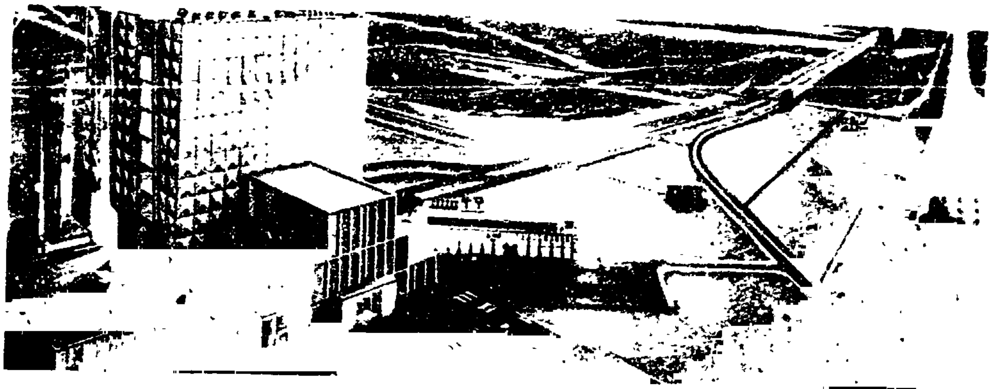


SA-D5 booster

Launch of SA-3 flight vehicle



Vertical Assembly Building at Michoud – artist's concept



LC-39 Vehicle Assembly Building at Cape Canaveral – artist's concept

1963

On February 4 MSFC decided to modify the west side of the MSFC static test tower for F-1 engine testing. The modification would allow single F-1 engine tests to begin several months earlier than scheduled. The stand would later be reconverted for S-I static testing [101].

On February 20 NASA began contract negotiations for design, fabrication, erection, and testing of the crawler-transporter which would transport the Saturn V vehicle to the launch pad of Launch Complex 39. The contract was signed on March 29. On the same day NASA Headquarters approved the plan for modification of the basic Chrysler contract. The plan provided for redesign of the S-I stages [102, 103].

For Saturn V, NASA Headquarters approved the Boeing S-IC definitive contract on February 21. Boeing would design, develop, and manufacture one ground test stage and nine flight stages at the Michoud Plant in New Orleans [104].

During the firsts week of February, NASA Headquarters announced a change in Saturn vehicle nomenclature. Saturn C-1 became Saturn I, Saturn C-IB became Saturn IB, and Saturn C-5 became Saturn V [105].

The first live Saturn I second stage would be powered by liquid hydrogen, still not flight proven. The S-IV battleship stage permitted tests of this new technology [106-108].

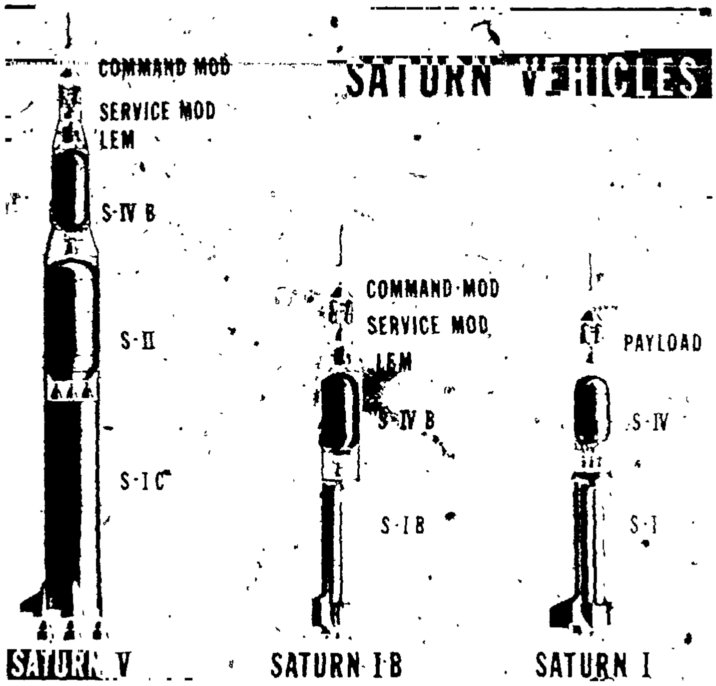
Dr. George N. Constan, general manager of Michoud Operations, announced on March 12 that he expected a peak total of some 10 000 government-contractor personnel to be employed by the Saturn Booster Manufacturing Facility of Michoud by mid-1964 [109].

Saturn SA-4, the fourth and last of the single-powered-stage, Block I vehicles, was successfully launched on March 28 from Launch Complex 34. The vehicle, carrying several Block II components for test, reached an altitude of 80 statute miles. Range was 218 statute miles and peak velocity 3660 miles per hour. As a secondary mission, the No. 5 inboard engine was cut off at 100 seconds to test the vehicle engine-out capability. Overall performance of the flight was very satisfactory [110].

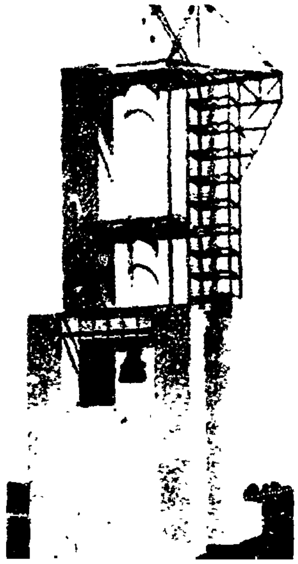
At its Sacramento Test Facility (SACTO) Douglas completed the S-IV battleship test program with a final lox depletion firing of 444 seconds on May 4. Sixteen tests totaling 4302.5 seconds were accomplished using the RL10-A-3 engines. The complete battleship test program (including both A-1 and A-3 engines) had a total firing time of 5440.1 seconds [111, 112].

President John F. Kennedy, on an all-day tour of North Alabama, stopped briefly at the Redstone Airstrip for a short address to a crowd of 10 000 people before boarding his jet to return to Washington. Before leaving, he talked about 5 minutes with Dr. von Braun about the space program [113].

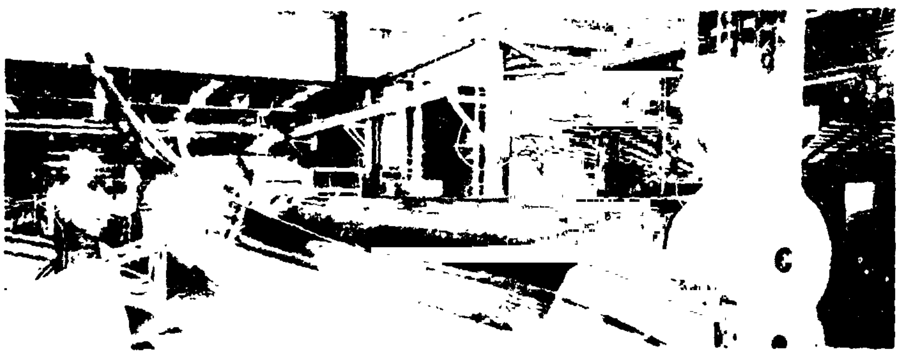
During early May the J-2 engine, used on S-IVB and S-II stages, was successfully fired for the first time at a simulated space altitude in excess of 60 000 feet. The engine developed



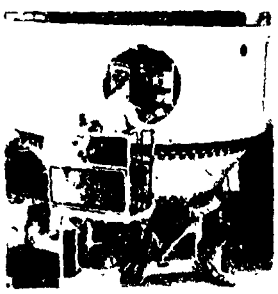
Saturn vehicles



F-1 test stand



S-IC bulkhead gore forming



SA-5 instrument unit

Saturn V dynamic tower

S-IC static test tower

200 000 pounds of thrust; after 20 seconds the test was terminated as programmed [114].

The MSFC Space Orientation Center, formerly the Space Museum, was drawing as many as 500 persons a day according to assistant curator Evelyn Falkowski during a June 11 interview.

Some 1200 MSFC employees began moving into Building 4200, the Center's new Central Laboratory and Office Building, in June [115].

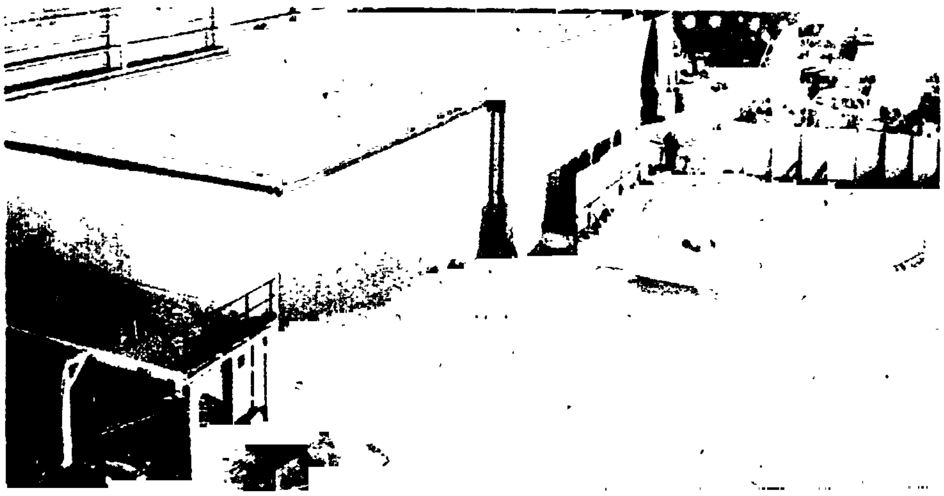
On August 5 NASA completed S-IB contract negotiations with Chrysler Corporation at Michoud. The following day S-IVB/Saturn IB contract negotiations were completed with Douglas Aircraft Corporation at Santa Monica [116].

In its lead story of August 22, the MSFC *Marshall Star* had the following: "BILLY GRAHAM RALLY SLATED HERE SUNDAY. Evangelist Billy Graham, said by many to be the greatest speaker in modern Christianity, will conduct a religious service at Redstone Air Field next Sunday at 4:00 p.m. The service is expected to draw thousands of visitors from all over north Alabama." In an announcement to MSFC employees Dr. von Braun stated: "I would like to urge all MSFC employees and their families to attend the Reverend Billy Graham's service Sunday afternoon. In this age of space flight and unprecedented scientific accomplishments, it is important that we be mindful of our spiritual necessities. Dr. Graham had devoted his life to the spiritual welfare of peoples all over the world. We are very fortunate to have him visit Huntsville." The announcements were successful. The expected big crowd attended the Billy Graham service the following Sunday.

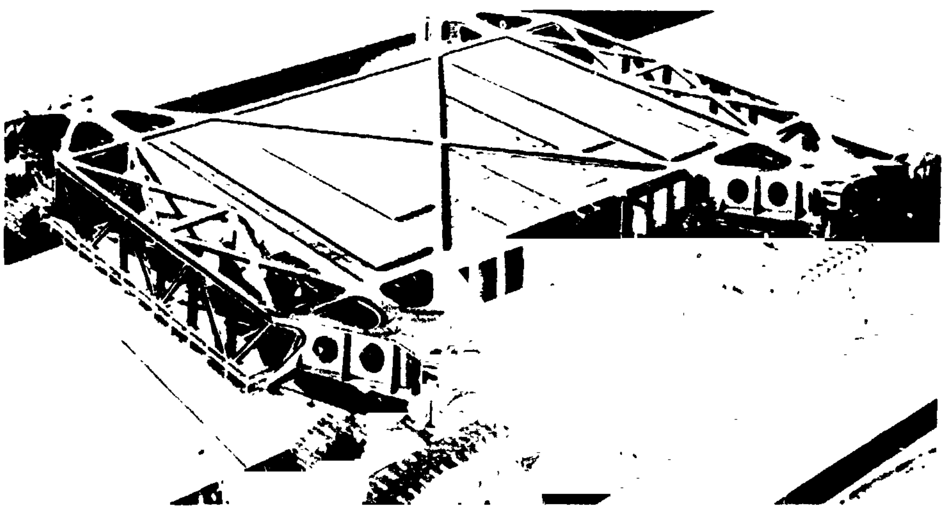
On September 1 Dr. Wernher von Braun, MSFC Director, announced a major reorganization of the Center. Progress in the Saturn program, and a rise in industrial participation to approximately 90 percent of the budget, necessitated the changes. The Center created two major subdivisions – Research and Development Operations and Industrial Operations. Research and Development Operations, composed of the nine technical divisions redesignated laboratories, was strengthened for its Huntsville-based operations and for specialized contractor assistance. Industrial Operations was created to direct the portion of the Center's work performed by prime contractors, mainly the development of stages and engines for the Saturn I, Saturn IB, and Saturn V multistage rockets [117, 118].

Dr. von Braun addressed a large gathering of Center employees outside Building 4200 in a special ceremony on October 15 marking the fifth anniversary of NASA [119].

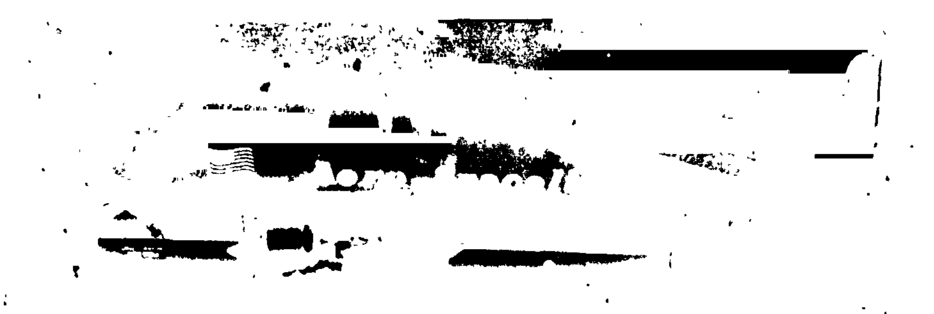
Nasa announced on October 30 a rephasing of Saturn manned flight missions. Saturn I manned missions were dropped, thereby deleting six Saturn I vehicles, The Saturn I program would terminate with completion of the research and development program for the 10 unmanned flight vehicles. NASA approved speed-up of Saturn IB development. The more powerful Saturn IB vehicle would launch the Project Apollo manned flights in preparation for Saturn V's manned moon mission. "All-up" testing would be utilized in



S-II Seal Beach facility



Crawler-transporter



Pregnant Guppy aircraft

future Saturn flights. That is, there would be no further flights with dummy stages; development flights would test Saturn vehicles in final configuration [120, 121].

On October 31 MSFC received from Rocketdyne Division of North American Aviation the first production model of the huge F-1 engine [122, 123].

NASA approved a Chrysler contract modification in October that provided for 12 Saturn IB boosters in lieu of operational Saturn I boosters. At Michoud, Chrysler continued design studies on components for these S-IB stages. MSFC approved the design release for the S-IB spider beam and completed the 50 percent design review of the gaseous oxygen line and diffuser. Douglas continued work on hydrostatic and dynamic test equipment for Saturn IB's second stage and began assembly of its S-IVB battleship stage at the Sacremento Test Facility. Douglas began fabricating an S-IVB liquid hydrogen test tank in Huntsville for use in J-2 engine tests [124].

MSFC and Chrysler completed their study of the use of uprated H-1 engines in Saturn IB's booster stage. On November 8, after Chrysler determined engine load criteria and Saturn IB schedule impact, MSFC directed Rocketdyne to develop the more powerful engine [125, 126].

On November 8 MSFC contracted for a $13.4 million test complex at Mississippi Test Operations for the Saturn V second stage (S-II). At Seal Beach, S&ID continued assembly of the S-II battleship stage for static tests. NASA contracted a few days later for a Saturn V launch pad at Kennedy Space Center Complex 39 [127]. The pad would cost over $19 million.

An important engine development milestone occurred on November 27 with Rocketdyne's first extended-duration firing test of the J-2 engine. This successful test of 200 000-pound thrust, liquid hydrogen-fueled engine lasted for more than 8 minutes. The J-2 would power upper stages of both the Saturn IB and the Saturn V vehicles [128].

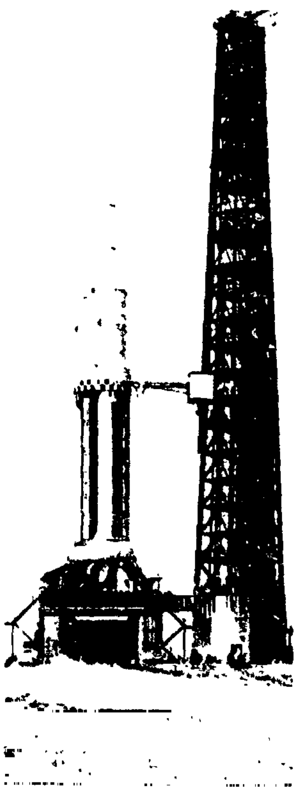
On November 28 the name of the NASA facility at Cape Canaveral was changed officially to John F. Kennedy Space Center (KSC) [129].

America's "second generation" of astronauts, as well as some of the original seven astronauts, spent November 29-30 at MSFC being briefed on the Center's space program. The astronauts included Walter M. Schirra and John Glenn along with newer astronauts Frank Borman, James Lovell, Thomas Stafford, Elliott See, Neil Armstrong, John Young, James McDivitt, Edward White, and Charles Conrad [130].

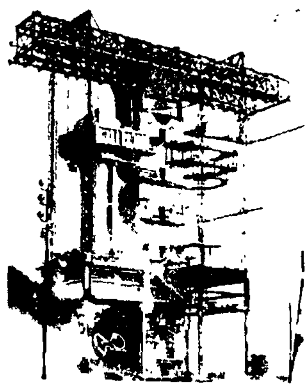
In November NASA postponed the fifth Saturn I flight because of technical problems with the SA-5 vehicle [131].

Saturn V progress during December included MSFC's first F-1 engine tests, these occurring on December 3 and 5. Duration of the first firing tests was 1.25 seconds; the second firing lasted 10 seconds [132]. On December 20 NASA updated the Boeing S-IC contract to amend the stage delivery schedule [133]. The contract as changed meant that

S-IV dynamic facilities stage at Cape Canaveral

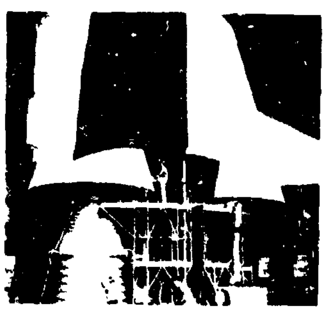


SA-4 on Launch Complex 34

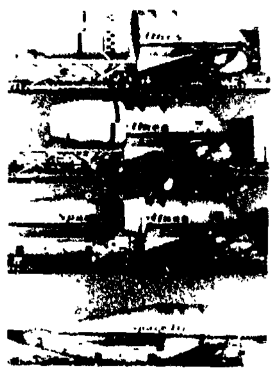


Static firing of S-I-5

Checkout of S-IV-5



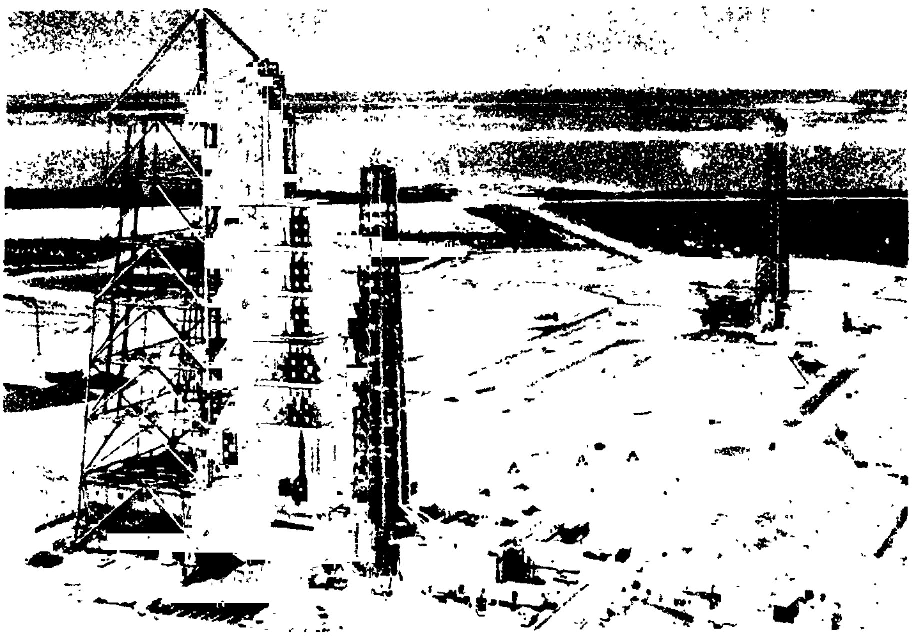
S-IC stage aft area mockup



Loading of S-IV stage

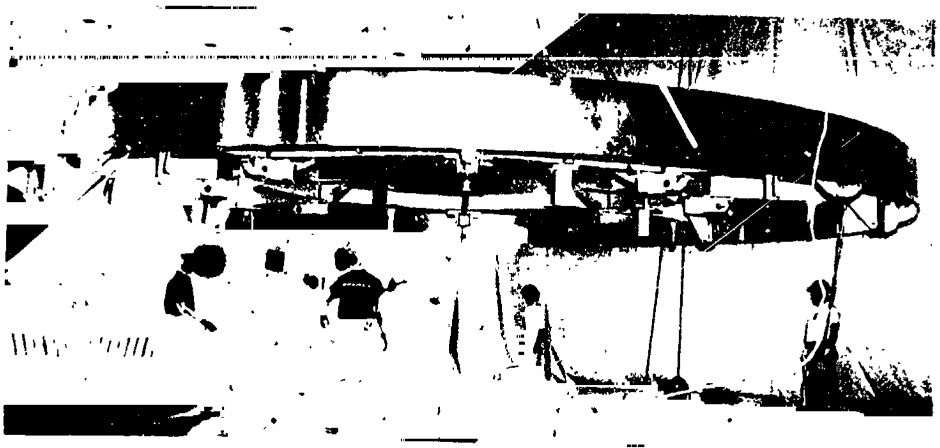
MSFC rather than Boeing would provide the second S-IC flight booster. On December 27 NASA amended the prime S-II stage contract with S&ID in order to make the first S-II flight stage "live" instead of dummy [134].

MSFC in December postponed the SA-5 flight until January 1964 after discovering cracks in fuel line fittings on the S-I-5 stage. MSFC decided to replace critical tubing on it and all remaining S-I stages. On December 13 MSFC accepted from Chrysler at Michoud the first industry-built Saturn I booster (S-I-8). By the end of December Chrysler had completed and MSFC had approved most of the structural redesign of Saturn IB's first stage [135].

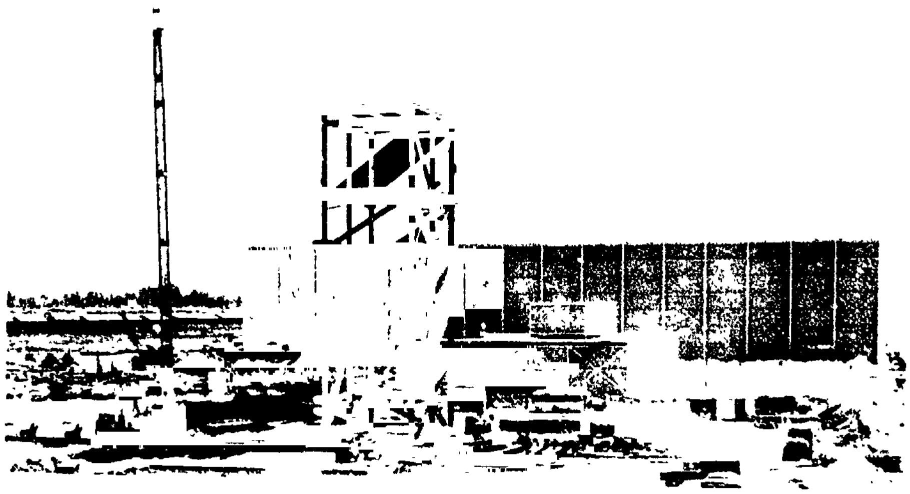


Facility checkout of Launch Complex 37B

Completion of S-IV battleship test program

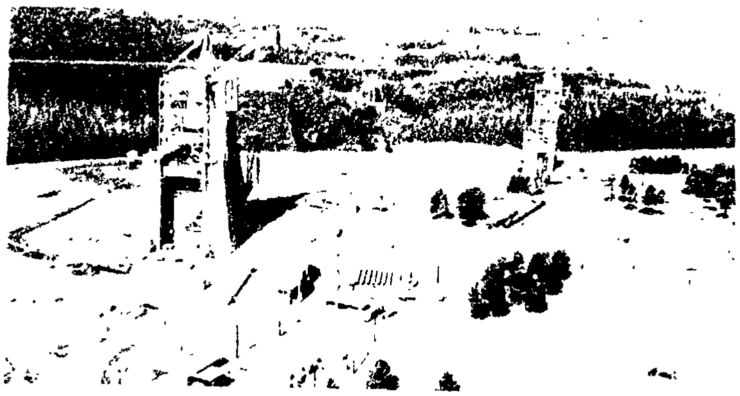


Complete Y-ring at Michoud



Douglas' Huntington Beach Facility

Chatting at Redstone Airfield during President Kennedy's brief stop at MSFC on May 18, 1963, were the President and MSFC Director Wernher von Braun.

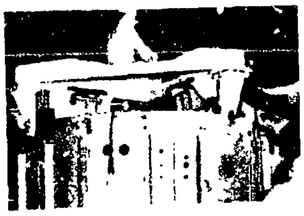


Saturn V Facilities at MSFC. Featured in this low aerial view are the S-IC Test Stand (left) holding a booster, and the F-1 Engine Test Stand.

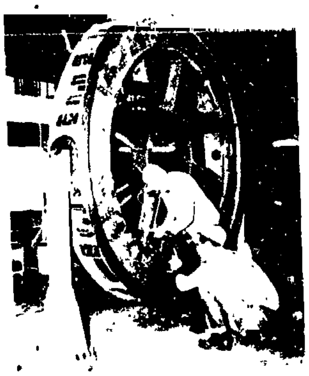
SA-4 launch

Scene at MSFC Family Day June 1963

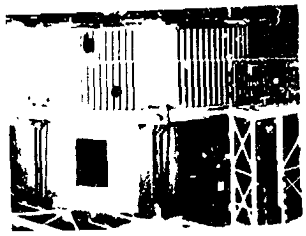
On October 15, 1963, MSFC held a special program to celebrate the fifth anniversary of NASA. Director Wernher von Braun addressed Center officials and employees in the ceremony outside building 4200.



a. Barrel assembly

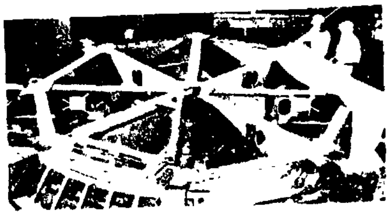


b. Lower thrust ring

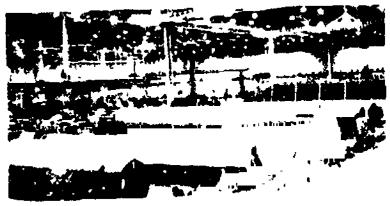


c. Tail unit

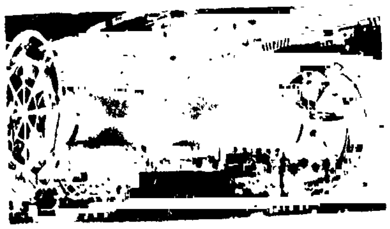
d. Thrust structure



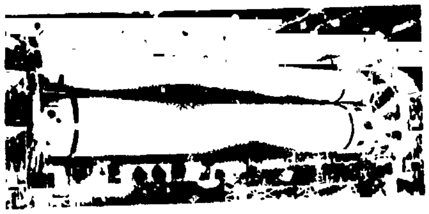
e. Spider Beam



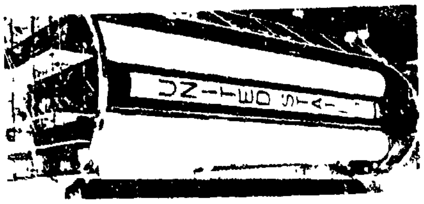
f. Lox and Fuel tanks ready for clustering



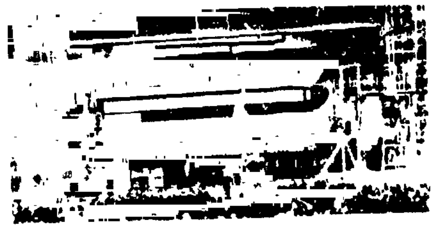
g. Installation of center lox tank



h. Clustering 70-inch lox tanks



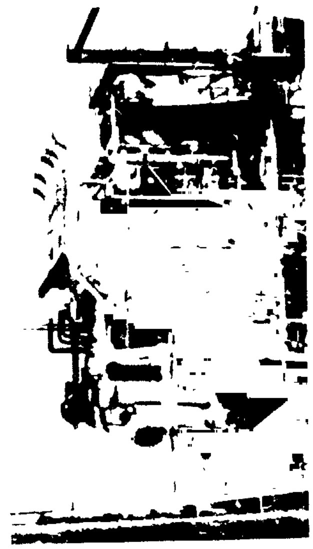
i Clustering 70-inch fuel tanks



j. Final assembly

Fabrication and assembly of S-I-8 at Michoud

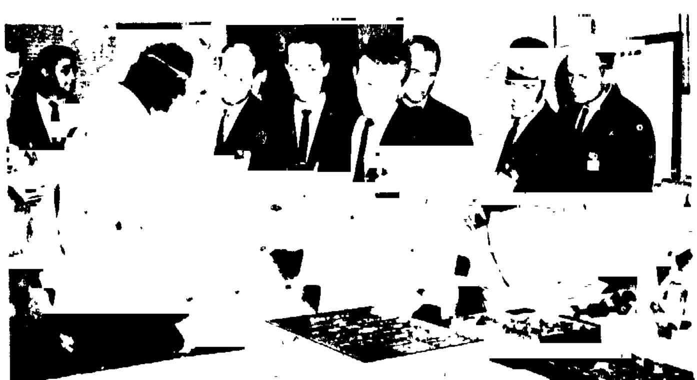
S-IC facility



S-IV-5 acceptance firing

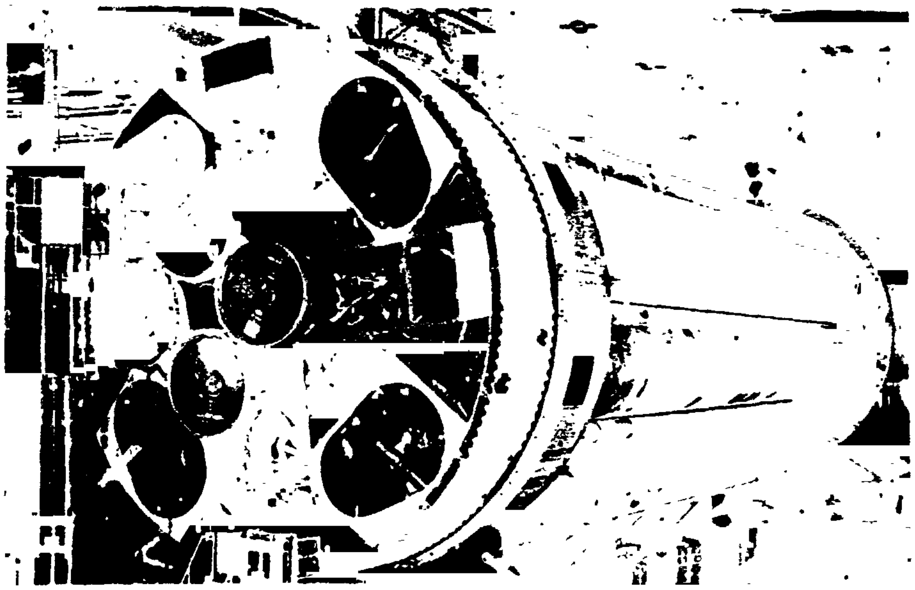
Assembly of S-II battleship stage

First J-2 extended-duration firing test

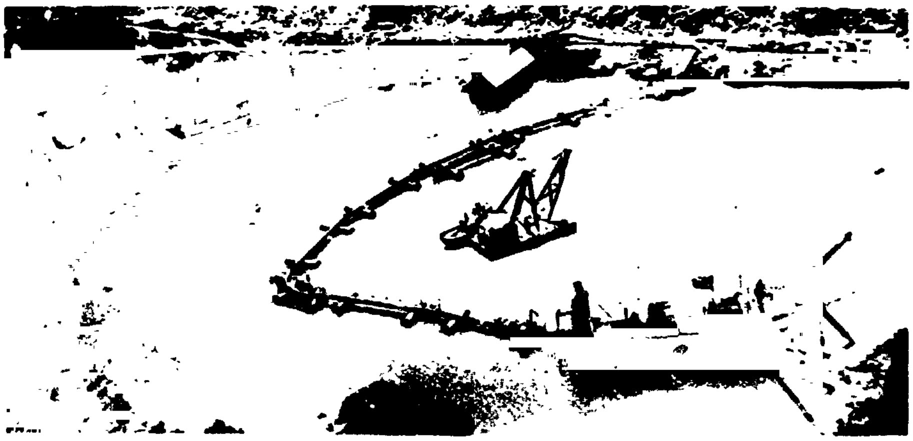


Twelve U.S. astronauts visited the Center on November 29 for a tour of facilities and for briefings on the manned lunar program.

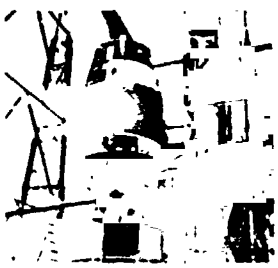
Construction at Launch Complex 39



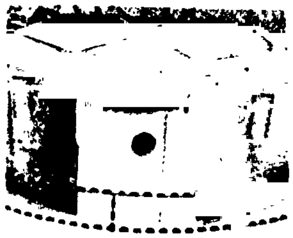
Assembly of S-I-9 stage



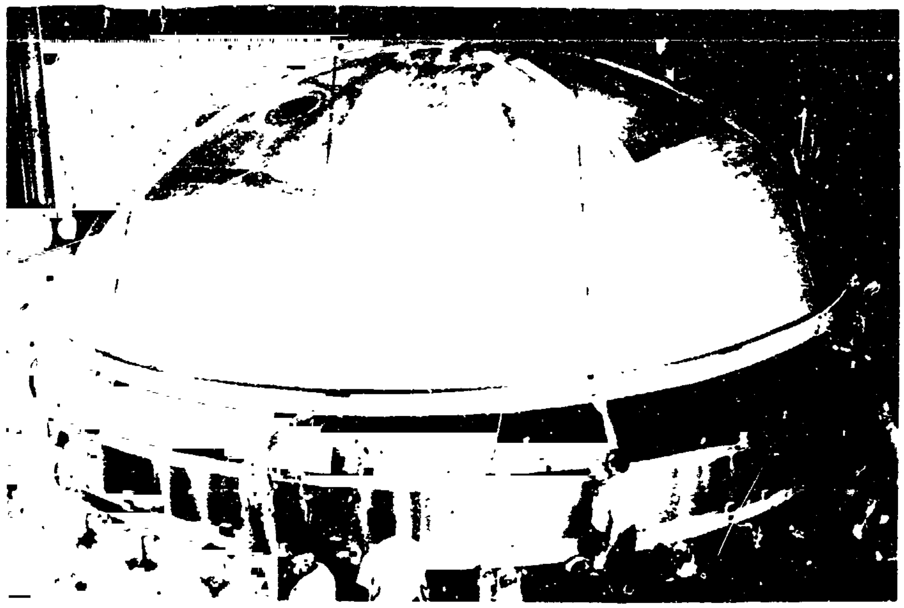
Dredging at Mississippi Test Facility



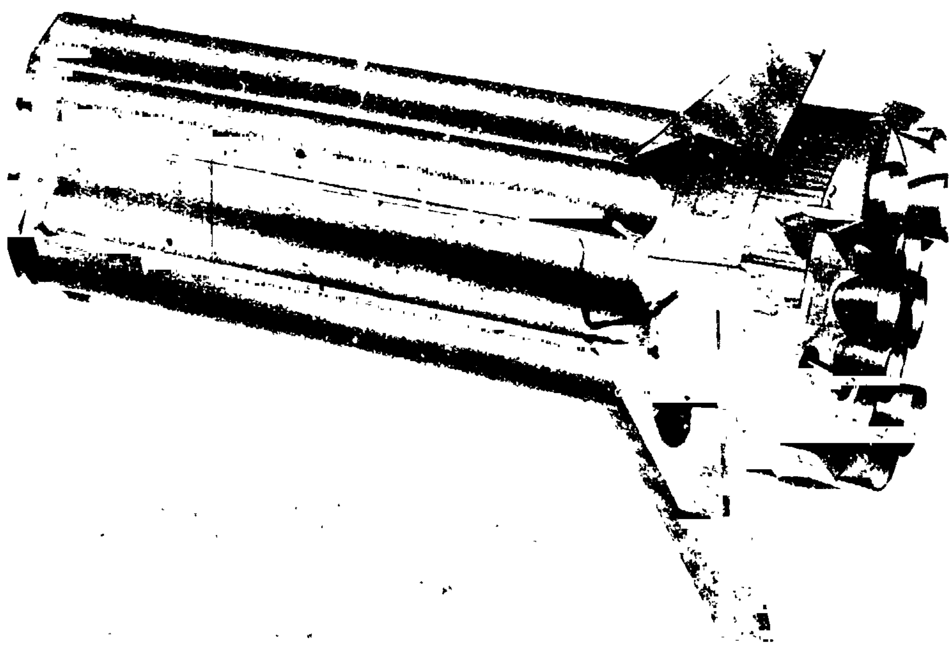
Second stage for SA-6 flight being placed in SACTO stand for acceptance testing



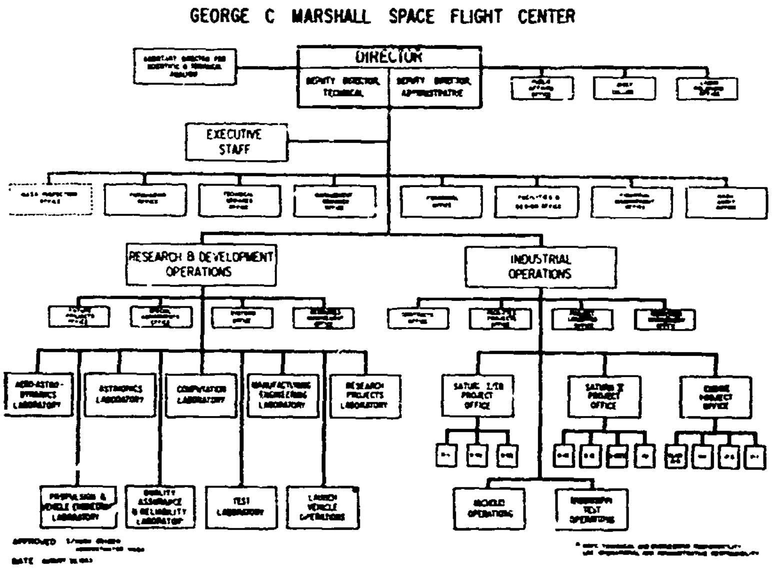
Spider beam mockup for Saturn IB's First, S-IB, Stage



Mating bulkhead to Y-ring

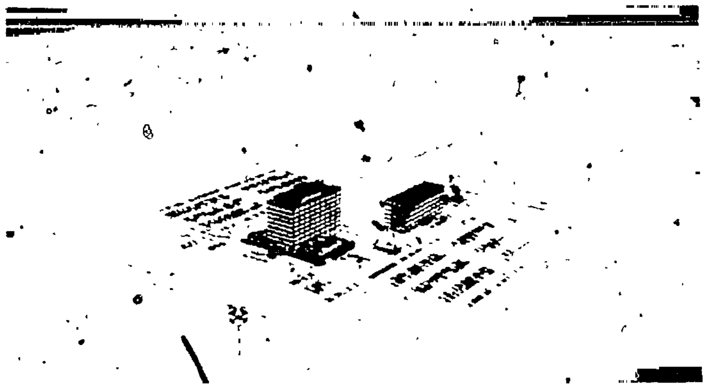


S-IB stage – artist's concept



MSFC organization chart

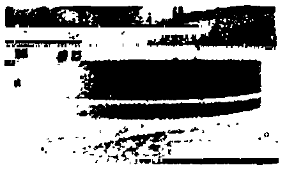
Intertank for S-IC-T



MSFC Headquarters Area – This aerial view photograph in October 1963 shows the MSFC office complex. When completed the complex would comprise three multistory buildings. Building 4200, the Central Laboratory and Office Building, is at left, and Building 4201, the Engineering and Administration Building, was under construction at right. A third structure, the Project Engineering Building, Building 4202, would be behind Building 4200.

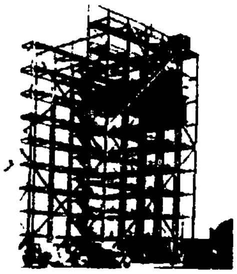
Experimental firing in sound suppressor development program

a. S-II aft interstage mockup



b. S-II forward interstage mockup

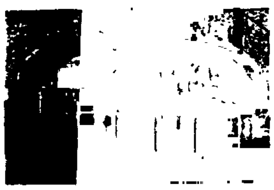
c. S-II bulkhead fabrication building at Seal Beach



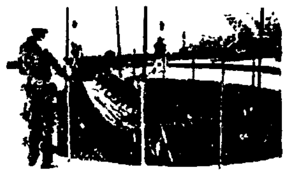
d. S-II structural test tower at Seal Beach

e. Bulkhead fabrication area at Seal Beach

f. Gore forming facility at El Toro



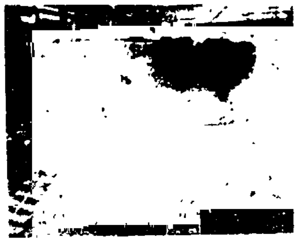
g. S-II skate bulkhead welders at Seal Beach



h. Explosive forming die at El Toro

S-II stage activities

Michoud mechanic drilling holes in the first S-IC lower thrust ring

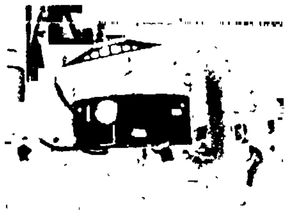


a. Assembly of S-IC test fuel tank

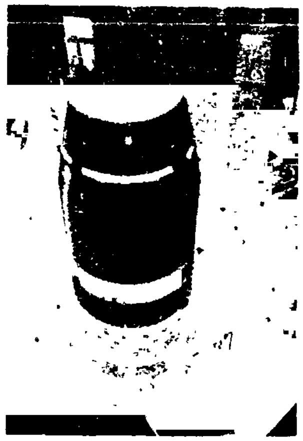
b. Welding S-IC bulkhead

Saturn V booster test stage components

MSFC F-1 engine firing test



a. Instrument unit



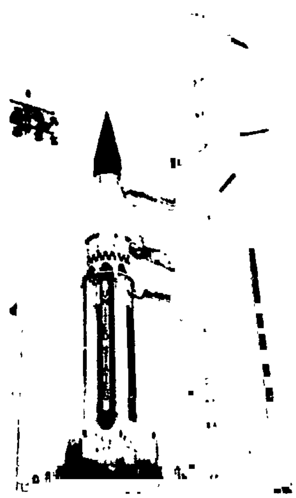
b. S-IV-5 stage

c. Hoisting instrument unit

d. Payload adapter

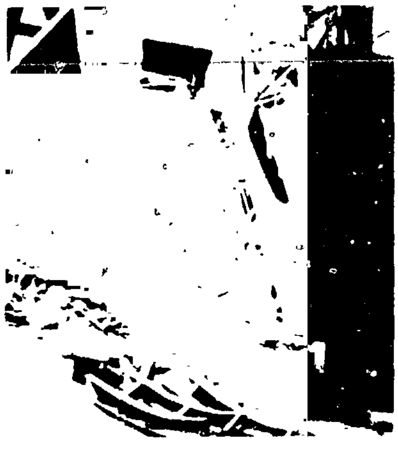
e. Hoisting payload

f. Payload



g. SA-5 at Launch Complex 37B

Erection of SA-5 at Cape Canaveral



a. Flame deflector in battleship test stand

b. All-systems test stand

c. Battleship test stand

S-II test stand construction at Santa Susana

S-IVB liquid hydrogen test tank, MSFC

1964

As reported January 20, the MSFC Space Orientation Center was drawing almost 100 000 visitors a year according to records kept by the Space Orientation Center (SOC) curator, Paul H. Satterfield. SOC visitors accounted for about half of the annual visitors to MSFC.

On January 29 NASA launched the fifth Saturn I, SA-5. The liquid hydrogen-fueled second stage, flight tested for the first time, functioned perfectly. First-stage engines shut off as planned, 147 seconds after lift-off. The second stage separated, ignited, burned for 8 minutes, and with the attached instrument unit and sand-filled nosecone attained orbit as an earth satellite. Time from lift-off until orbit was 10.32 minutes. The almost 19-ton satellite was the heaviest ever orbited [136].

NASA announced in January that construction budgets for Saturn IB and Saturn V facilities at Michoud and the nearby Mississippi Test Operations would be $6 534 000 and $61 991 000, respectively, for FY 65 [137].

Mrs. Lyndon B. Johnson made a 1-day visit to MSFC on March 24. Accompanied by NASA Administrator James E. Webb and other officials, Mrs. Johnson toured MSFC, viewed two static firings, and made three speeches [138].

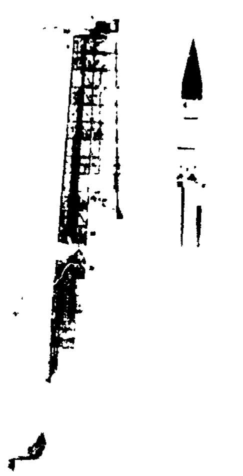
On April 24 the first industry-produced Saturn I booster arrived at MSFC from Michoud. The Chrysler-built S-I-8 stage went directly to MSFC's static test stand [139].

Building 4201, the second of three buildings in the MSFC Central Laboratory and Engineering complex, was completed in April. Approximately 650 Industrial Operations personnel began moving into this six-story Engineering and Administration Building [140].

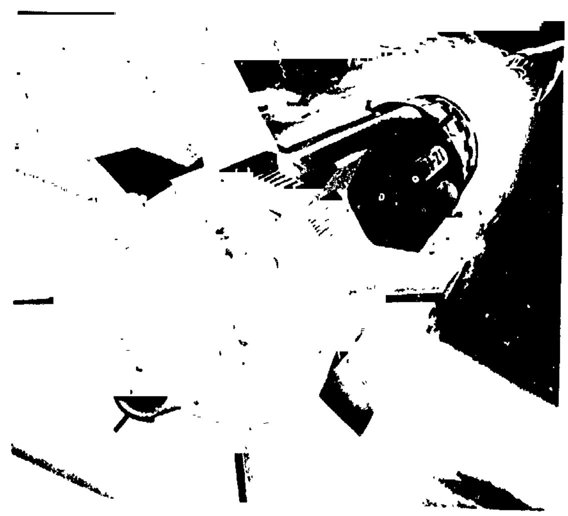
Early in April MSFC negotiated with Radio Corporation of America (RCA) for 19 ground computer systems to be used in checkout, static test, and launching of Saturn IB and Saturn V vehicles. Cost of these systems and seven ordered during 1963 would total more than $47 million. They would be used at Michoud, Mississippi Test Operations, and Cape Kennedy Launch Complexes 34, 37, and 39. Also in April NASA completed instrument unit arrangements for Saturn IB and Saturn V. IBM became lead contractor for work which, together with previous instrument unit assignments to IBM, was expected to cost $175 million over a 5-year period. NASA delegated management of this work to MSFC [141].

The sixth Saturn I flight occurred on May 28. The SA-6 flight was successful, as all preceding flights had been. The vehicle's guidance system, active in this flight for the first time, corrected a deviation from the planned trajectory caused by premature shutdown of one of the engines. The payload, 37 300 pounds and slightly lighter than that of the record SA-5 load, included a boilerplate Apollo spacecraft which reentered the atmosphere and disintegrated as expected after 3.3 days and 50 orbits of the earth [142].

The cast of the Space Is So Startling show visited MSFC. Shown here in the Space Orientation Center where they saw many of the components used in the probes into space.



Fifth Saturn I Flight



Saturn I second stage separation

Joining Apollo to SA-6

MSFC announced in May that it had leased office space in Huntsville's new West Clinton Street building for some 280 of its personnel currently housed in the Twickenham Hotel building. MSFC's lease for the Twickenham would expire June 30. MSFC would occupy some 35 350 square feet of net usable floor area in the top four floors of the eight storied Clinton Street building [143].

As a further indication of an expanding MSFC, the MSFC Personnel Office announced in mid-June that it had hired 140 new employees in the first 2 weeks of June [144].

The total number of contractor and civil service personnel working at the MSFC Michoud Operations passed the 10 000 mark early in June of 1964. There was a total of 10 101 persons working at the Michoud plant for the following organizations: Boeing Company, 5868; Chrysler Corporation, 1995; Mason-Rust, 818; NASA, 281; Rocketdyne, 17; and Telecomputing Company Services, 124 [145].

Automatic Retailers of America (ARA) assumed operation of MSFC cafeterias on June 29. The firm succeeded the Southern Cafeteria Company as the MSFC concessionaire [146].

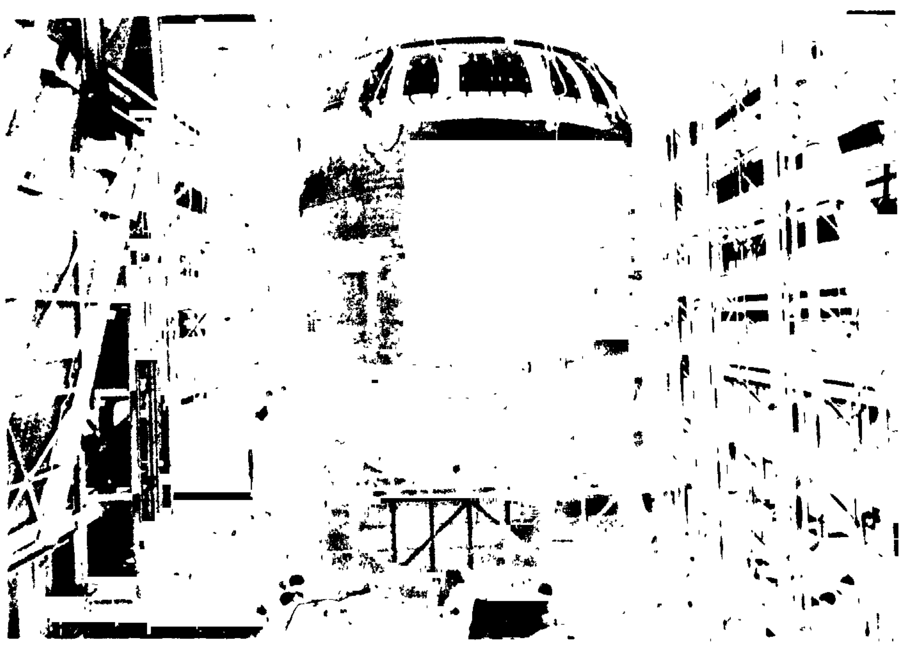
NASA's middle-sized Saturn, Saturn IB, progressed during June to beginning of manufacture of the first flight booster. By mid-June North American Aviation-Rocketdyne had delivered the first four uprated 200 000-pound-thrust, H-1 engines to Michoud for the Saturn IB booster [147].

The first of two test stands for the Saturn V second stage (S-II) was completed by North American Aviation at its Santa Susana Field Laboratory in July. On July 11 Douglas delivered its first Saturn V third stage test hardware to Huntsville. Flown from Long Beach, California, this S-IVB stage forward skirt would connect the top of that stage to the vehicle instrument unit [148]. On July 13 Army's Corps of Engineers of Mobile, Alabama, acting as NASA's agent for Mississippi Test Operations construction, awarded a contract worth more than $17 million for construction of the first test position on the giant S-IC dual test stand [149].

By mid-July Chrysler at Michoud had clustered all tanks for the first Saturn IB booster, S-IB-1, and by the end of the month installed all eight uprated H-1 engines [150]. Chrysler worked on the second booster (S-IB-2) components and began the third booster. Chrysler personnel also began converting the Saturn I dynamic test booster to a Saturn IV dynamic test stage. After dynamic tests, this stage would be used to check out Kennedy Space Center Saturn IB launch facilities. This modified stage was designated S-IB-D/F [151].

During August the Fairchild Hiller Corporation continued work on meteoroid detection satellites to be orbited by the last three Saturn I vehicles. Each satellite, soon after second stage separation and orbit, would extend its wings to a span of 96 feet. During the month NASA named the satellites Pegasus after the winged horse of ancient mythology. Problems with their development threatened the schedule of the last three Saturn I launches [152, 153].

Saturn I lox tank which would be modified for Saturn IB



Saturn V test fuel tank

NASA launched its seventh Saturn I from Cape Kennedy on September 18. The two-stage SA-7 rocket placed approximately 37 000 pounds of payload into an orbit similar to the interim orbit for future three-man Apollo lunar missions (145-mile apogee, 112-mile perigee). Boilerplate Apollo spacecraft command and service modules, instrument unit, and the spent S-IV stage comprised the satellite. All major test objectives were met: final development testing of Saturn I propulsion, structural, guidance, and flight control systems; development testing of Apollo spacecraft structure and design; demonstration of physical compatibility of launch vehicle and spacecraft; and test-jettisoning of spacecraft launch escape system. Cameras ejected after the flight were abandoned because of Hurricane Gladys, but some were later unexpectedly recovered. After this flight Saturn I was declared operational, achieving its goal three vehicles early [154, 155].

Major construction ended on the Saturn V Dynamic Test Facility on September 30 at MSFC [156].

On October 6 MSFC concluded 3½ years of Saturn I first stage static testing with a test of the final booster. The 156-second test indicated that the S-I-10, manufactured by Chrysler at Michoud, was satisfactory [157, 158].

Mr. and Mrs. Robert B. Young departed Huntsville on October 23. In an unusual approach to MSFC contractor management, Young had been director of Industrial Operations at MSFC for the past year. He was vice-president and general manager of Aerojet General Corporation's Sacramento Plant before joining MSFC. While at MSFC he directed that portion of the Center's work carried out by prime contractors in industry [159].

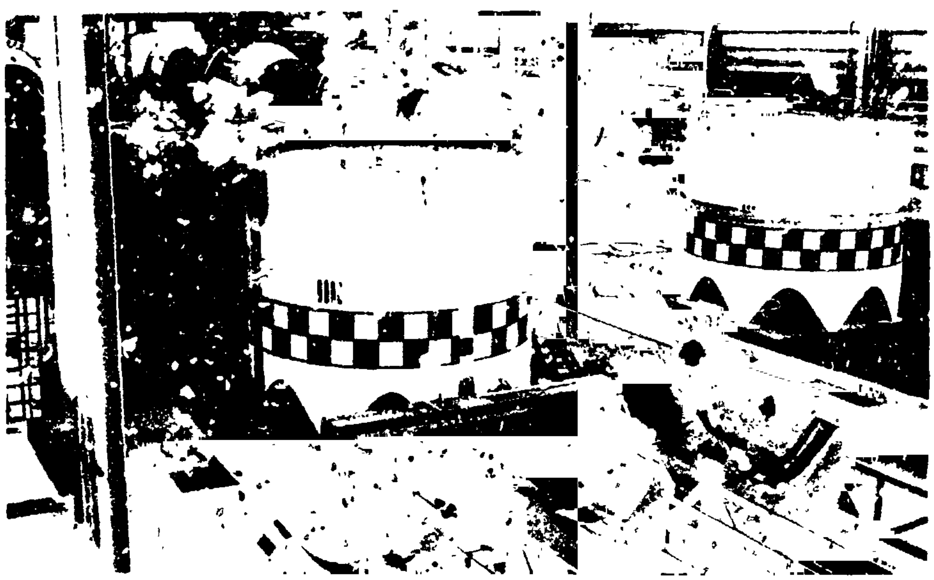
Astronaut M. Scott Carpenter and MSFC Director Wernher von Braun spoke to employees at a special awards ceremony in front of Building 4200 on October 28 [160].

Nasa Administrator James E. Webb visited Huntsville and MSFC on October 29 to discuss the role of the Center in future NASA programs [161].

A surprising recovery of films from the seventh Saturn I flight took place in November. Almost 2 months after the flight, two barnacle-encrusted capsules, each containing 100 feet of color motion-picture film in good condition, were found, one on a beach of an island in the Bahamas, the other in San Salvador in Central America. Hurricane weather had thwarted recovery efforts after the flight [162].

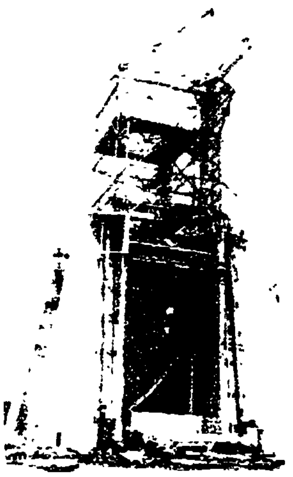
NASA provided for construction of Pad B at NASA's Saturn V Complex 39, Merritt Island, Florida, by awarding in November an almost $20 million firm fixed-price contract [163-165].

MSFC Director Wernher von Braun presents a safety hard hat to Mrs. Lyndon B. Johnson, wife of the President, during her visit to the Center on March 24, 1964. Dr. von Braun wears a Texas hat given him by the President in a visit to the LBJ Ranch. This picture was made in the Saturn V mockup area prior to static firings of the S-1 engine and the S-I stage.

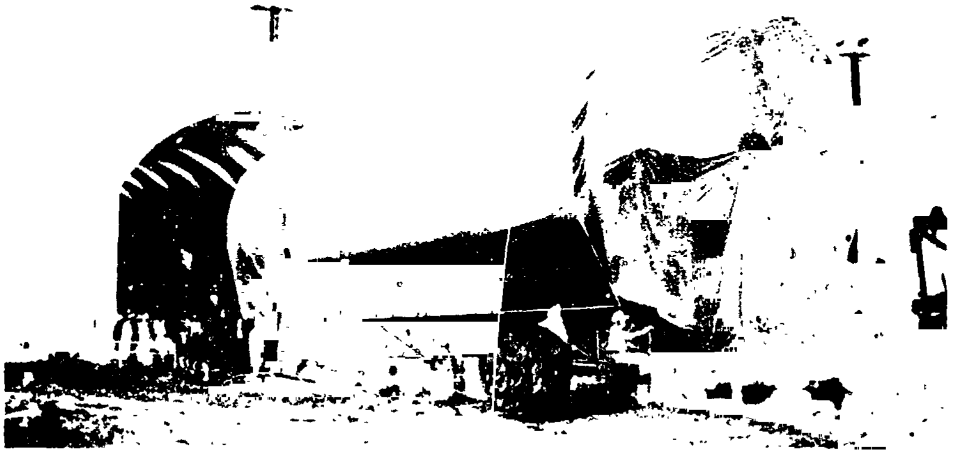


Saturn I second stage production

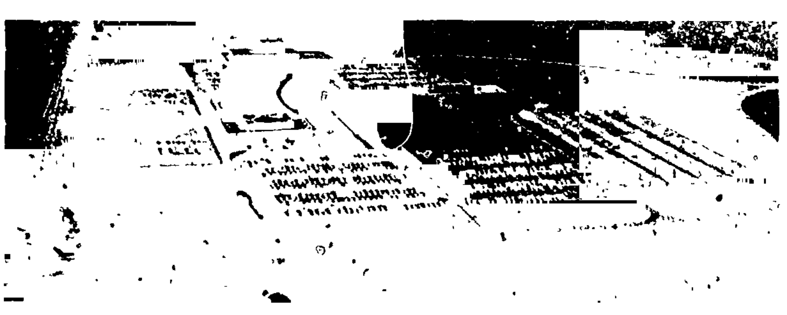
S-IVB dynamics test stage



MSFC static test stand for Saturn V booster

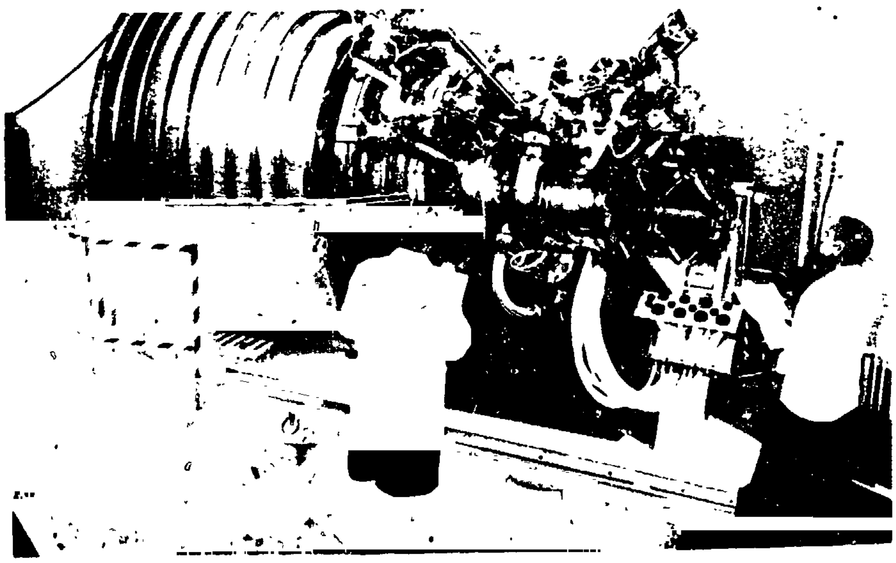


S-I-8, first industry-produced Saturn booster, being unloaded from barge at MSFC

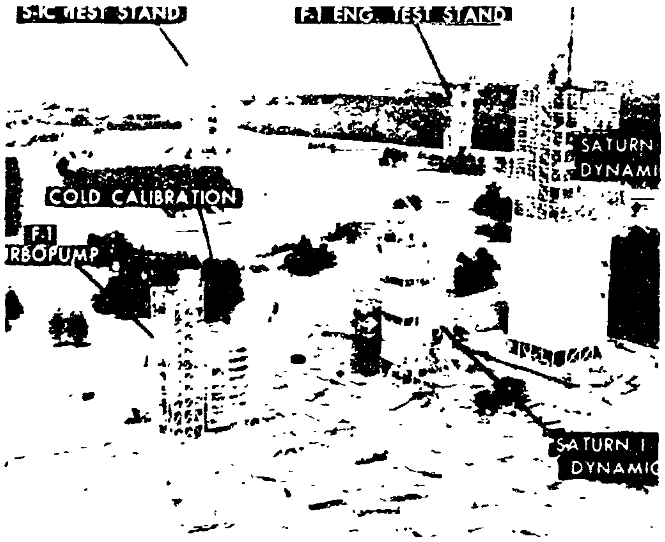


MSFC Headquarters Complex The two laboratory and office buildings completed are shown in this Spring 1964 photo looking northeast at MSFC. Buildings 4200, left, and 4201 would be joined by Building 4202 which would occupy the space between the two structures in this picture. Work on Building 4202 began in May 1964.

Mockup of instrument unit for Saturn IB and Saturn V



First J-2 production engine delivered to Douglas

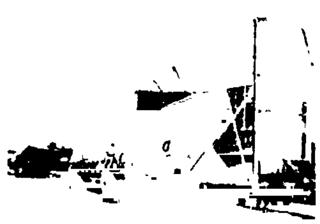


Aerial view of MSFC Saturn test stands

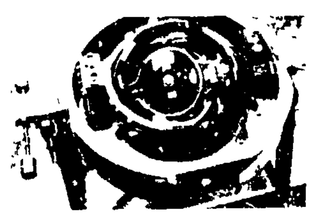
Sixth Saturn I flight

Onboard camera photograph of SA-6 stage separation

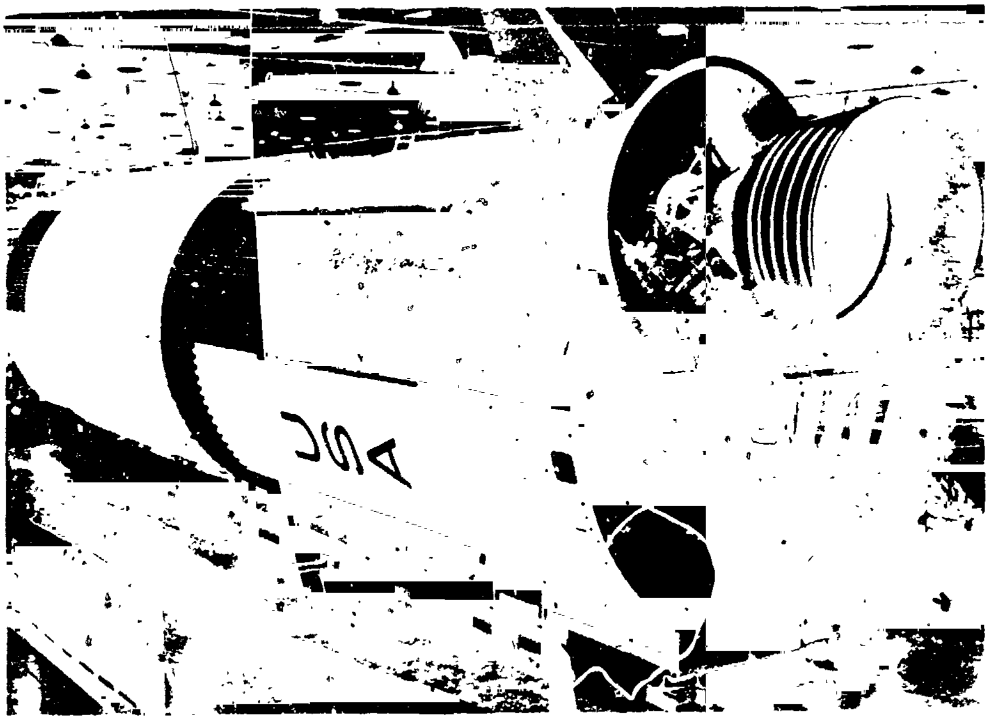
S-IU-9 checkout



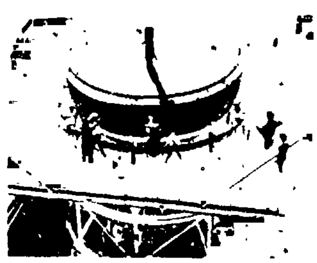
First Saturn V hardware from Douglas



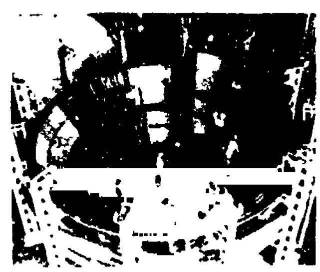
ST-124 guidance stable platform



Lox tank assembly for S-IVB stage, upper stage for Saturn IB and V



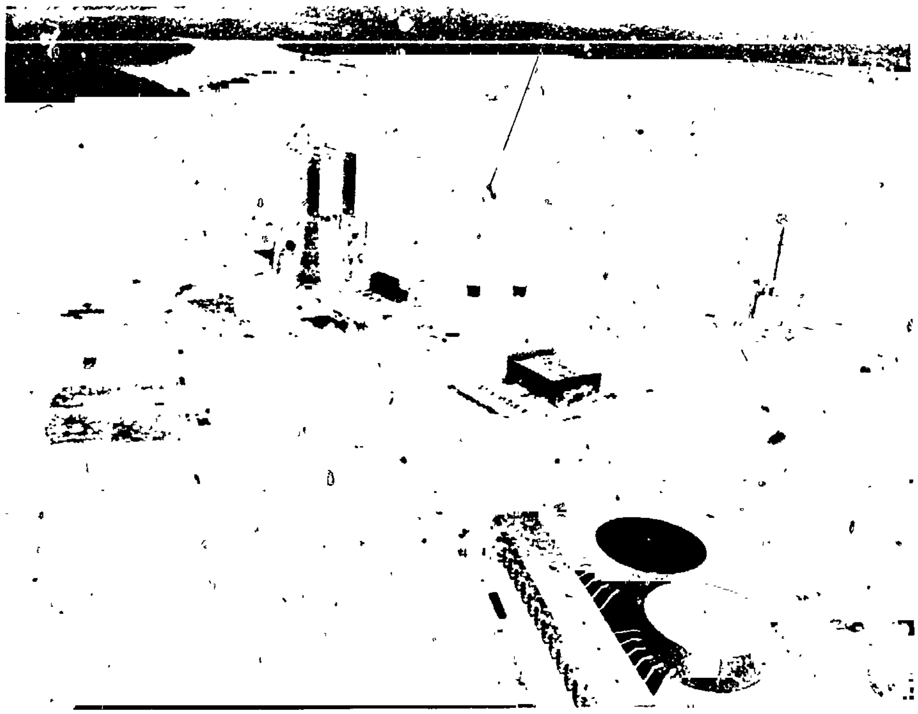
First Saturn V second stage, S-II, flight hardware



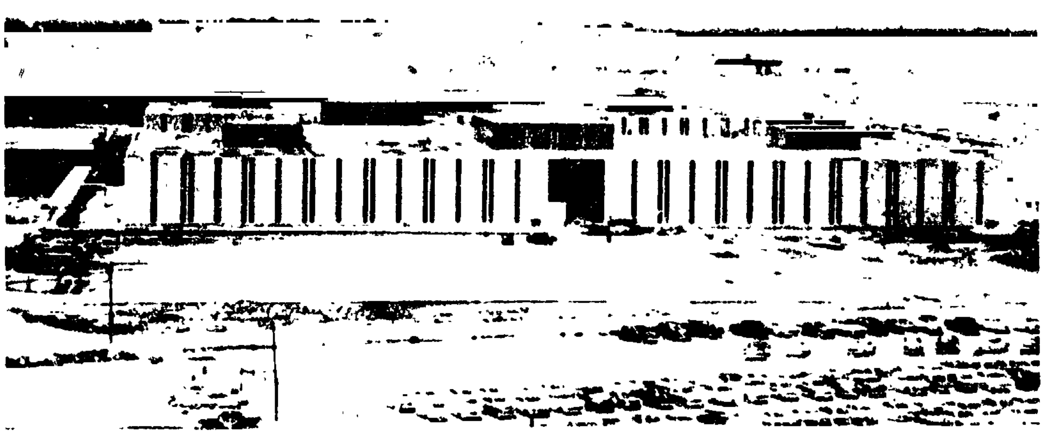
Saturn V booster full-scale mockup at Michoud

Saturn IB and Saturn V progress at time of sixth Saturn I flight

Michoud dock facilities

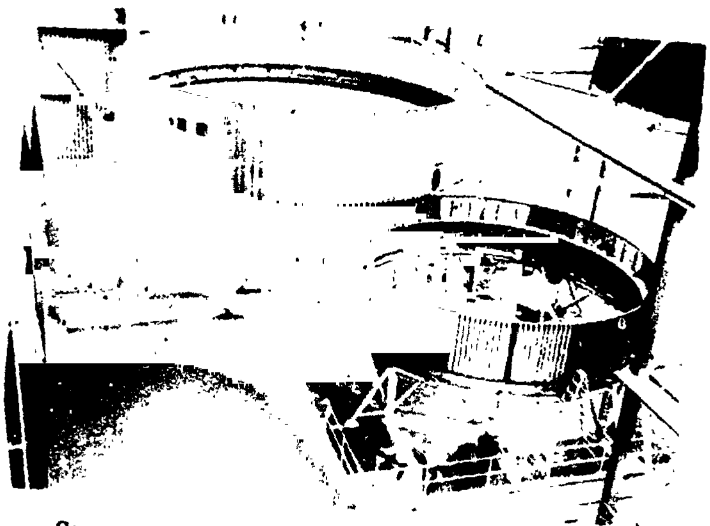


Major portions of the Saturn V ground test complex are shown in this June 1964 aerial view of the West Test Area at MSFC. Left center is the S-IC static Test Stand. The F-1 Engine Stand is at right. The high-pressure water system for the stands is in foreground, and the Blockhouse is at center of picture.



The Engineering and Administration Building at Michoud Operations was near structural completion in this summer 1964 picture. When completed later in the year, the three-story building would accommodate about 5000 contractor and government personnel.

Fuel and lox tanks being built in Huntsville for the Saturn V first stage, S-IC



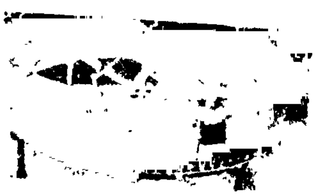
Structural test stage thrust unit at Seal Beach for the Saturn V second stage, S-II

Fabrication of Saturn V

SA-7 rises

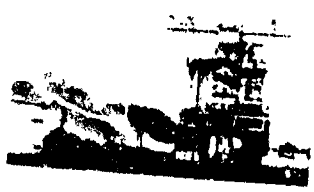
S-IB spider beam

H-1 engine, uprated for Saturn IB booster



Saturn IB nonflight instrument unit

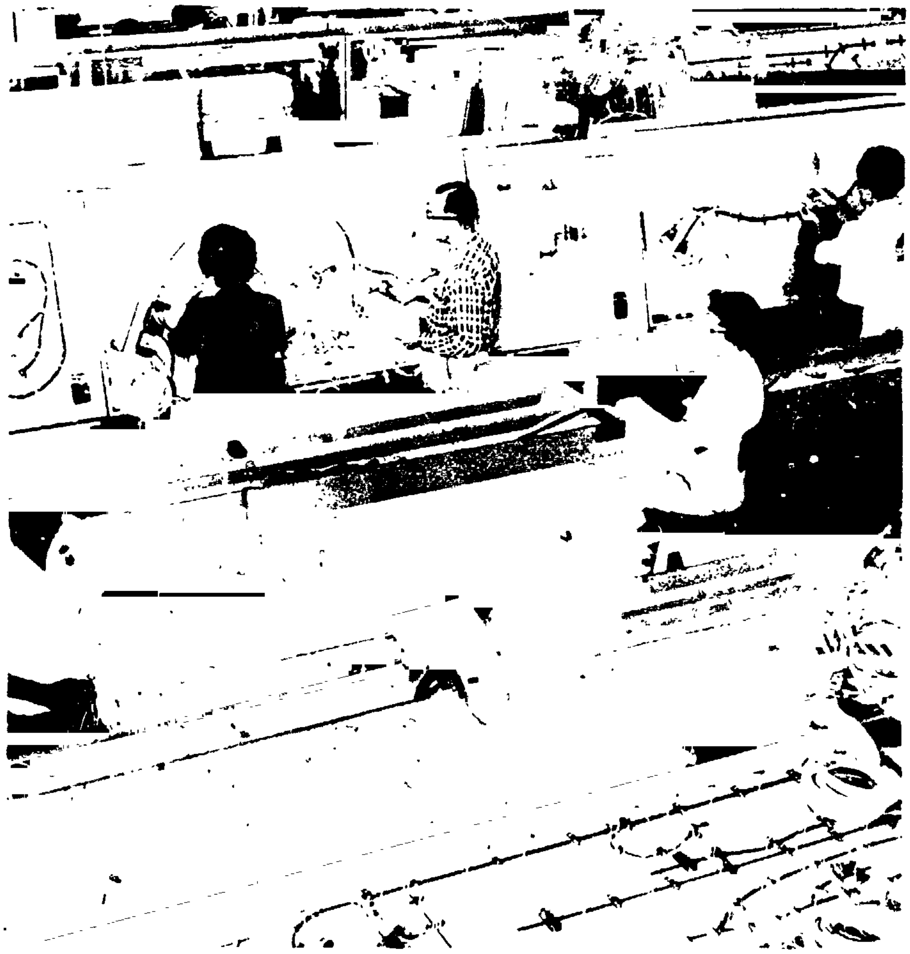
S-IB tail section



Last Saturn I booster ground test

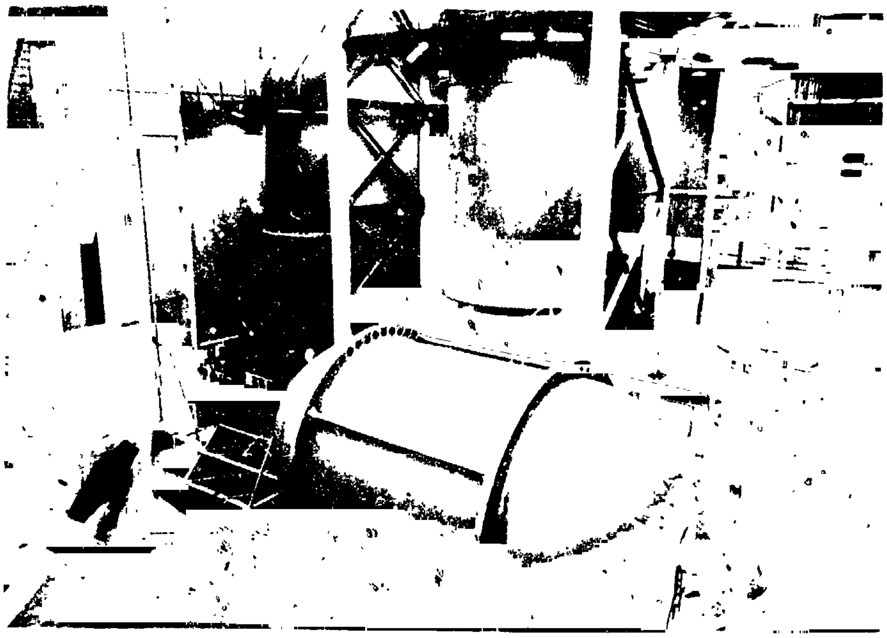
Chrysler personnel working on S-IB-2 thrust structure at Michoud

Blockhouse activity at SACTO during S-IV-9 acceptance firing

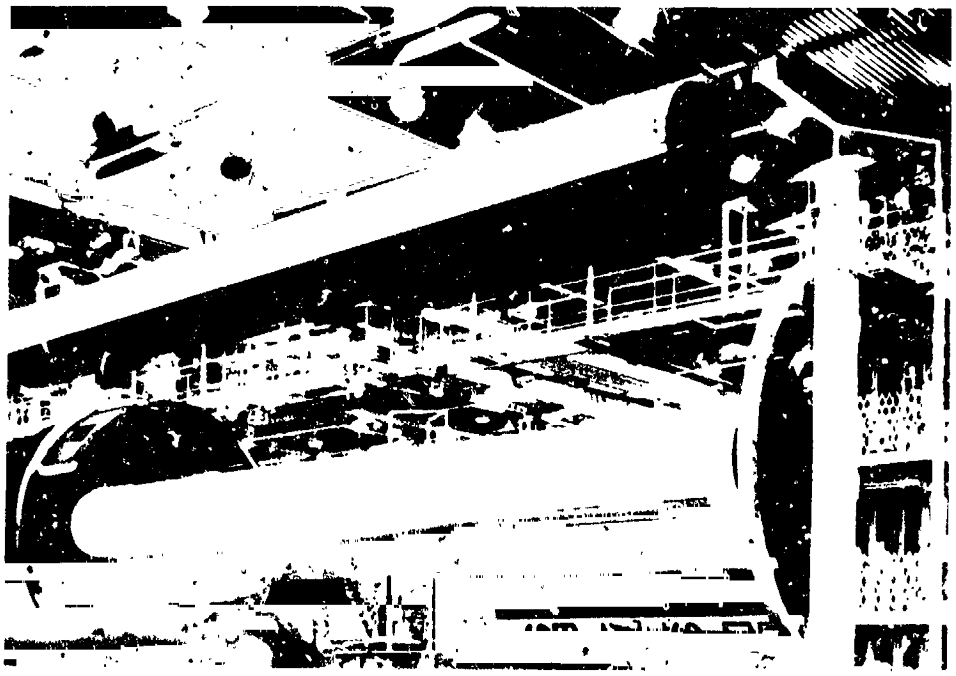


Douglas personnel working on ground support equipment at Huntington Beach

Electromechanical mockup for Saturn V second stage, S-II



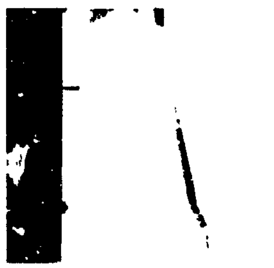
Saturn IB second stages, S-IVB, in Douglas tooling tower, Huntington Beach



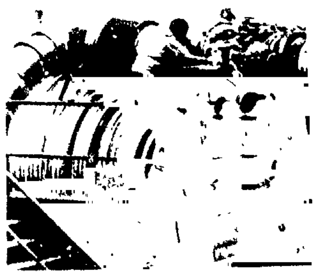
Clustering Saturn IB Dynamic Test stage at Michoud

Bulkhead for Saturn V second stage

J-2 engine assembly



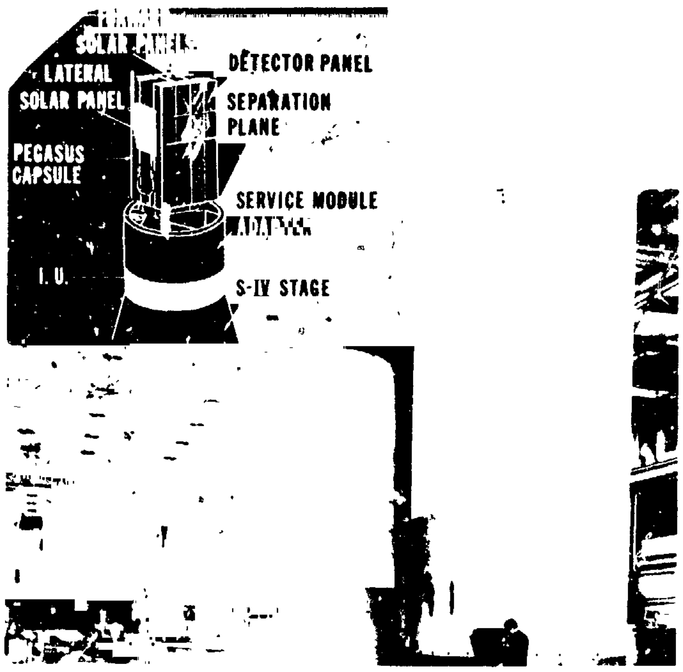
F-1 furnace brazing operation



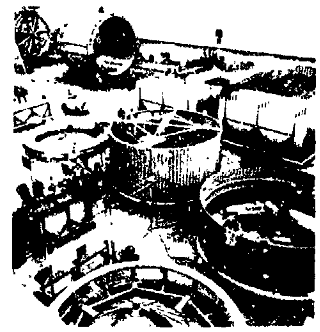
F-1 engine assembly

Saturn engine manufacturing by Rocketdyne at Canoga Park

Guidance and control systems test facility in Building 4487 at MSFC

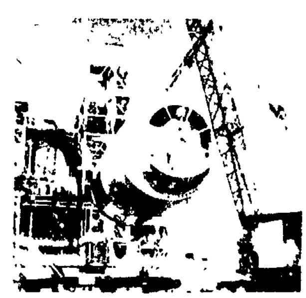


Two of three Pegasus satellites for last Saturn I flights housed inside adapted service modules

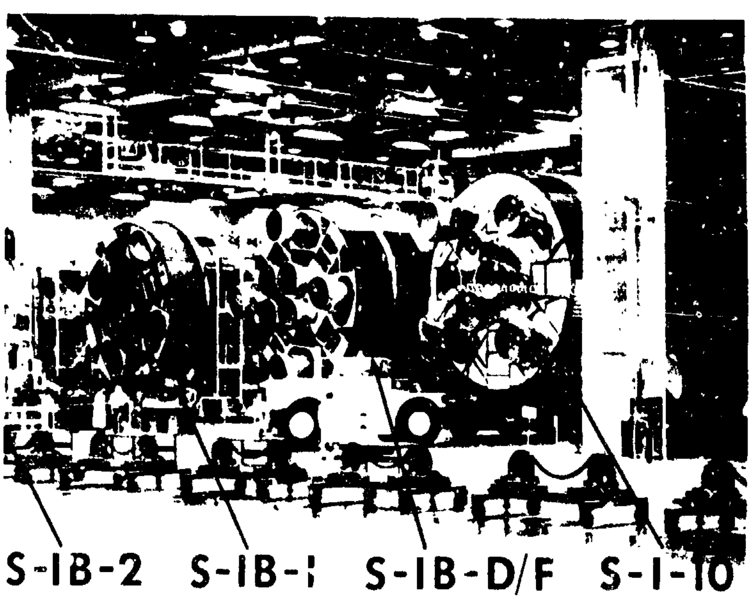


Douglas S-IVB stage fabrication area

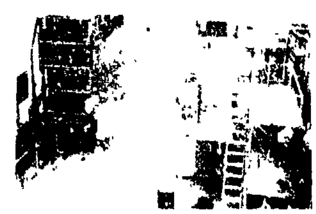
Recovered cameras



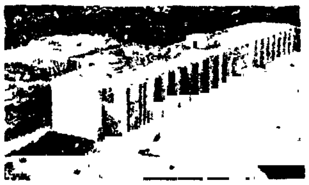
S-IV-10 being moved to stand at SACTO



Chrysler Saturn IB booster work



Pegasus B, folded, at left, and Pegasus prototype in spacecraft integration area of Fairchild Hiller Company, Hagerstown, MD

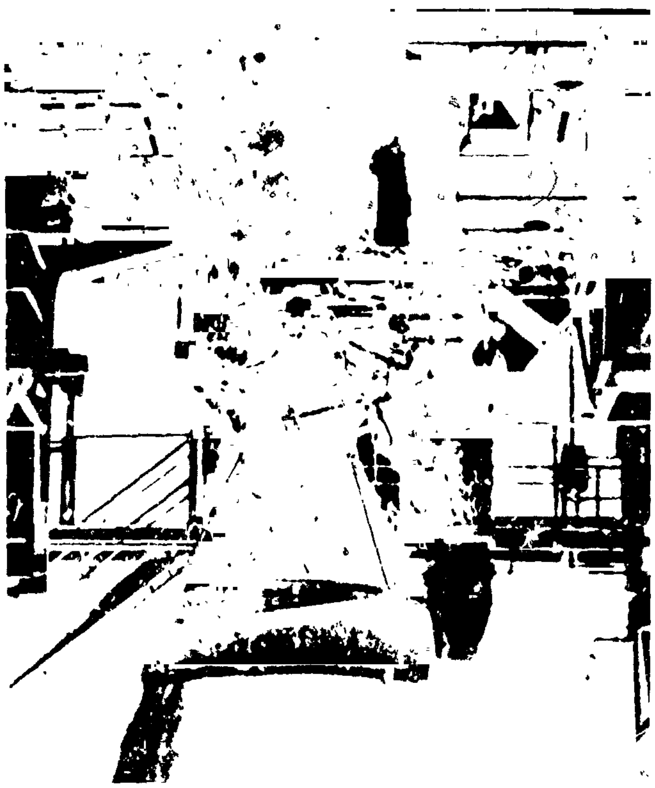


Laboratory and engineering building

Test stand for second Saturn V stage, S-II

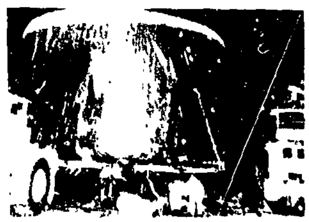
Test stand for first Saturn V stage, S-IC

Mississippi Test Operations

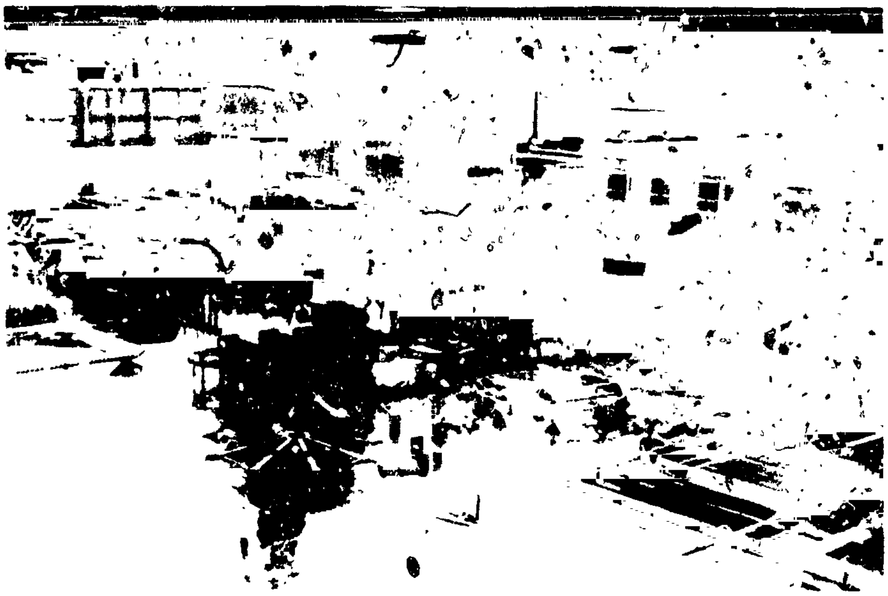


F-1 engine test at rocket engine test site, Edwards, California

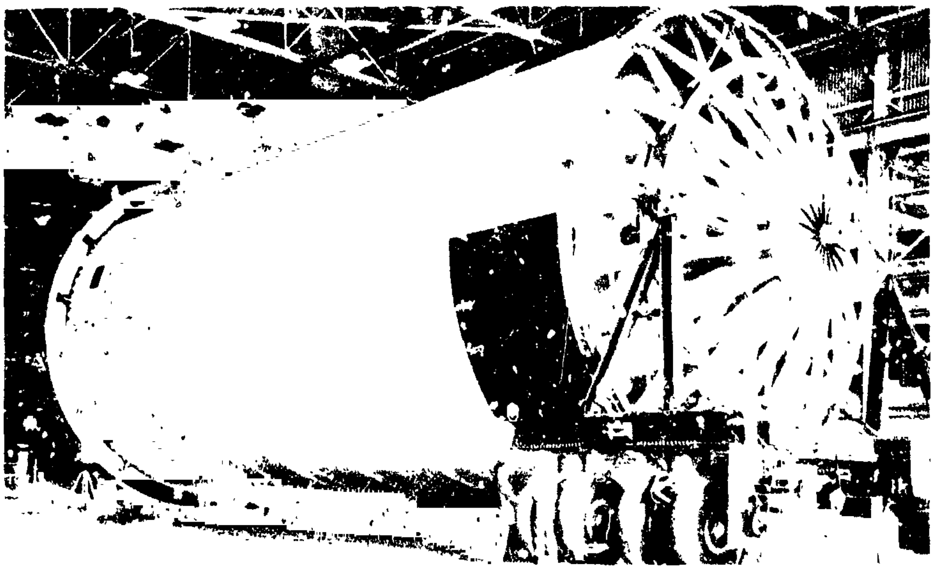
Auxiliary propulsion system for Saturn IB second stage



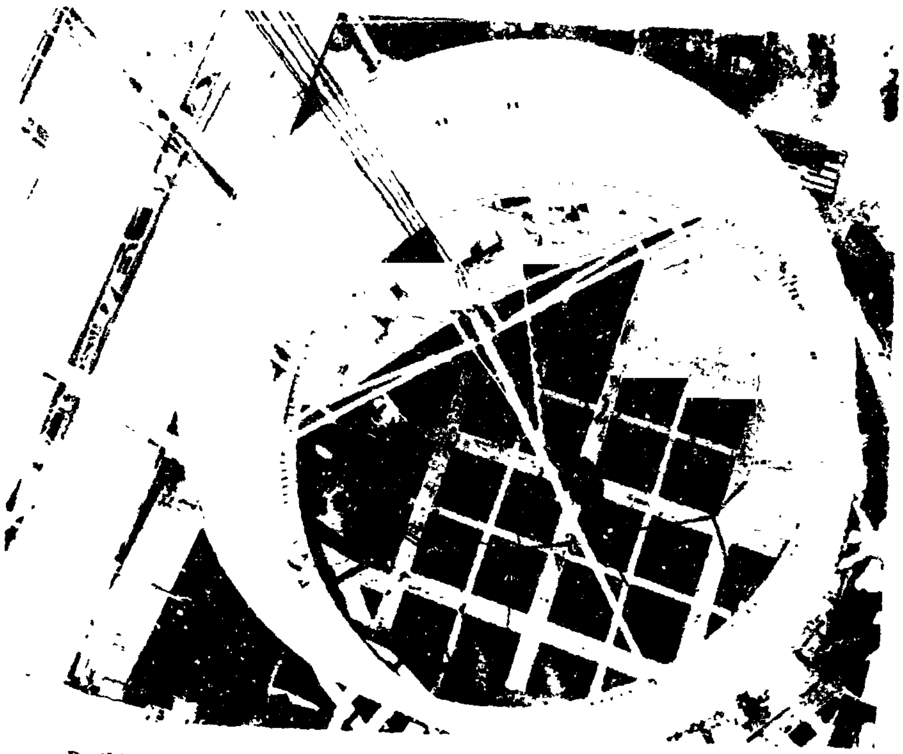
S-IC-S thrust structure on barge at Michoud



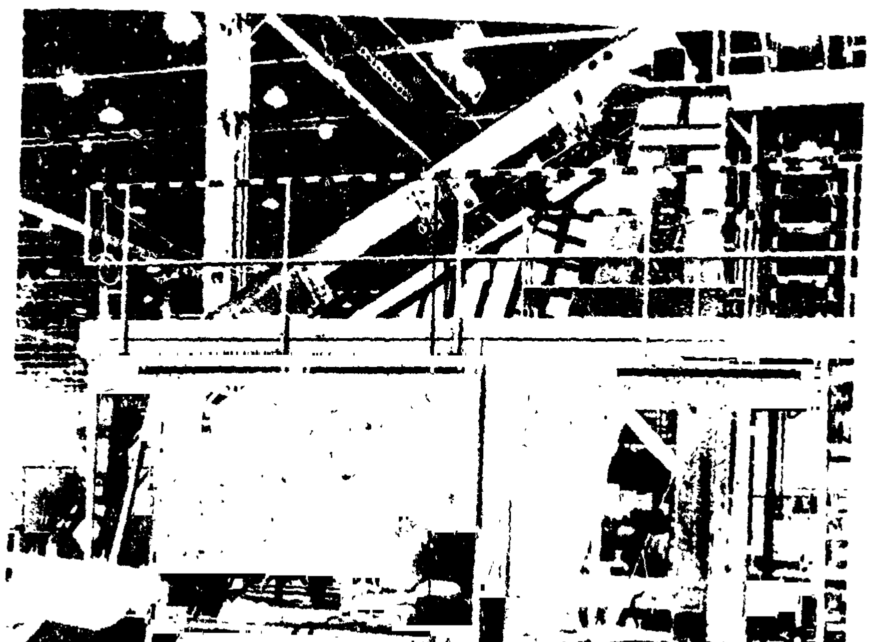
Chrysler Saturn IB fabrication and assembly area at Michoud



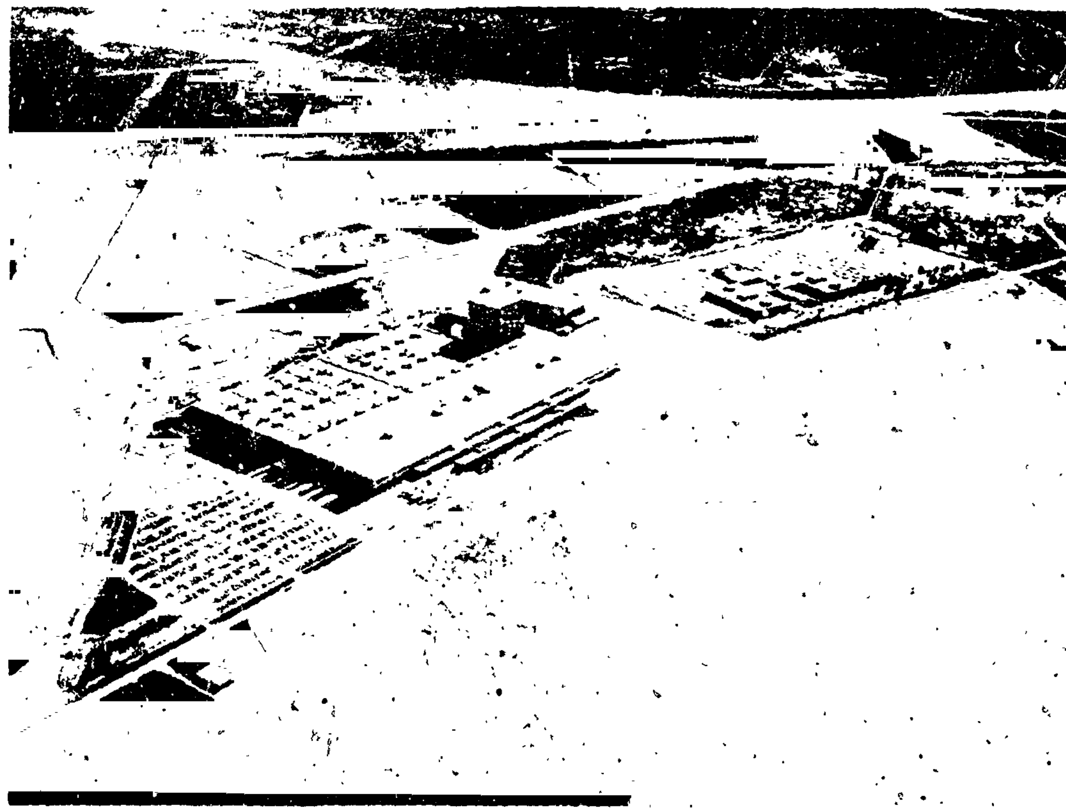
First Saturn V booster, a nonflight version for static tests



Buildup of Saturn V second stage, nonflight version for tests



Internal ribs of first Boeing-built Saturn V fin, assembled and ready for attachment of skins



This aerial view of Michoud Operations in December 1964 shows the entire facility including the barge dock and waterway (top right). In the sprawling building at left center Chrysler manufactured Saturn I/IB boosters and Boeing produced Saturn V boosters.

1965

MSFC completed negotiations with Douglas on January 28 for the remaining eight S-IVB/IB stages and a set of ground support equipment. Another Saturn IB milestone on this date occurred when KSC awarded R.E. Clarson, Inc., a $2 179 00 contract for Phase II modification of the Launch Complex 34 service structure to support Saturn IB launches [166].

MSFC on February 1 completed component assembly of the instrument unit, S-IU-200D/500D, for the Saturn IB and Saturn V dynamic tests. NASA began February with several Saturn milestones. On February 19 the space agency amended Chrysler's S-I/S-IB contract (NAS8-4016) to include prelaunch checkout support, an amendment that added about $34 642 878 to the contract cost [167]. Also in the Saturn program, effective this date, MSFC announced the following major revisions in the S-II stage program: cancellation of the dynamic test stage, S-II-D; substitution of the structural test stage, S-II-S, as a dynamic stage; transfer of all-systems test stage, S-II-T, from Santa Susana to Mississippi Test Operations; assignment of the facilities checkout stage, S-II-F, directly to KSC; and scheduling of an end to the Electro-Mechanical Mockup test program [168]

On February 5 workmen at Seal Beach completed the S-II-S stage, first ground test stage in the Saturn S-II stage program [169].

Douglas completed final assembly of the S-IVB facilities checkout stage, S-IVB-500F, on February 12 and turned the stage over to NASA at Seal Beach, California. Workmen then loaded it aboard the NASA barge *Orion* for transportation to the Sacramento Test Facilities [170].

On February 16 NASA launched from KSC the Saturn I SA-9 vehicle. It performed excellently during the flight and placed the Apollo boilerplate spacecraft, BP-16, and the first Pegasus satellite into separate orbits. The Pegasus A satellite deployed its "wings" to a span of 96 feet and exposed 2300 square feet of instrumented surface to gather meteoroid data, sort the information, and transmit it to earth receiving stations. NASA launched SA-9 instead of SA-8 on this date because SA-9's S-I stage, built in house, had progressed through manufacture and testing more rapidly than had S-I-8 [171, 172].

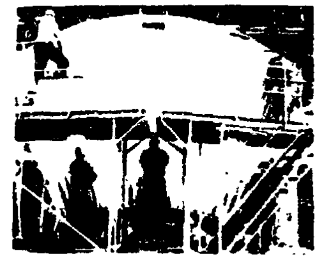
On February 28 the first industry-produced Saturn I first stage, S-I-8, arrived at KSC from Michoud [173].

During February NASA modified the H-1 engine research and development contract to include uprating the H-1 from 188 000 pounds thrust (188K) to 200K for Saturn IB application. NASA approved modifications to the Rocketdyne H-1 engine production contract converting it from cost-plus-fixed-fee (CPFF) to cost-plus-incentive-fee (CPIF) [174].

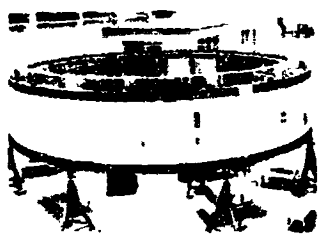
NASA on March 31 approved award of the Saturn IB/V instrument unit contract to IBM. This contract (NAS8-1400) was the first major incentive contract to be negotiated in the Saturn IB program [175].

Pegasus with solar panels fully extended

SA-9 launch at Kennedy Space Center

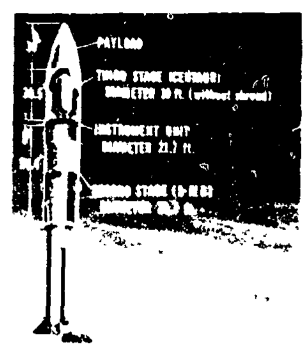


S-II-1 thrust structure fabrication at Tulsa

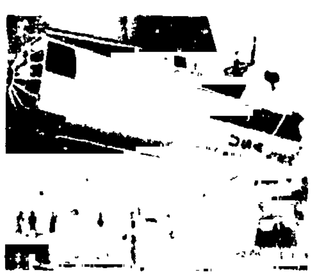


Assembly of S-IU-200D/500D for the Saturn IB and Saturn V

S-IC-T en route from ME lab to test stand



Saturn IB/Centaur Configuration



Erection of S-IC-T in test stand at MSFC

Michoud Operations

In March NASA delineated specific management roles for the Saturn IB/Centaur System to MSFC and Lewis Research Center. MSFC received project management for the Saturn IB/Centaur System and Lewis management of the Centaur System [176].

By March MSFC program analysts and developers were beginning to use the terms "spent stage" and "wet workshop" in reference to the possibility of emptying fuel from a Saturn S-IVB stage in space and then using the stage as a laboratory [177].

On April 1 in the IB program NASA authorized Rocketdyne to increase the 200K H-1 engine to 205K to support Saturn IB application to even larger missions [178].

The first single-engine S-IC-T firing occurred at MSFC on April 9. On April 16 Marshall personnel successfully test fired all five of the S-IC-T stages's F-1 engines. This first S-IC-T five-engine test occurred 2 months ahead of schedule and lasted 6.5 seconds [179].

MSFC announced on April 30 that Ashburn and Gray had received a $1,656,867 contract to build 7 miles of road for MSFC, including one road to connect Martin and Rideout roads. The roads would route traffic around the eastern boundary of MSFC [180].

On May 10 Douglas delivered the 10th and last Saturn I S-IV stage (S-IV-10) to KSC aboard the Pregnant Guppy aircraft. A week later, on May 17, MSFC submitted the procurement plan for nine additional Saturn V S-IVB stages to the NASA Office of Manned Space Flight (OMSF) for approval [181].

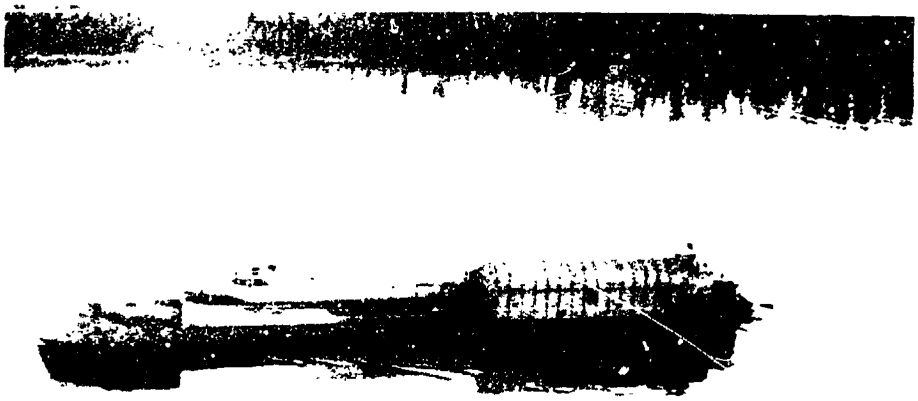
Final period of countdown for the SA-8 launch started on the afternoon of May 24 and, except for a scheduled 35-minute hold, continued uninterrupted to lift-off which occurred the next day. SA-8 the ninth successful Saturn I flight, placed in orbit Pegasus B [182].

Members of the Alabama legislature, Governor George Wallace, and some 50 newspaper editors witnessed for the first time a test firing of the Saturn V launch vehicle booster during a 1-day visit to Huntsville on June 8 [183].

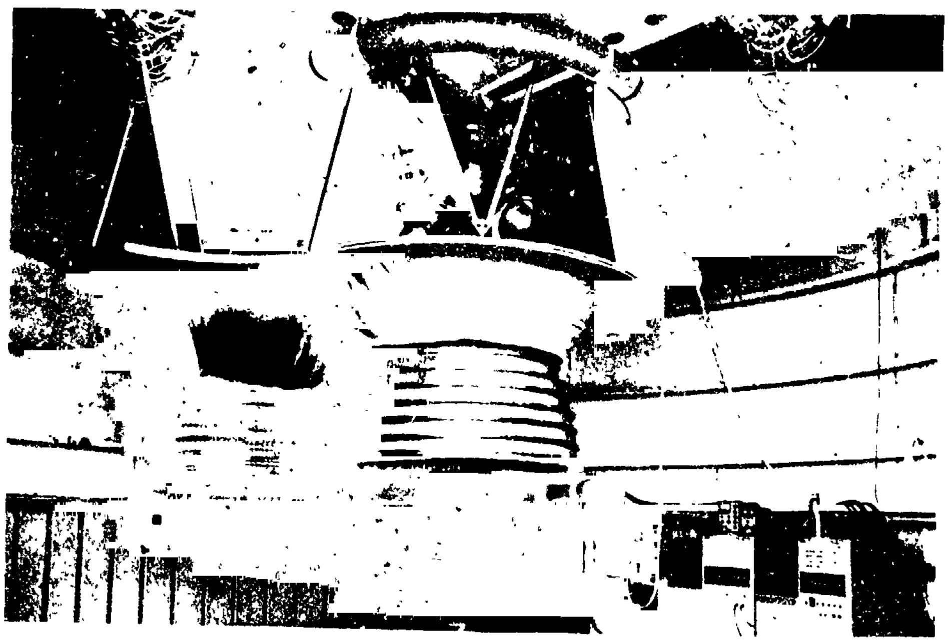
The KSC launch crew successfully performed the countdown demonstration test for SA-10 on July 27. Final phase of countdown for the SA-10 launch was under way at 9:25 p.m. EST on July 29 and continued to lift-off without any technical holds. On July 30 SA-10, in the final flight test of the Saturn I program, performed excellently. The launch vehicle inserted its dual payload of Pegasus C and BP-9 into an orbital trajectory. This SA-10 flight concluded NASA's Saturn I program [184].

In mid-July several hundred employees began moving into Building 4202, the third building to be completed in the MSFC headquarters complex. Industrial Operations employees were the first workers to make the move [185].

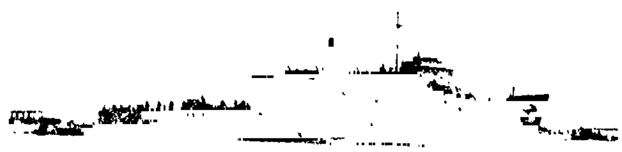
On August 2 MSFC personnel conducted the first successful ignition test of the MSFC S-IVB battleship. It lasted for 2.1 seconds. This first firing of the MSFC S-IVB battleship completed activation of the J-2/S-IVB test stand at MSFC [186, 187].



Saturn stages in route to MSFC by barge



J-2 engine gimballing test



Point Barrow, carrier for S-IVB-500F stage

The first full-duration run of S-IC-T occurred at MSFC on August 5. The firing lasted 143.6 seconds [188, 189].

On August 6 Dr. George E. Mueller, Associate Administrator for Manned Space Flight, NASA Headquarters, announced the establishment at Headquarters of an Apollo Applications Program Office. Effective with this announcement, the Apollo Applications Program came into being, replacing the old Apollo Extension Systems program [190].

In an August 13 memorandum to MSFC employees, Dr. von Braun stated: "With the completion of the Saturn I program, with the Saturn IB program well into production, and with the Saturn V in final design and into the testing stage, we are entering an advanced phase of the space program. While Saturn IB and Saturn V still remain as our primary and most important job, we must turn attention to the future role of Marshall in the nation's space program, such as the Saturn IB/Centaur, Apollo Extension Systems, and Supporting Research. As a consequence, some skills and capabilities that have been invaluable in earlier projects will have less value in the future role of the Marshall Center. As I announced last week, the Manned Spacecraft Center at Houston is entering a build-up for the operational phase of the Apollo program, and, as a result, 200 MSFC positions are being transferred to the Manned Spacecraft Center. This provides an opportunity for MSFC employees to join an organization which will undoubtedly have a critical need for skills that are less critical to the future activities at MSFC" [191].

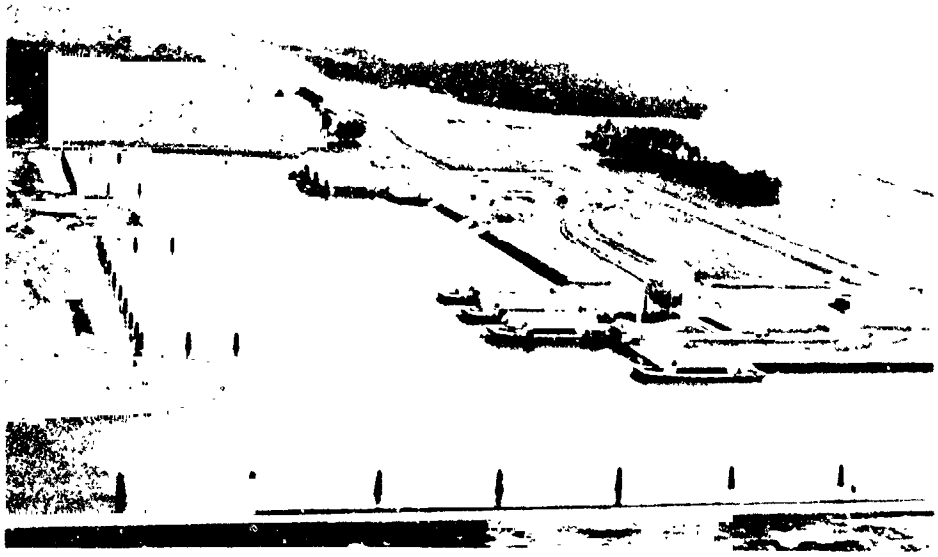
Hurricane Betsy entered the Michoud area about 8 p.m. on September 9 and left severe roof and building damage at Michoud. It also washed the NASA barge *Promise* upon the levee, inflicting damage to the barge in the amount of $89 138. The NASA barge *Palaemon*, with the S-IB-3 stage as cargo, weathered Hurricane Betsy near Baton Rouge, Louisiana, without damage during the first day of its journey from Michoud to MSFC in Huntsville [192].

The upper stage testing in the Saturn IB dynamic test program ended at MSFC on September 11 [193, 194].

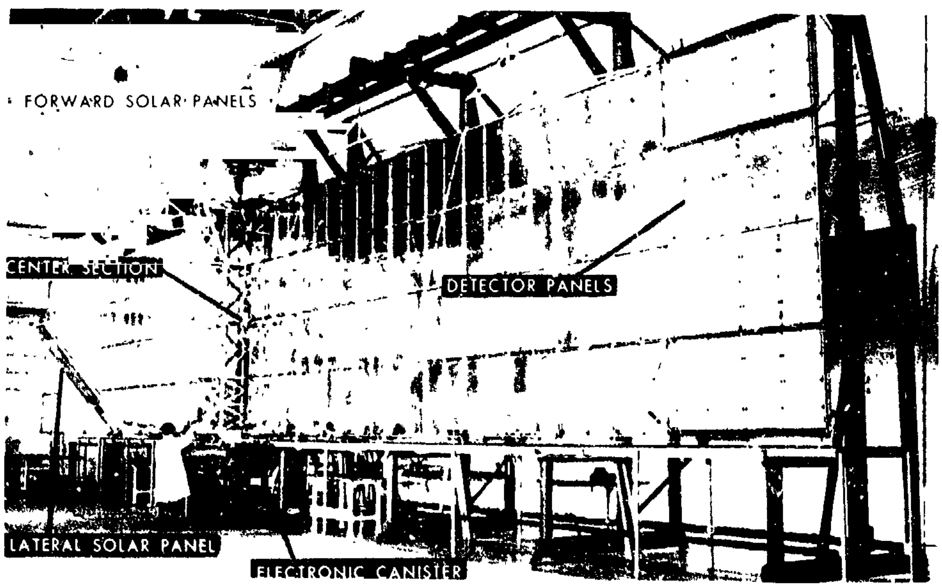
On September 29 the S-II-S/D ruptured and disintegrated during a structural loading test at Seal Beach. The failure occurred at 144 percent of limit load on the aft skirt. This failure necessitated redirection of the S-II program by substitution of the S-II-T as a dynamic test vehicle following static testing at MTF. Meanwhile, workmen at Seal Beach completed manufacture of the S-II-T stage on September 30 [195].

The S-II-T, first "live" launch vehicle stage at MTF, arrived October 17 for start of stage all-systems testing. S&ID personnel at MTF placed S-II-T into Test Stand A-2 on October 19 [196, 197].

On October 28 Rocketdyne delivered to Chrysler at Michoud the first two H-1 engines uprated from 200K to 205K. Eight of the uprated engines would add about 40 000 pounds thrust to the S-IB stage and increase the total thrust of the stage to 1 640 000 pounds [198].



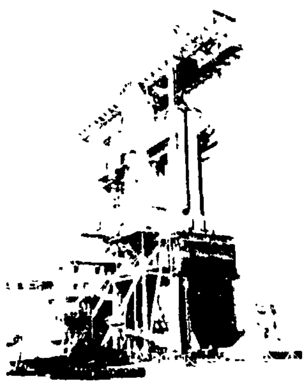
Cryogenics dock at MTO after completion



Meteoroid measurement capsule

Thirty-six MSFC employees walked across a platform in front of Building 4200 on November 5 and received a variety of awards including a presidential citation and six invention awards. It was part of a local ceremony to observe the seventh anniversary of NASA. Highlight of the event was an address by Dr. von Braun. Visitors included Huntsville Mayor Glenn H. Hearn and Chairman of the Board of Madison County Commissioners, James R. Record [199].

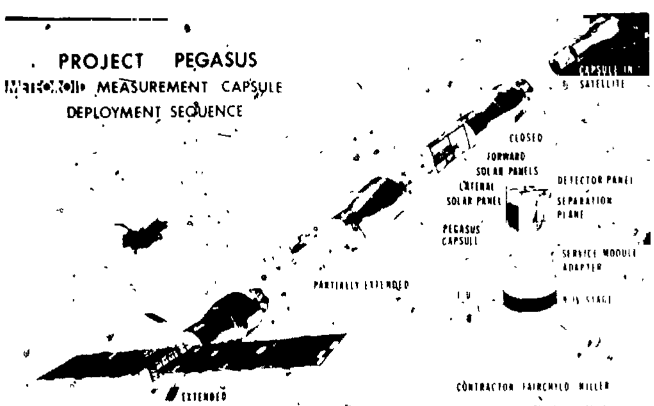
In November NASA announced that the J-2 engine contract would be amended to add 48 engines. NASA, in addition, asked Rocketdyne to provide 52 additional J-2 engines for delivery in 1967 and 1968 [200,201].



Saturn IB booster being moved into static test stand

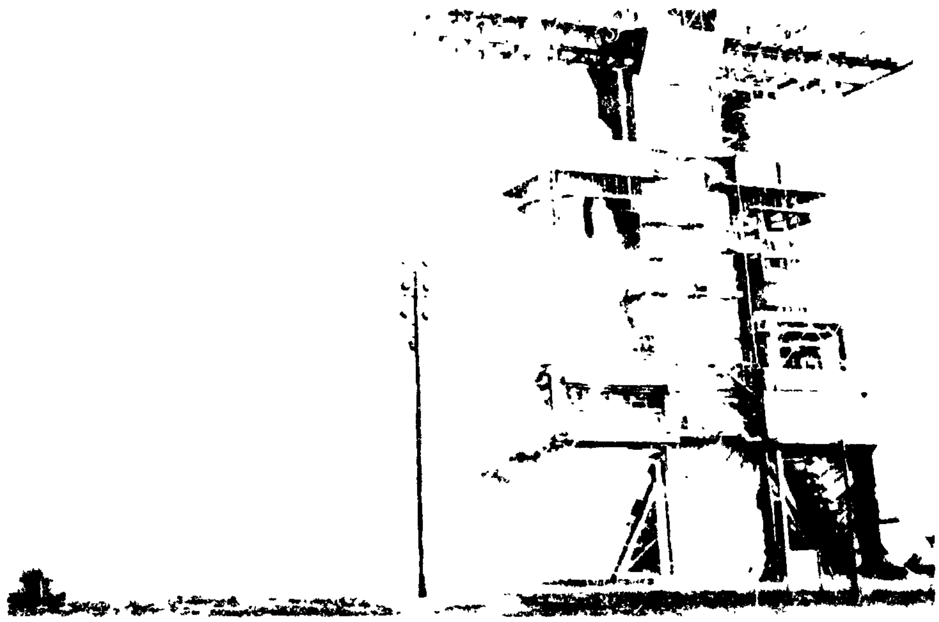
Positioning S-IV on S-I at KSC

S-IVB-201 en route to Courtland, California, aboard the Orion

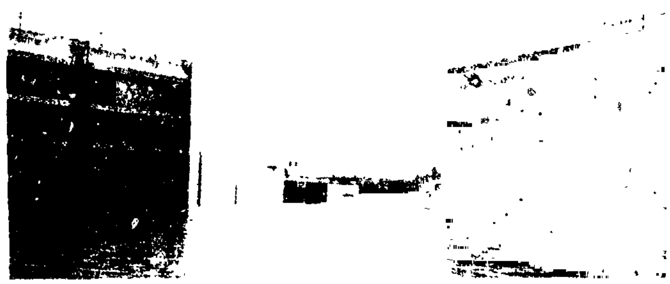


Deployment sequence of the Pegasus

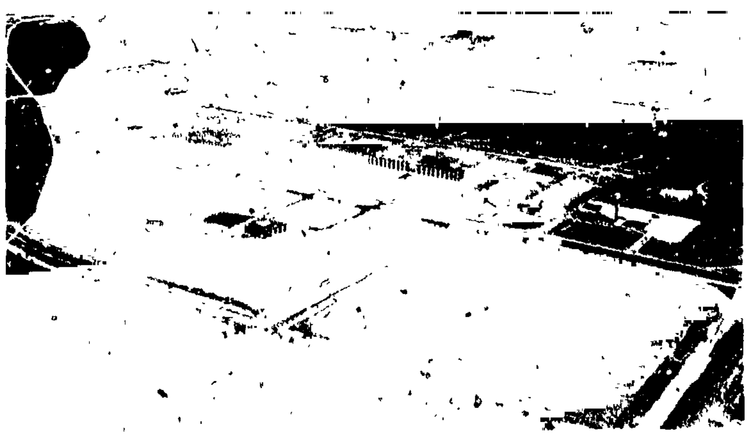
Launch of SA-1 from pad 37B at KSC



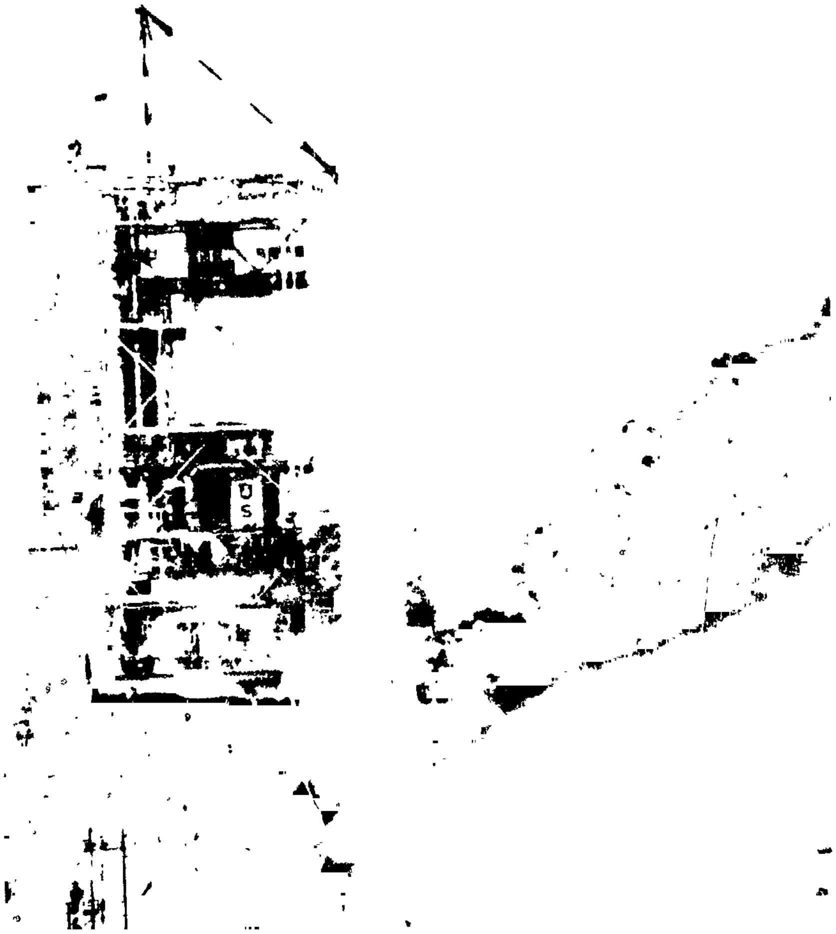
Static firing of S-IB-1 at MSFC

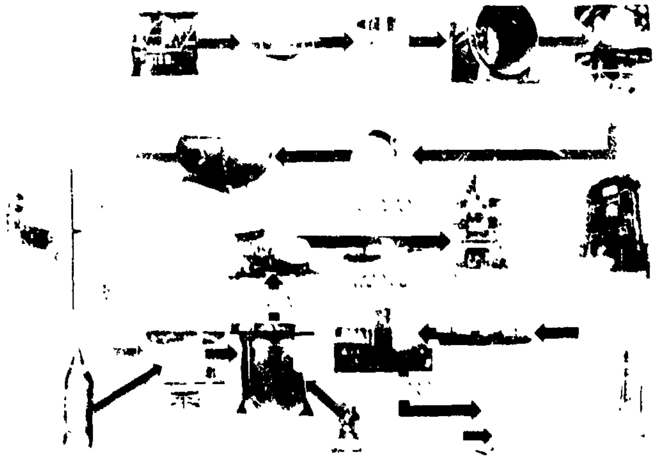


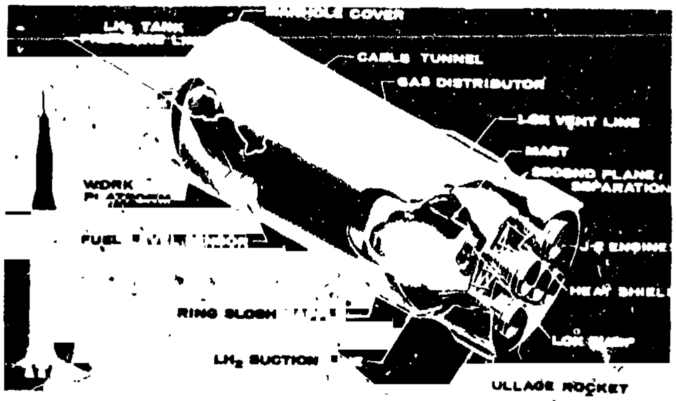
The big doors of the Mississippi Test Facility lock system open in May 1965 signifying completion of the MTF canal system.



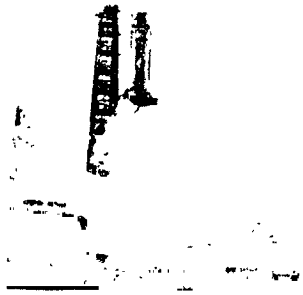
This aerial photograph made in July 1965 shows administrative buildings at Mississippi Test Facility.


Static test of all five engines of Saturn V booster (S-IC stage)

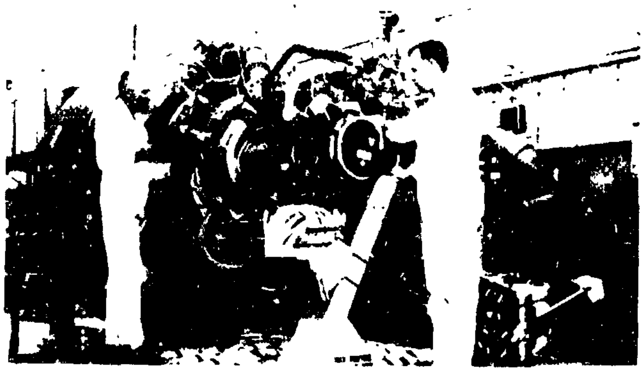

S-IVB production sequence



S-II stage

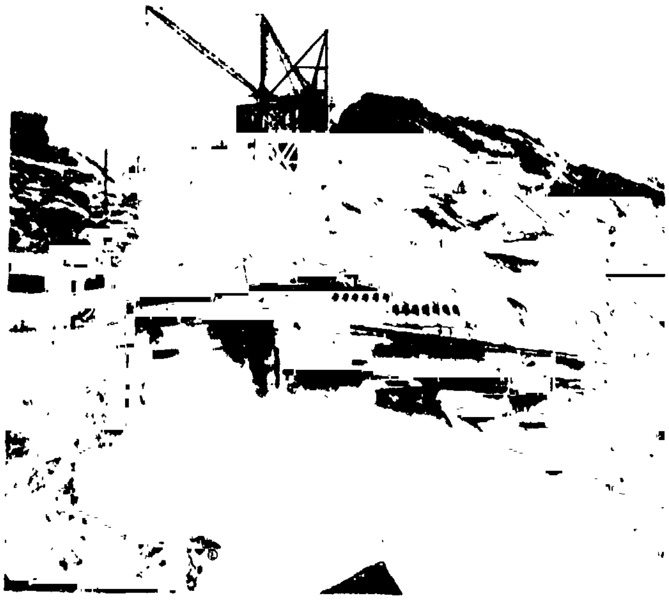


Launch of SA-10 from pad 37B, KSC

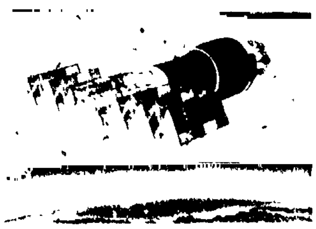


Rocketdyne technicians checkout out a J-2 engine

Launch Complex 34 gantry at KSC



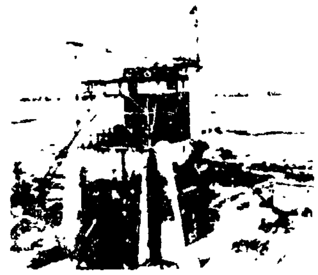
S-II battleship cluster firing at Santa Susanna



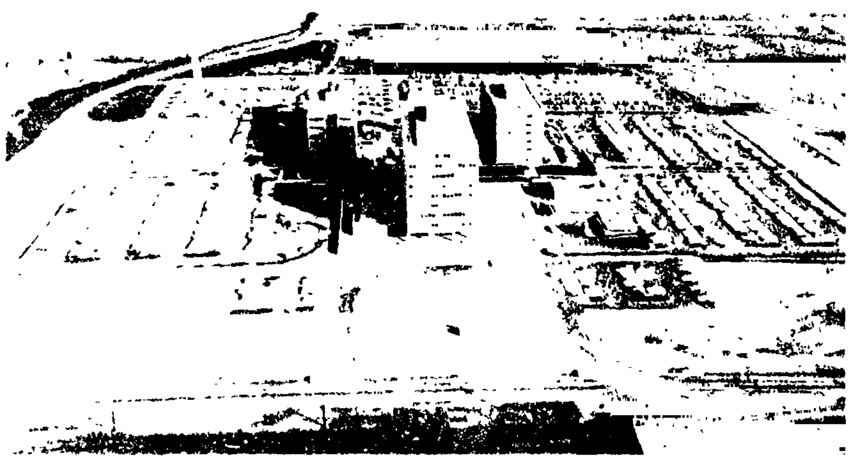
Pegasus with partial deployment of meteoroid detection panels

Saturn SA-10, during countdown demonstration test

S-IC static firing

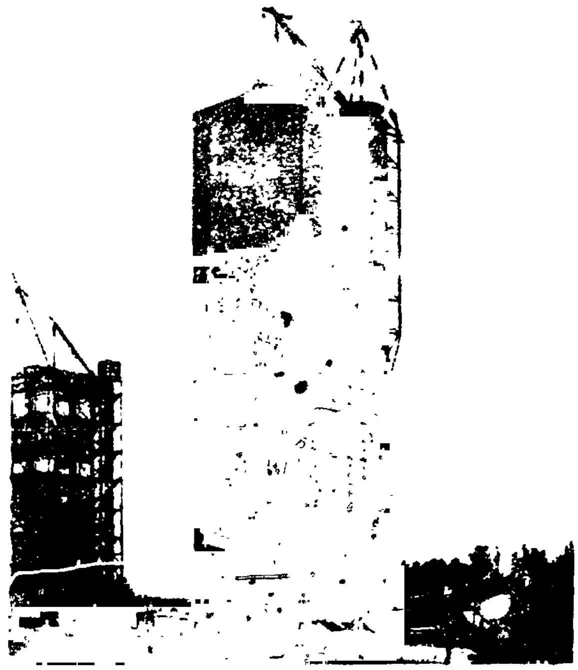


S-II A-2 test stand, Mississippi Test Facility

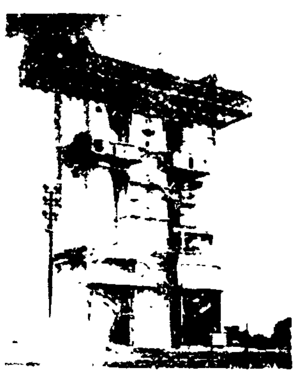


This aerial view shows the completed MSFC headquarters complex on Rideout Road. The nine-story structure in foreground is the Central Laboratory and Office Building, 4200. The Engineering and Administrative Building, 4201, is right and the Project Engineers Building, 4202, is left.

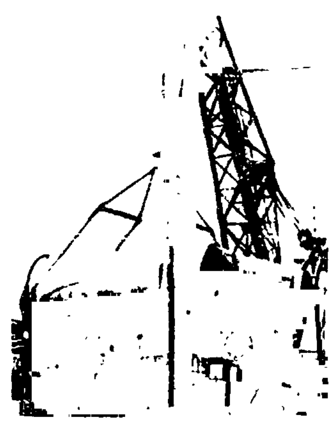
Computer room during S-IVB-201 firing at Sacramento



The tallest structure at MSFC, the Saturn V Dynamic Test Facility, is shown late in 1965 as it awaits interior erection of the Saturn V dynamic test vehicle. The facility is over 400 feet high.

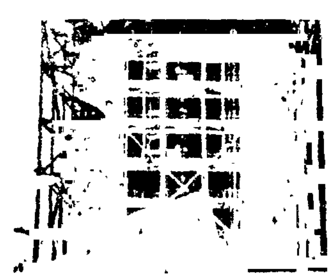


S-IB static test in Huntsville

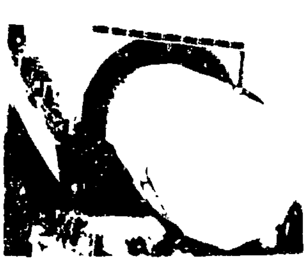


S-IVB-201 being hoisted on the Steel Executive

S-II-T arriving at S-II-A2 stand at MTF

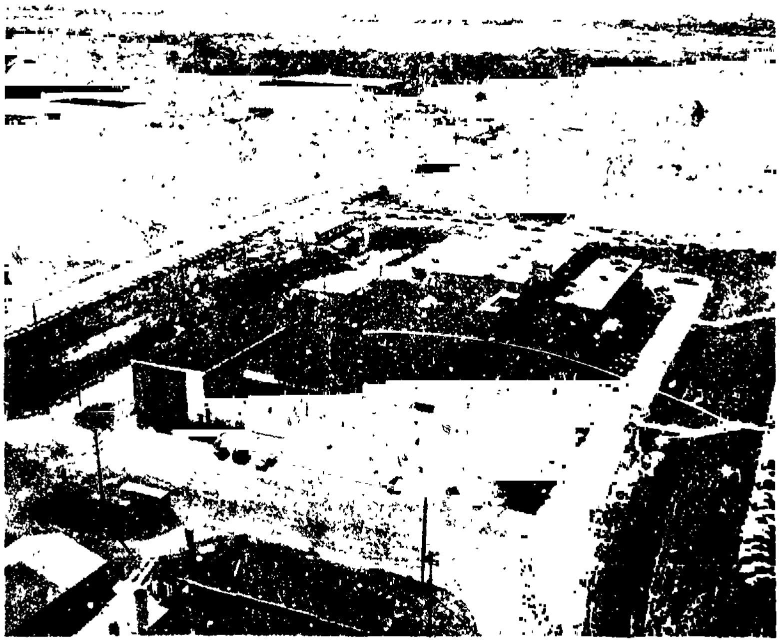


S-II-S/D ruptured during structural loading test

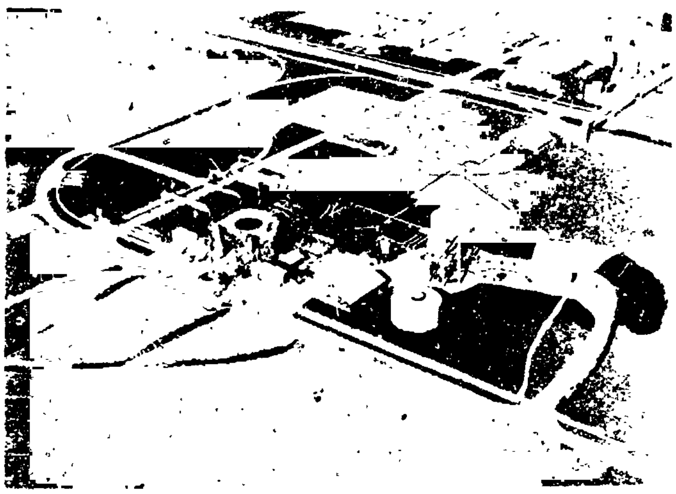


Loading S-II-T on AKD Point Barrow

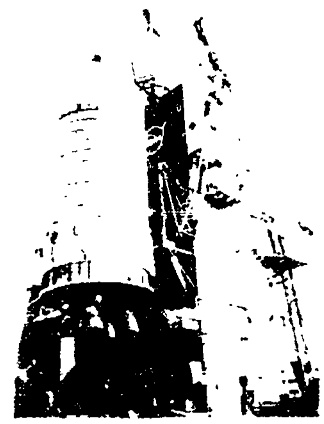
Technicians checking Rocketdyne-built J-2 engines on S-II stage



The structure in foreground is Building 4708 at MSFC where Saturn boosters were checked out following assembly. At upper left is another Quality Lab building, used for receipt and inspection of components and subassemblies from contractors. At upper right is a Manufacturing Engineering Laboratory building.



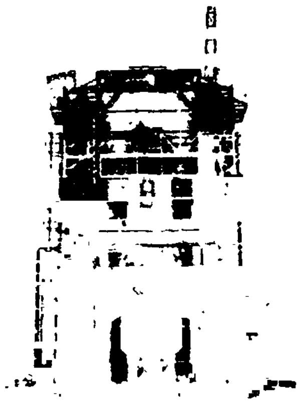
Altitude simulation test facility at Tullahoma, Tennessee



Installation of S-II-T in MTF test stand A-3

Aftermath of Hurricane Betsy at Michoud

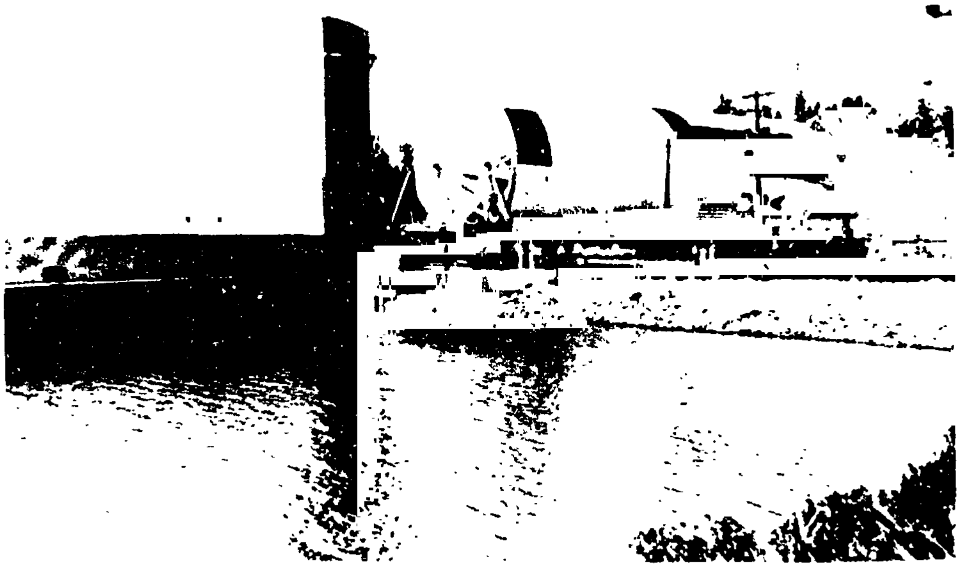
Building 420 at MAF, the Stage Test Position Facility, is shown after Hurricane Betsy in September 1965.



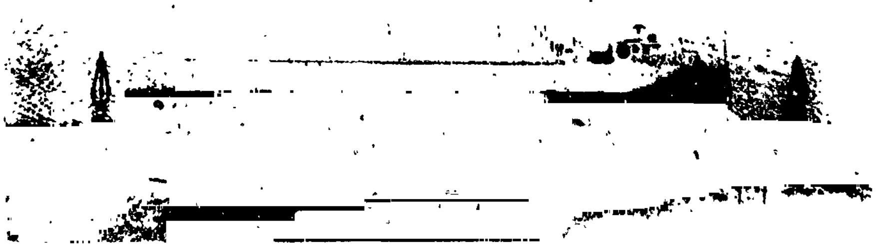
S-IVB-202 installed in
Test Stand Beta 3 at
Sacramento Test Facility

H-1 engine

S-II common bulkhead
test tank (CBTT)



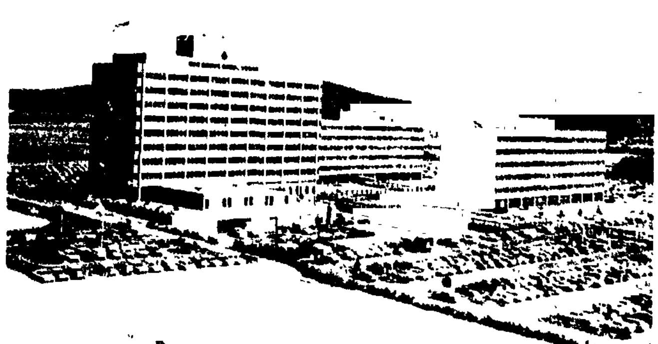
S-IC-D being unloaded from barge Poseidon



NASA barge Promise upon levee after Hurricane Betsy

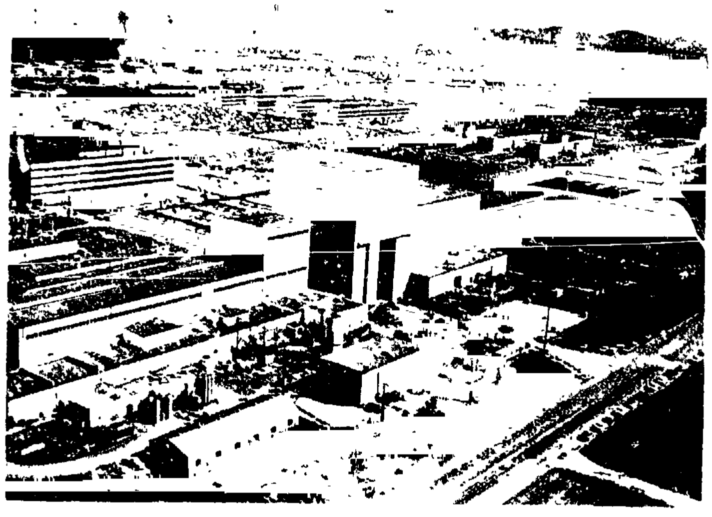
Damage at Michoud by Hurricane Betsy

Hurricane Betsy leaves Promise on levee

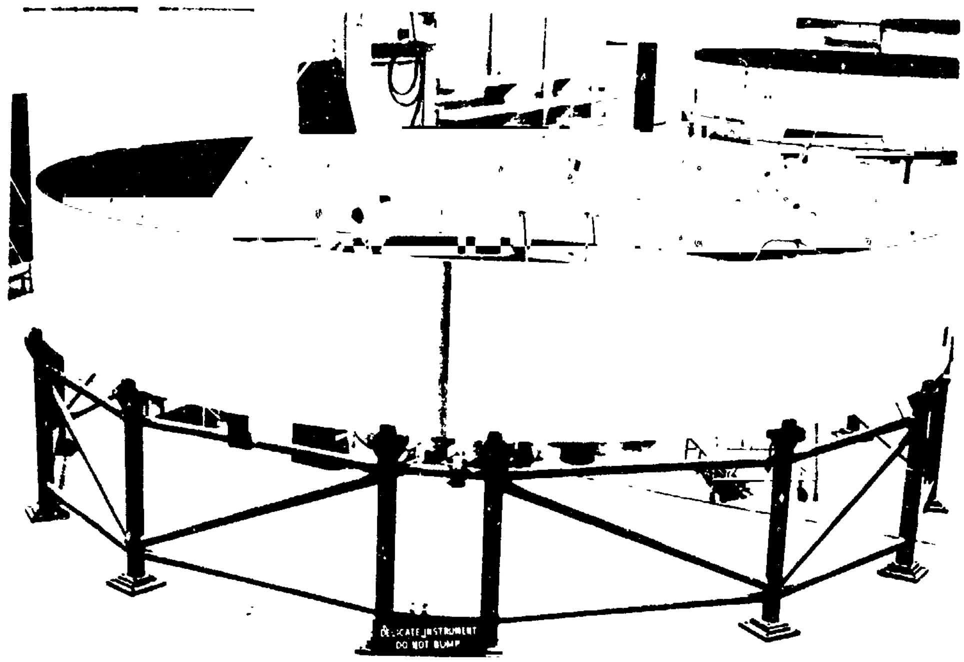


The MSFC headquarters complex is seen in this low aerial view in the Fall of 1965.

This aerial photograph made in October 1965 shows a wide view of the West Test Area at MSFC. Principal structures include the S-IC Test Stand, F-1 Engine Test Stand, Dynamic Test Stand, Blockhouse, and High-Pressure Water Facility.

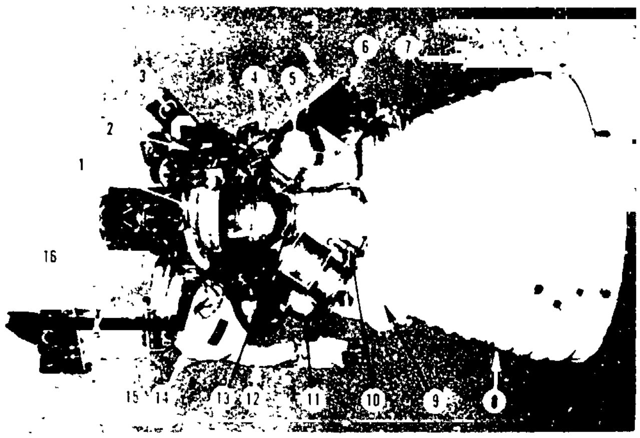


Portions of the Propulsion and Vehicle Engineering (P&VE) Laboratory area at MSFC are pictured here in October 1965. At left rear is the principal office building, Building 4610. The Load Test Annex is shown in foreground.

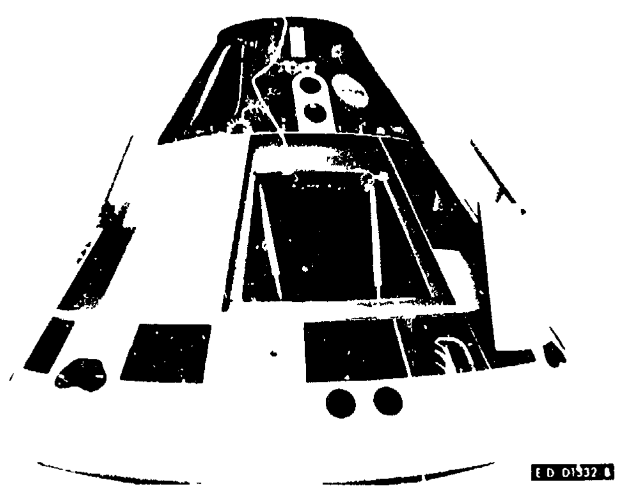


S-IU-200/500S on fabrication stand No. 1

S-IC-T static test firing



Major components of J-2 engine



Apollo spacecraft

1966

On January 4 MSFC announced the awarding of seven new Saturn contracts, five of them to Saturn prime stage contractors, for continuation of studies aimed at improving S-IB and Saturn V launch vehicles. North American, Boeing, and Chrysler each received one of the contracts; Douglas received two. The remaining two of the seven contracts were for continuation of engineering studies relating to a manned reusable transport system: (1) a 9-month $237 000 contract to Lockheed Aircraft Corporation to study possibilities of developing a reusable transport system based on presently approved launch and space vehicles and (2) a 6-month $51 000 contract to Martin-Marietta Corporation for comparison study of launch modes for reusable launch vehicles. Both contracts would be under MSFC's direction [202].

NASA announced on January 7 the award of a $7 837 500 contract to the Radio Corporation of America, Aerospace Systems Division, Van Nuys, California, effective December 1, 1965, for logistic support of Saturn ground computer checkout systems. Under the 2-year contract, managed by MSFC, RCA would provide spare parts, logistic management, maintenance support, and report services for the Saturn ground computer checkout systems. On this same date MSFC announced that the Air Force's Arnold Engineering Development Center (AEDC) near Tullahoma, Tennessee, was being expanded for test of a third stage (S-IVB battleship) of NASA's Saturn V launch vehicle [203, 204].

Removal of the S-IC-T from the static test tower on January 20 at MSFC concluded the S-IC-T planned test program at Huntsville. MSFC moved the booster to the Manufacturing Engineering building for storage and later conversion to the functional configuration of S-IC-4 [205].

After postponement on three consecutive days because of continuous bad weather, NASA on February 26 launched Saturn vehicle SA-201 from KSC Launch Complex 34. The vehicle performed throughout the powered and coast phases of flight. No major system malfunctions occurred in this unmanned suborbital Apollo flight. In lifting the spacecraft, SA-201's first stage had generated 1.6 million pounds of thrust. After burning 2 minutes and 26 seconds, propelling the Apollo to 37 miles altitude, the booster's eight H-1 engines, fueled with kerosene and lox, shut down and the stage separated from the S-IVB. Four seconds later, a 200 000-pound thrust S-IVB (second) stage engine, burning liquid hydrogen and liquid oxygen, ignited [206].

NASA signed with the Boeing Company a March 4 supplemental agreement converting the Saturn V first stage (S-IC) contract from a fixed fee to an incentive fee contract. It was the first Saturn stage contract to be converted to an incentive type. At the time of this conversion the Boeing contract was valued at $850 114 303 [207].

The Apollo Extension Systems had been proposed as a program to utilize Apollo Saturn capabilities and hardware to fly future missions and, thereby, to minimize the initial development cost of new systems. Subsequently, the name of the project was changed to Apollo Applications. NASA's first "officially released" schedule in the Apollo Applications Program (AAP) was Schedule ML-4, released by NASA on March 23, 1966.

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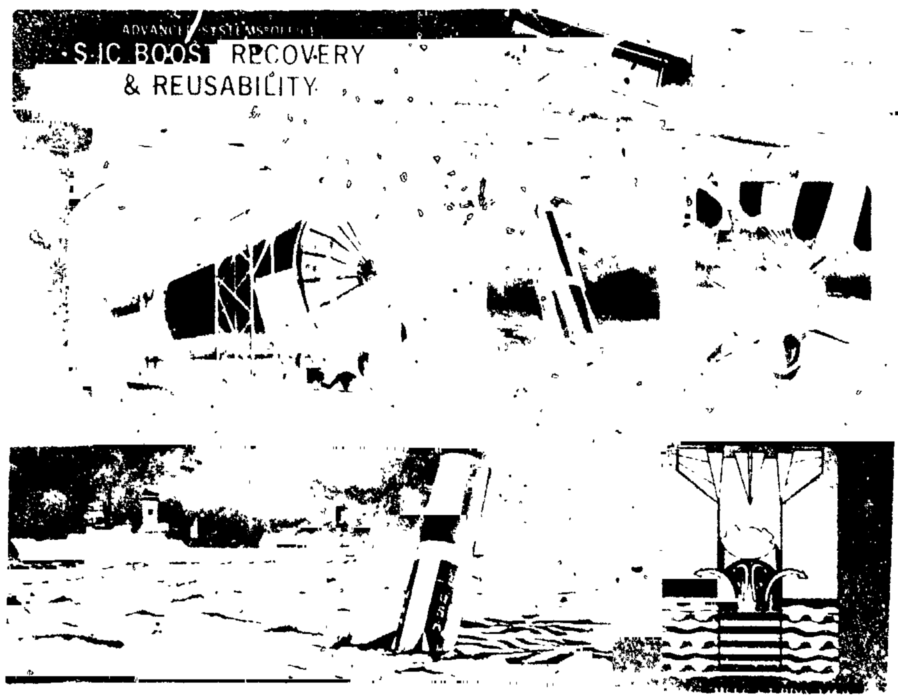
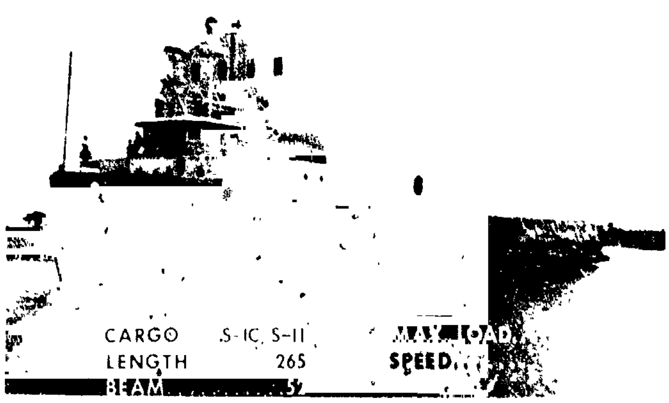


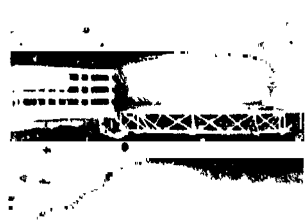
Studies on reusable transport system



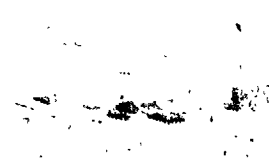
Barge Poseidon used to move Saturn stages

S-IC-1 (right) and S-IC-2 (left) in transit at MSFC

MSFC dock activity



S-IU-202 moving to KSC



S-IVB facilities at Sacramento Test Facility

This schedule called for 26 Saturn IB launches and 19 Saturn V launches. Involved in the launches would be four Apollo Telescope Mounts (ATM's). This schedule also included five lunar missions and two synchronous orbit missions [208].

NASA announced on March 24 that it would negotiate incentive contracts with two major aerospace firms for the procurement of five additional Saturn V first stages (S-IC) and 33 F-1 rocket engines. NASA would negotiate with the Boeing Company for the stages and with Rocketdyne for the F-1 engines for these stages. The five S-IC stages would cost in excess of $165 million. These contracts were in line with NASA's plan to launch 15 Apollo/Saturn V space vehicles by the end of 1970 [209].

On April 1 NASA transferred project management of its first hydrogen-fueled engine, the RL10, to Lewis Research Center at Cleveland, Ohio. A cluster of six RL10 engines had powered the Saturn I's S-IV second stage before the conclusion of MSFC's Saturn I program the previous year [210].

In an April 4 release NASA announced a change in sequence of the S-IB-202 and the S-IB-203 launches. Uprated S-IB-202 was rescheduled to follow the AS-203 mission. The purpose of the sequence change was to provide additional time for checkout of Apollo spacecraft to be flown in the AS-202 mission. AS-203 was a launch vehicle development mission and would not carry an Apollo spacecraft [211].

Nine Astronauts visited MSFC for briefings on the Saturn IB launch vehicle, April 19-21, 1966. Visiting were Virgil I. Grissom, James A. McDivitt, David R. Scott, Russell Schweickart, Edward H. White II, Frank Borman, Walter M. Schirra, Jr., Roger Chaffee, and Walter Cunningham [212].

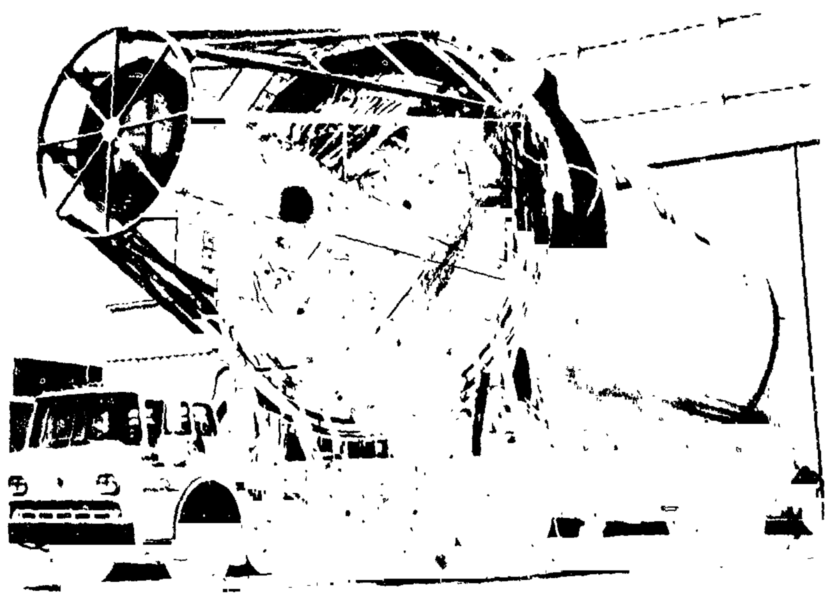
MSFC announced on April 21 that NASA had awarded $50 000, 60-day fixed-price contracts to Douglas Aircraft Company, McDonnell Aircraft Corporation, and Grumman Aircraft Engineering Corporation to perform definition and preliminary design studies and to evaluate a plan to make spent Saturn V S-IVB stage hydrogen tanks habitable for manned space missions up to 30 days in duration. MSFC would manage the contracts [213].

On May 6 the first uprated J-2 rocket engine arrived at MSFC from Rocketdyne. In uprating the J-2, Rocketdyne had increased the thrust to a new capability of 230 000 pounds. NASA schedules called for use of the higher thrust J-2 in the second stage of the S-IB beginning with vehicle AS-208 and in the second and third stages of the Saturn V beginning with vehicle AS-504 [214].

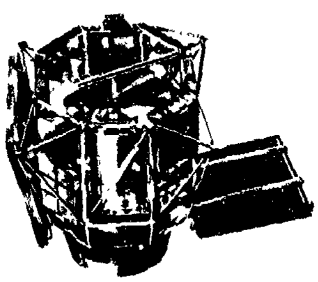
On May 19 MSFC announced the following nomenclature changes:

> Lunar Excursion Module to be called Lunar Module; the Saturn IB to become 'the Uprated Saturn I.' At first the changes will be noted as 'the Uprated Saturn, the Saturn IB' gradually dropping reference to the Saturn IB as the new name becomes more familiar. This would enable us to continue the string of Saturn I successes. Realistically the Uprated Saturn I is what we have anyway;

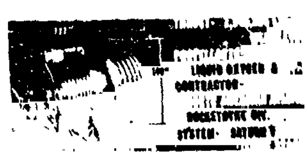
S-IC-T removed from test stand at MSFC



Moving of S-IVB-501 after post-manufacturing checkout



Apollo Telescope Mount



F-1 engine

S-IVB stage hydrogen tanks

in general public releases we should begin referring to Saturn stages simply as the first, second, or third stages, and, where helpful, to semi-technical press and in press kits follow the technical nomenclature, i.e., 'the third stage of the Saturn V (S-IVB),' etc; future releases and announcement should make use of the new nomenclature [215].

The first full-duration firing of the S-II flight stage occurred May 20 at MTF when S-II-T test-fired for 354.5 seconds. Lox cutoff sensors initiated cutoff automatically. The firing passed all major test objectives with the exception of the propellant utilization system. This was the fourth static firing of the S-II-T. The stage developed 1 million pounds of thrust from its five hydrogen-oxygen-powered J-2 engines [216].

"Rollout" of the SA-500F occurred at KSC May 25. The 500 000-pound facility test vehicle, 363 feet long, moved from the Vehicle Assembly Building (VAB) on its 3000-ton diesel-powered, steel-link crawler transporter to Pad A to verify launch facilities, train launch crews, and develop test checkout procedures [217].

Twenty astronauts toured MSFC laboratories and test facilities and received briefings on Saturn IB and Saturn V launch vehicles on May 25-27. Among those attending was Joseph P. Kerwin, a medical doctor slated to fly in the Skylab program as a scientist-astronaut [218].

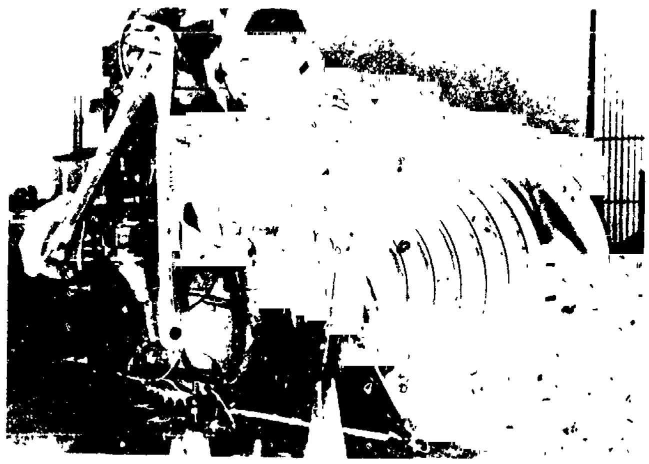
On May 27 NASA announced selection of two aerospace companies for negotiation of parallel 1-year study contracts covering integration of experiments and experiments support equipment for manned Apollo Applications. Each contract was estimated at 1 million dollars. The two firms selected were the Lockheed Missiles and Space Company and the Martin Company [219].

Because Hurricane Alma approached Kennedy Space Center on June 8, it was necessary to interrupt the processing and test activities of SA-500F and move the vehicle back to the VAB. The hurricane threat passed, and 2 days later the vehicle was again back on Pad A [220].

On June 27 the establishment of the Saturn/Apollo Applications Program Office at MSFC under the direction of Leland F. Belew was officially approved by the NASA Administrator [221].

On July 5 the 12th Saturn vehicle, AS-203, flew from KSC Launch Complex 37B. AS-203 preceded AS-202 into space to allow more time for preparation and checkout of AS-202. After 1 hour 53 minutes and 17 seconds of countdown holds, AS-203 lifted off the pad to begin the second unmanned flight of the uprated Saturn I. The vehicle's second stage (S-IVB), instrument unit, and nosecone, weighing 58 500 pounds, comprised the heaviest U. S. satellite ever placed in orbit. Primary mission of this July 5 flight was an engineering study of liquid hydrogen fuel behavior during orbit [222, 223].

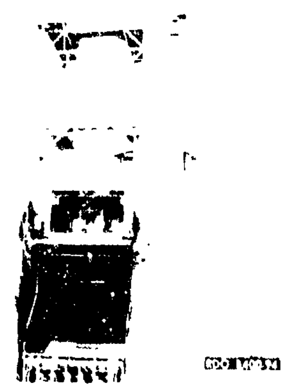
NASA Deputy Administrator Robert C. Seamans, Jr., in a July 26 memorandum stated: "It is a fundamental policy of NASA that projects and programs are best planned and executed when these responsibilities are clearly assigned to a single management group.



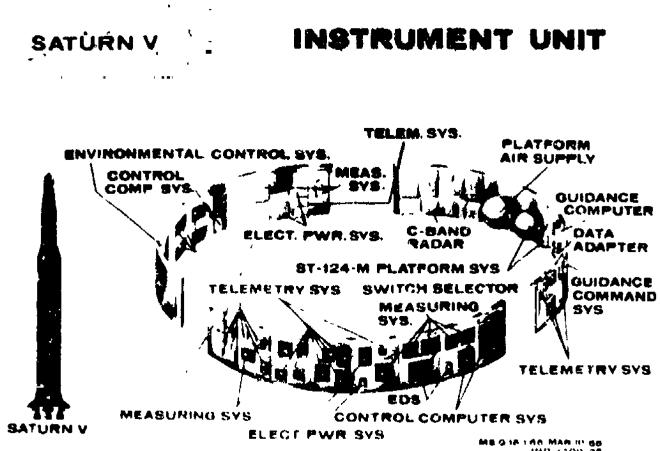
H-1 engine

AS-201 awaits launching, KSC

Transfer of S-II-F and interstage from dock to VAB, KSC



S-IC development test stand, Huntsville



Instrument unit configuration

am therefore assigning to the Office of Manned Space Flight the full responsibility for the conduct of Apollo and Apollo Applications missions" [224].

NASA Headquarters unconditionally approved J-2 engine program contract NAS8-19 on July 29. This contract established the provision for production support effort through December 1968 and for delivery of the 155 J-2 engines required for the Apollo program. The contract combined what had been two major J-2 contracts [225].

A meeting of the NASA Manned Space Flight Management Council held at Lake Logan, North Carolina, August 13-15 is considered a pioneering milestone in the Skylab Program. At this meeting NASA delineated "Post Apollo Manned Spacecraft Center and Marshall Space Flight Center Roles and Missions in Manned Space Flight." Relative to MSFC and MSC roles, NASA officials discussed the broad parameters of a "Space Station Concept." Also outlined were the MSFC/MSC roles relative to the Orbital Workshop and the Apollo Telescope Mount. As part of the agreement reached at the Lake Logan meeting, the roles and missions concept was applied to the Apollo Applications Program – specifically, to the Orbital Workshop and the Apollo Telescope Mount. By previous agreement MSFC was responsible for experiment integration on both of these projects. For the Orbital Workshop itself it was agreed that the combination of the Apollo Command and Service Modules and the Airlock Module were MSC's responsibility. The Orbital S-IVB stage was MSFC's responsibility. Experiment Modules would be either Center's responsibility, depending upon whether they were installed in the S-IVB or attached to the Airlock Module [226].

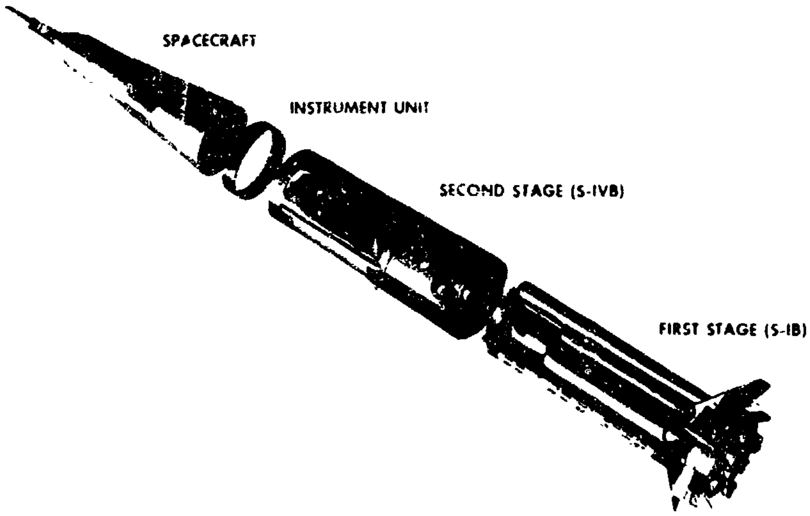
A lox line leading to the Saturn V launch pad at KSC ruptured on August 19, spilling more than 800 000 gallons of lox. The incident occurred during the first-stage tanking test when vacuum created inside the tank caused a depression in the tank's 2.5-inch-thick dome [227].

On August 19 NASA selected the McDonnell Aircraft Corporation for negotiations on a fixed-price contract to produce an airlock for an experiment in which astronauts would enter the empty hydrogen tank of a spent Uprated Saturn I second stage. Estimated cost of the work was 9 million dollars [228].

Apollo/Saturn vehicle AS-202, the third vehicle to fly in the Uprated Saturn I series, rose from Launch Complex 34 at Cape Kennedy on August 25. AS-202 was the 13th Saturn vehicle in a row to fly successfully through space. This was the second successful flight test of the Apollo spacecraft command and service modules before earth orbital manned missions. The flight proved the Apollo command module ablative heat shield by subjecting it to extended high heat loads during flight [229].

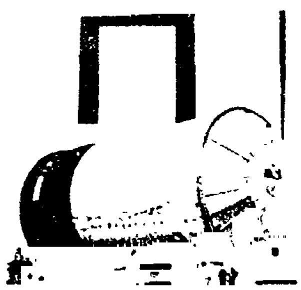
NASA announced on August 28 that the August 19 rupture of the 900 000 gallon stainless steel storage tank for the Saturn V booster's lox would delay the booster's first flight, scheduled for the first quarter of 1967, by at least 45 days [230].

MSFC announced on September 7 that four barges carrying 400 000 gallons of vitally needed liquid oxygen were enroute to KSC after being dispatched from MTF. The shipment, together with 40 000 gallons brought into KSC by truck and rail tank cars,

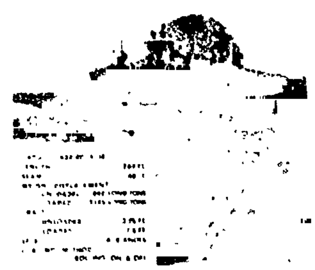


Uprated Saturn I launch vehicle configuration

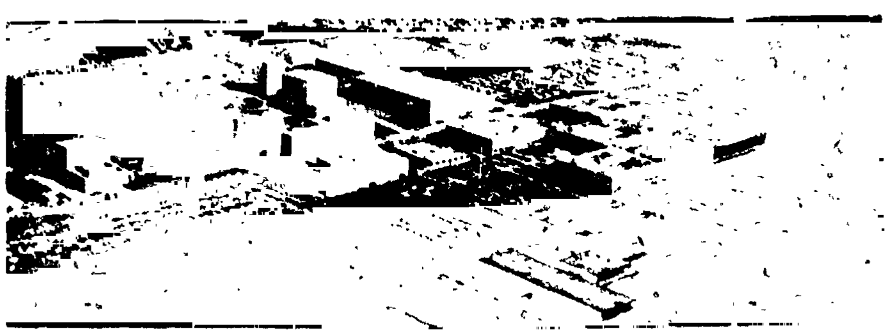
AS-201 launch, KSC



S-II-F stage arrival, KSC



Barge Promise



S-IVB facilities at Huntington Beach

would replenish the liquid oxygen lost on August 19 when a line ruptured below the lox storage tank serving Saturn V'S Launch Complex 39. Schedules called for propellant loading tests to resume September 20 [231].

MAF was host to approximately 18 000 visitors at its annual NASA-contractor open-house event on November 12 [232].

Technicians at MSFC successfully acceptance-fired the S-IC-3 on November 15 for 121.7 seconds mainstage. This was the last planned firing of the S-IC stage at MSFC. Future firings would be accomplished at the B-2 stand at MTF [233].

On November 17 NASA announced several Apollo/Saturn manned space flight schedule changes because of launch vehicle and spacecraft development problems. The principal change called for rescheduling a manned earth orbital mission, Apollo/Saturn 205, which was to have followed the first manned Apollo flight, AS-204 [234].

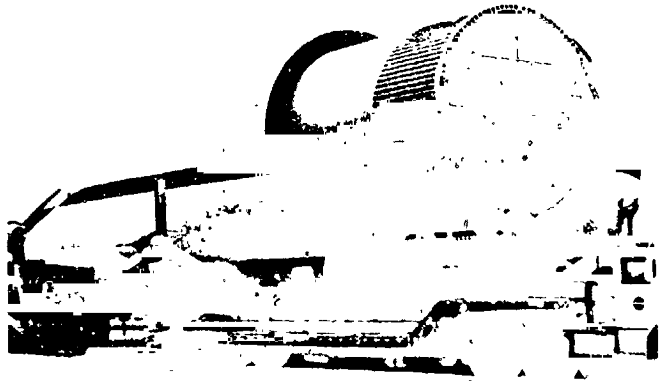
On November 18 NASA approved F-1 engine contract NAS8-18734 CPIF. This contract provided for 30 F-1 engines needed in the Apollo program and continued production support and GSE through June 1970. These F-1 rocket engines furnished by Rocketdyne Division of North American Aviation would complete the number of engines (106) required by the 15 scheduled Saturn V vehicles, plus spares. The cost would be about $141 million. The delivery of 30 engines would begin in November 1967 and continue through October 1968 [235].

Charles W. Mathews, MSC Gemini Program Manager, was named Director of Saturn-Apollo Applications in the NASA Headquarters Office of Manned Space Flight, effective November 30 [236].

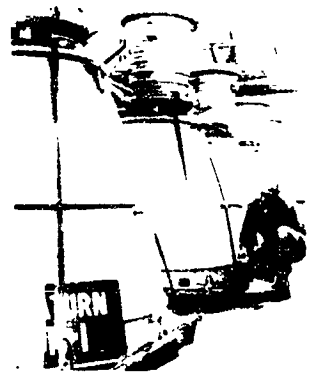
At MTF on December 1 North American Aviation conducted a successful 384-second captive firing of the first flight hydrogen-fueled engines, developing a total 1 million pounds of thrust. During the test number 2 and 4 engine SLAM arms did not drop, resulting in the successful gimballing of engines 1 and 3 only. The test included the recording of about 800 measurements of the stage's performance, including propellant tank temperatures, engine temperatures, propellant flow rates, and vibrations [237].

With Schedule ML-5B, issued by NASA on December 5, the cluster concept entered the AAP design, following studies completed a short time earlier. The ML-5B schedule called for 22 Saturn IB and 15 Saturn V launches. Included in the launch of the 22 Saturn IB's would be two Saturn IB's launched approximately a day apart, one Saturn IB manned and the other one unmanned. Among the Saturn flights scheduled in ML-5B would be flights utilizing two Saturn V Workshops and four LM/ATM missions. Lunar missions were also included in this schedule [238].

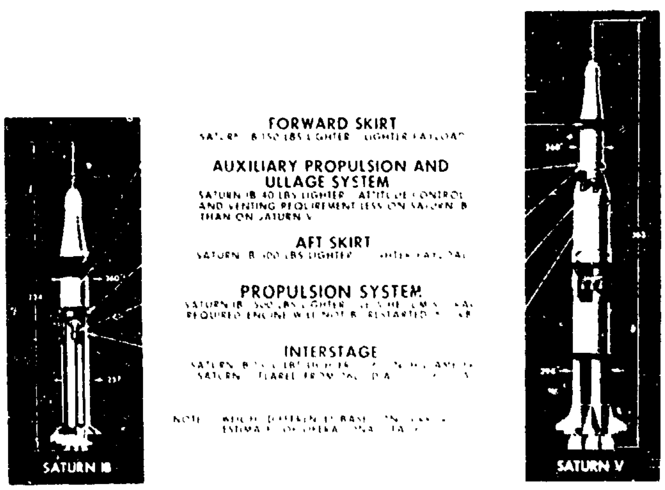
On December 17 an estimated 2500 children greeted Santa Claus at the first annual Marshall Athletic Recreation-Social Exchange (MARS) Christmas Party for Children at MSFC. Each youngster received a small gift and enjoyed movies from 10:00 a.m. to 3:00 p.m. [239].



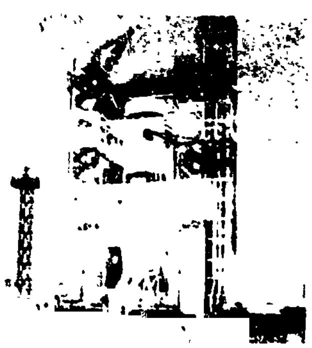
S-IVB aboard Super Guppy



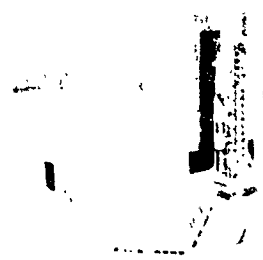
Final check of H-1 engines before shipment



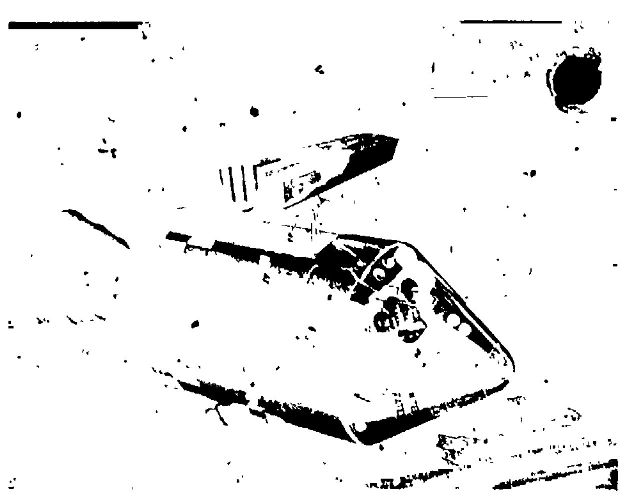
S-IVB differences, Saturn IB versus Saturn V



S-IVB stage in Test Stand Beta 1, SACTO

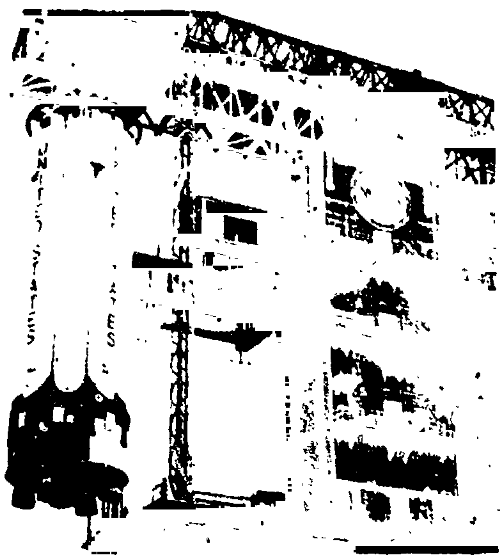


Saturn V in movement at KSC

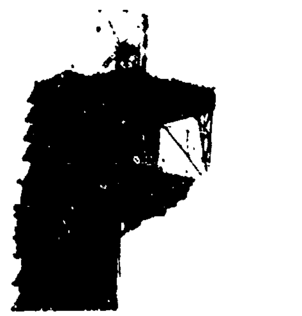


Early simplified ATM concept using Apollo CSM

MSFC announced on December 20 the award of a $7.2 million contract modification to Chrysler Corporation to begin procurement of long-lead-time items for additional Uprated Saturn first stages (S-IB). Under this agreement to be completed by June 30, 1967, Chrysler would procure the materials, components, and engineering support necessary to maintain its capability to assemble four Uprated Saturn I boosters per year. Chrysler was currently under contract to assemble and test 12 of the 1.6 million-pound first stages at Michoud [240].

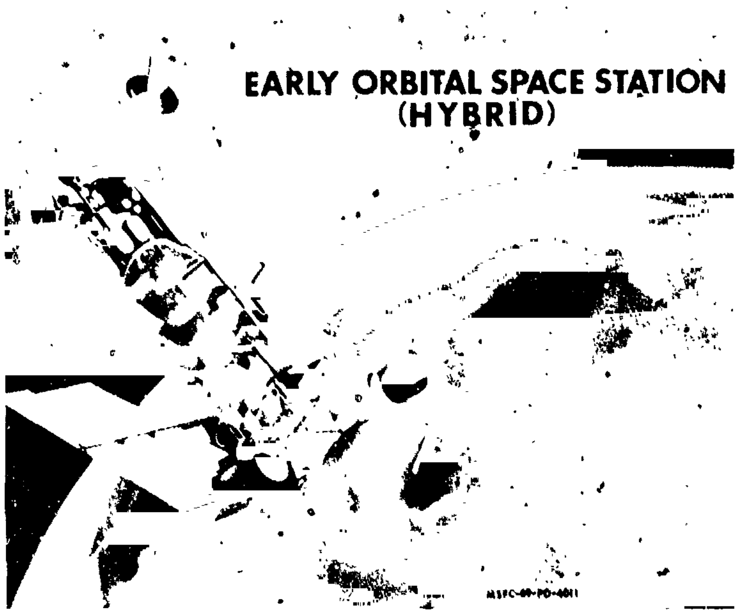


S-IB stage erection in test stand, Huntsville



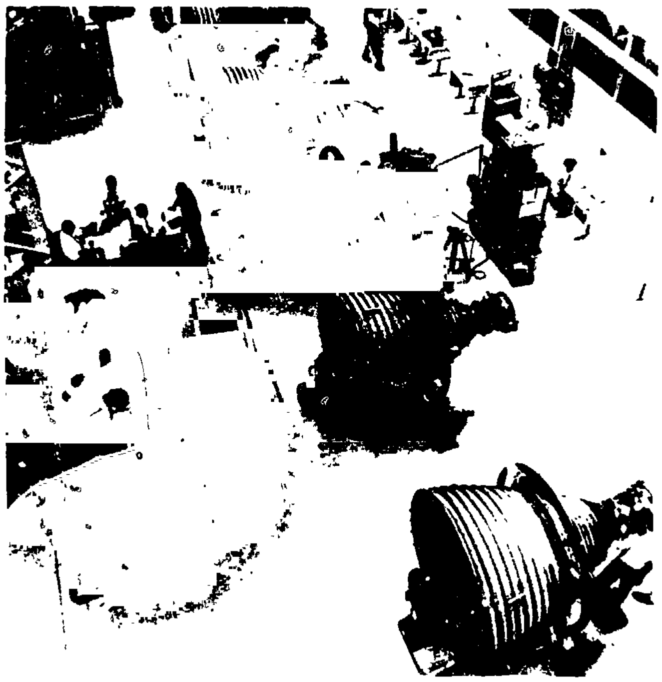
First duration firing of an S-II flight stage

Destroyed S-II-T/D due to overpressurized liquid hydrogen tank



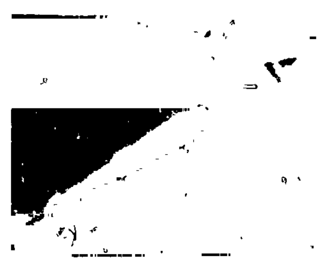
Early orbital Space Station (hybrid) artist's concept

Loading sequence of Super Guppy



J-2 production at Rocketdyne

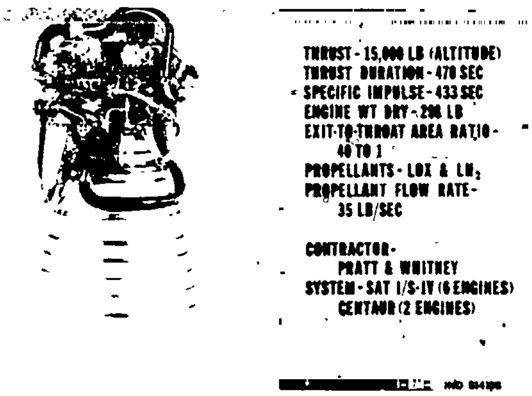
Saturn V and mobile launcher on crawler emerging from VAB, KSC



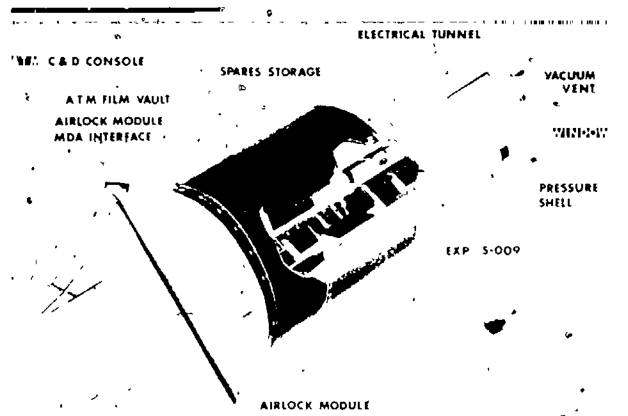
AS-203 in flight, showing shock wave formation around nose cone

Buildup of the SA-501 vehicle using the H7-17 fit-up fixture as a spacer to replace the S-II-1 at KSC

S-II facilities at Seal Beach



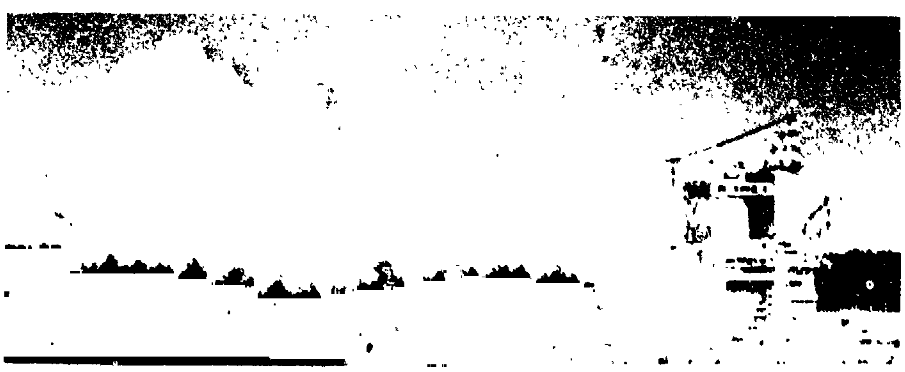
RL10 engine



Multiple Docking Adapter – artist's concept

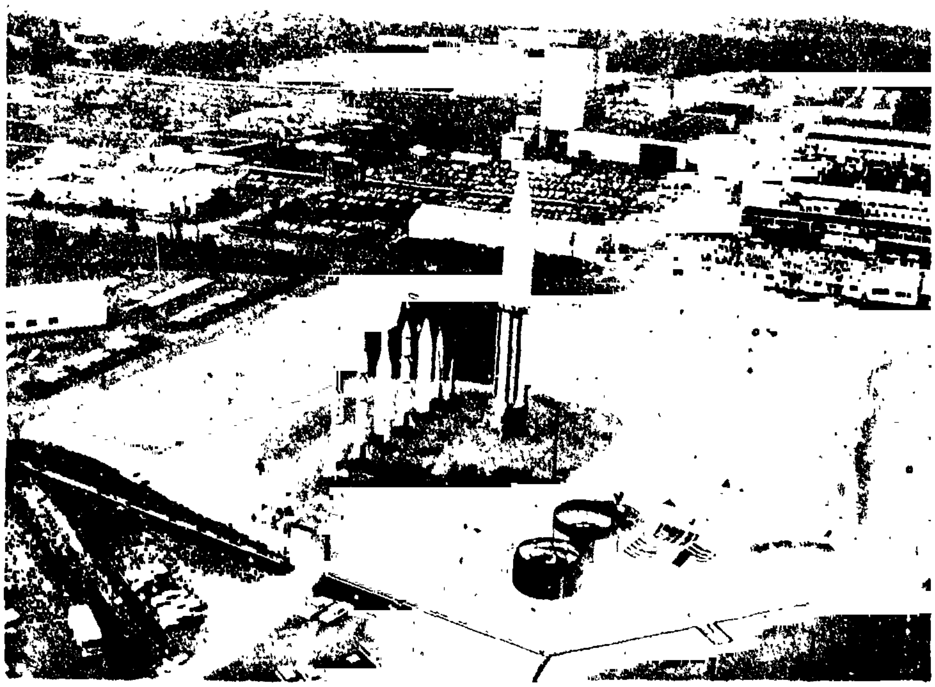
DIMENSIONS		SPECIFICATIONS (APPROXIMATE)	
WING SPAN	156 ft 3 in		
FUSELAGE LENGTH	141 ft 2 in	EMPTY WEIGHT	110 000 LBS
TAIL HEIGHT	46 ft 5 in	PAYLOAD (APPROXIMATELY)	45 000 LBS
FUSELAGE HEIGHT	36 ft 6 in	TAKEOFF WEIGHT (MAXIMUM)	175 000 LBS
CARGO COMP (DIAMETER)	300 in	CRUISE SPEED	250 MPH
CARGO COMP LENGTH	94 ft 6 in		
LENGTH CARGO COMP 25 ft DIA	30 ft 8 in		IND B20258

Super Guppy

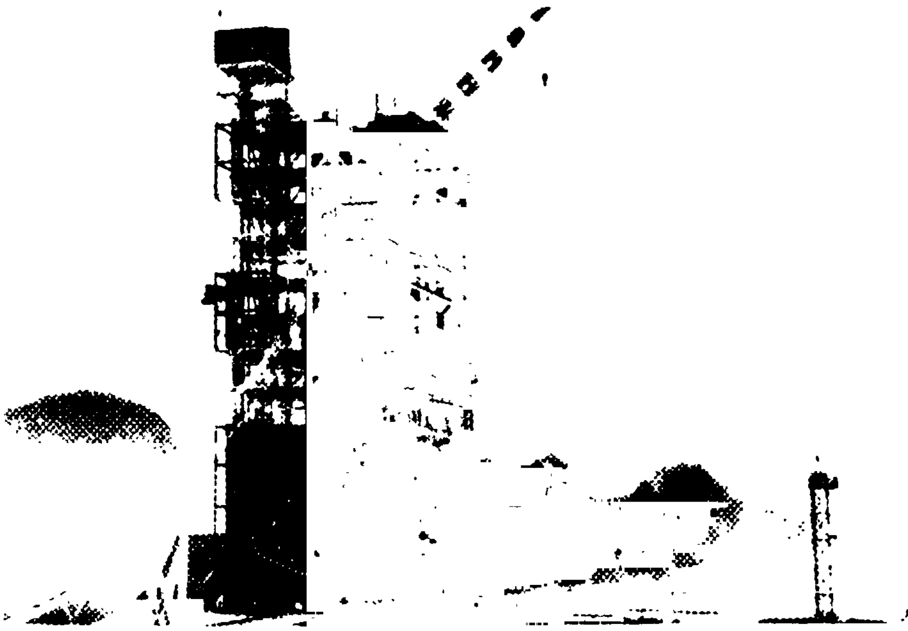


S-II-T static firing at MTF

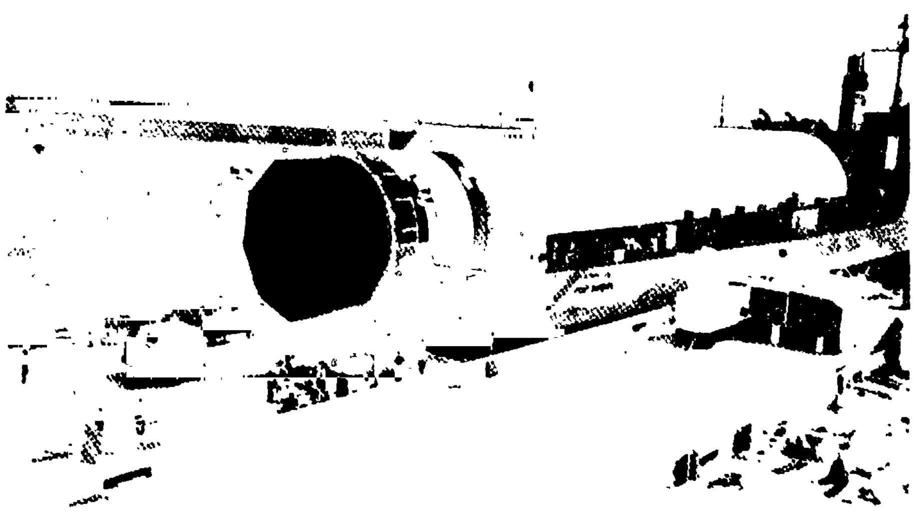
S-IVB-302 acceptance firing at SACTO



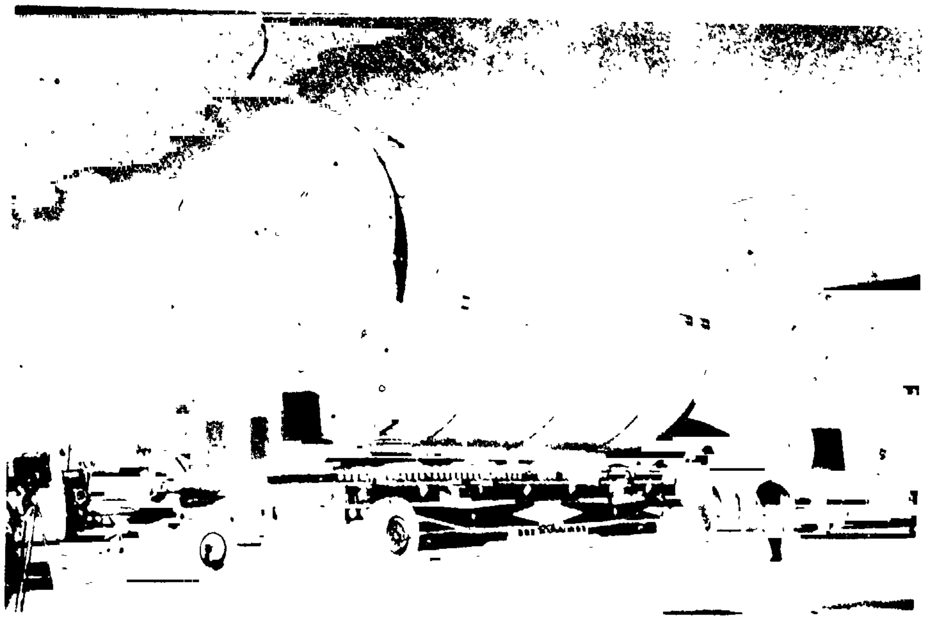
A giant Saturn I launch vehicle towering over a group of smaller rockets became an early part of the skyline in front of the Space Orientation Center at MSFC. Vehicles from the left are Mercury-Redstone, Jupiter C, Juno II, Redstone, Jupiter, V-2 and Hermes. This shot, taken from a helicopter, shows the Manufacturing Engineering and Quality and Reliability Assurance Laboratories' buildings in the background.



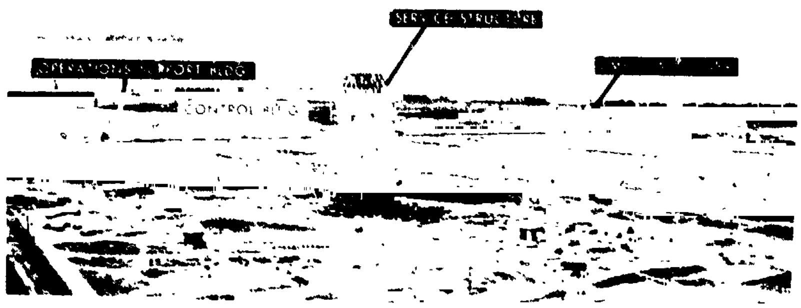
Acceptance firing of the S-IVB-502 at Sacramento



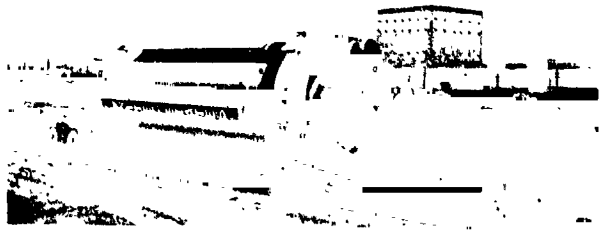
Transfer of the S-II-1 from the Point Barrow to the Pearl River at Michoud en route to MTF from Seal Beach



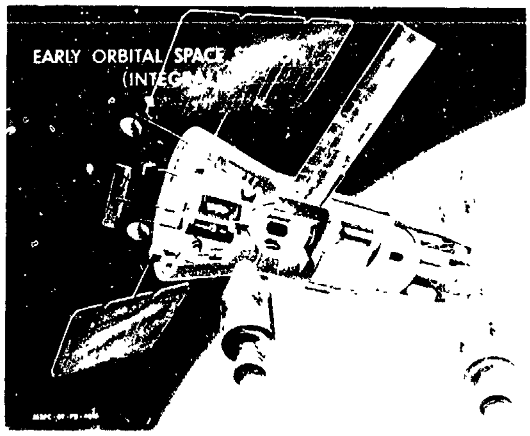
General view of S-IVB-501 aboard Super Guppy



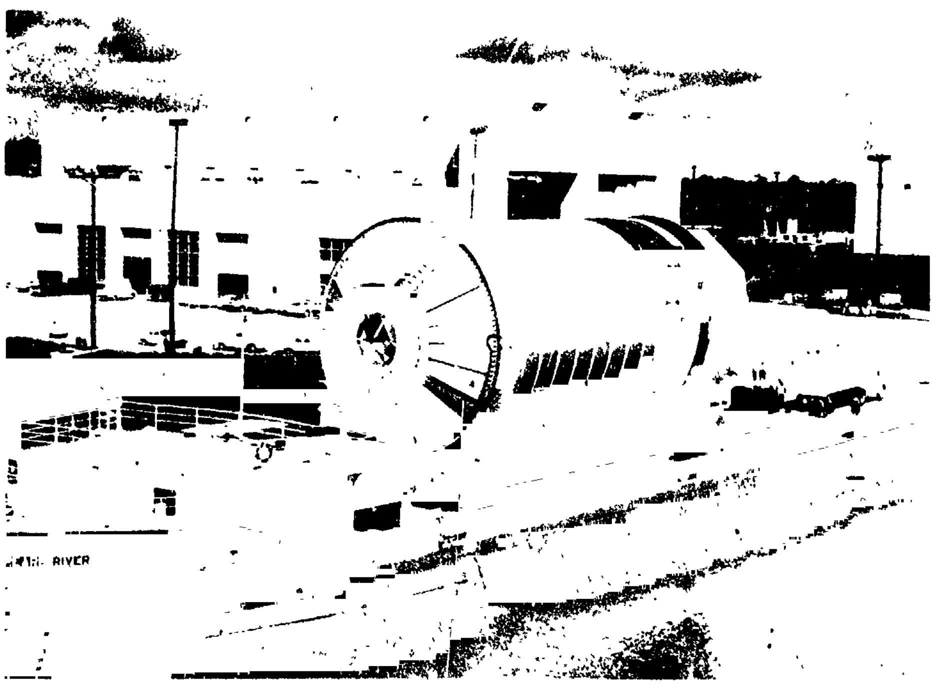
Launch Complex 34, KSC



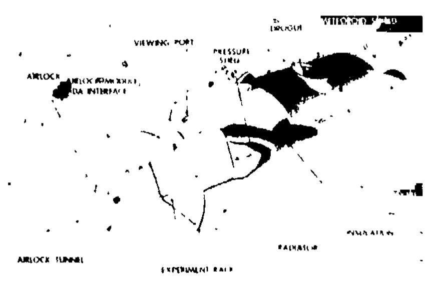
Fourth Uprated Saturn I, S-IB-4, in first stage of journey to KSC



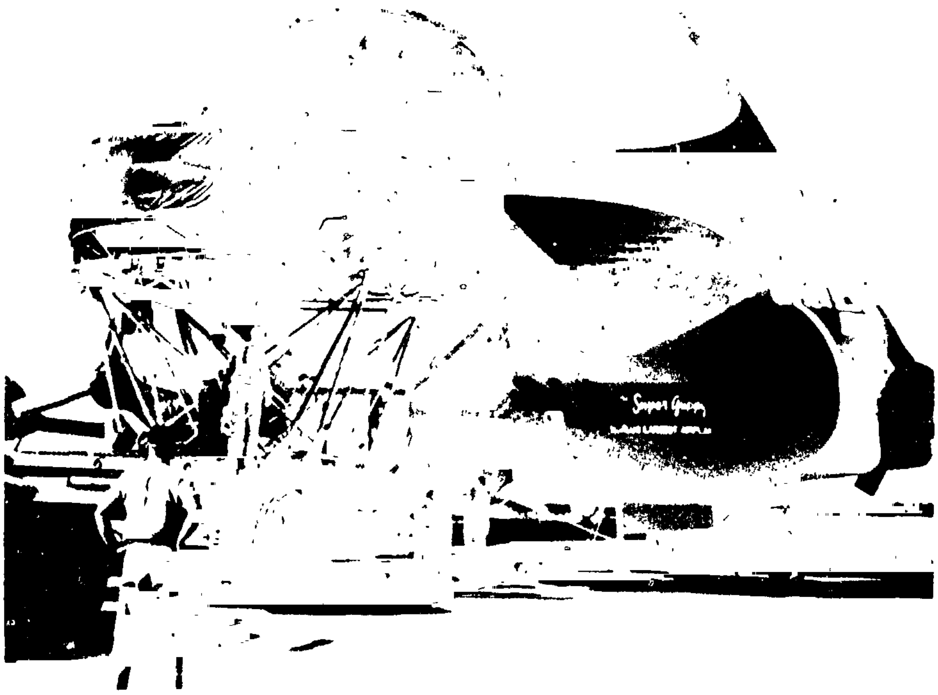
Artist's concept of integral Space Station



S-II-1 arriving at MTF for acceptance testing

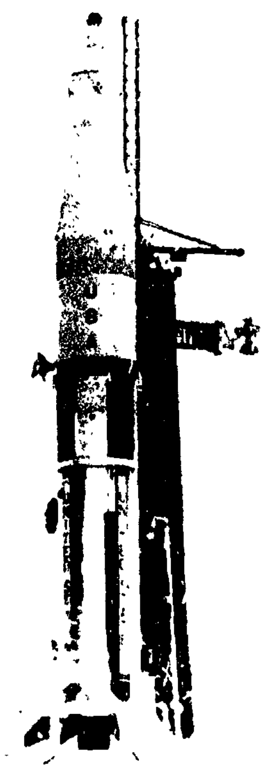


Multiple Docking Adapter

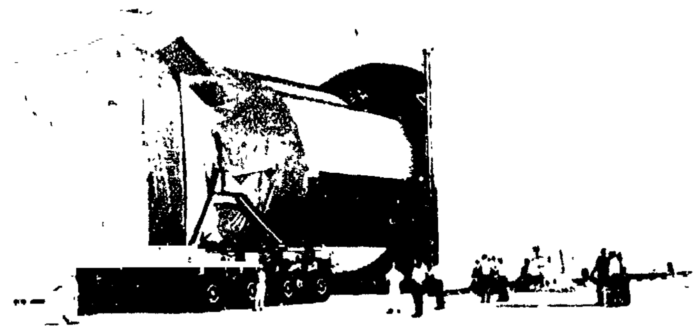


IU-501 arrives at KSC aboard Super Guppy

Wet Workshop cluster with ATM, CSM, and Lunar Mapping and Survey System Module docked

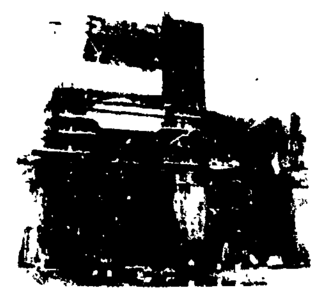


AS-202 rises from KSC on August 25, 1966



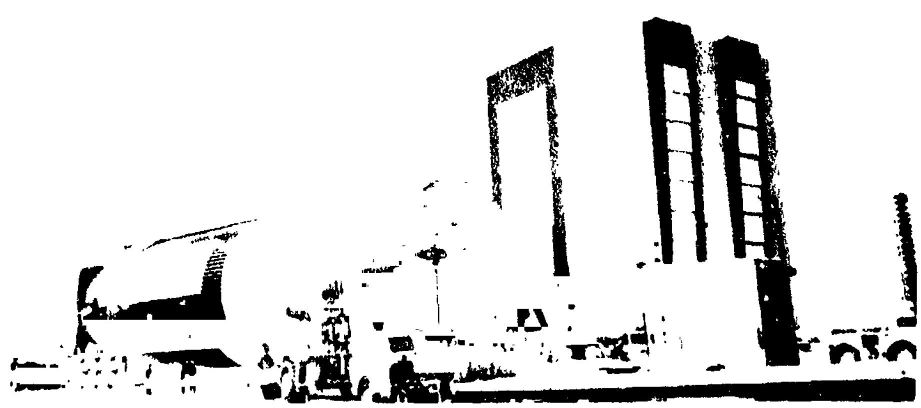
S-IC-3 being loaded on barge Poseidon for shipment to MSFC

S-IU-200S/500S during structural test, MSFC

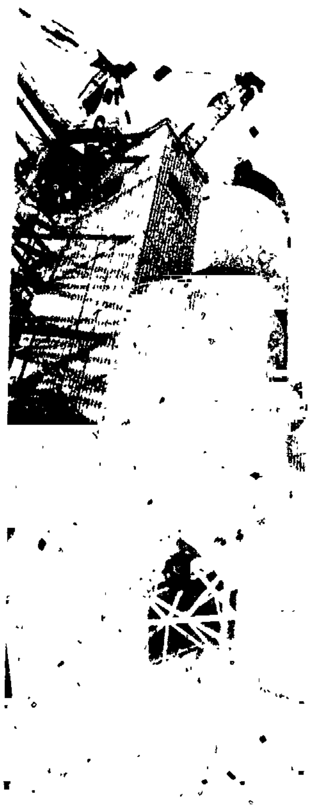


S-IC test stand at MTF

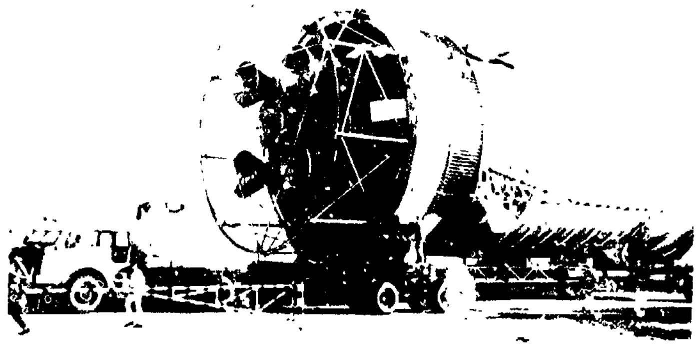
AS-202 rises from KSC on August 25, 1966



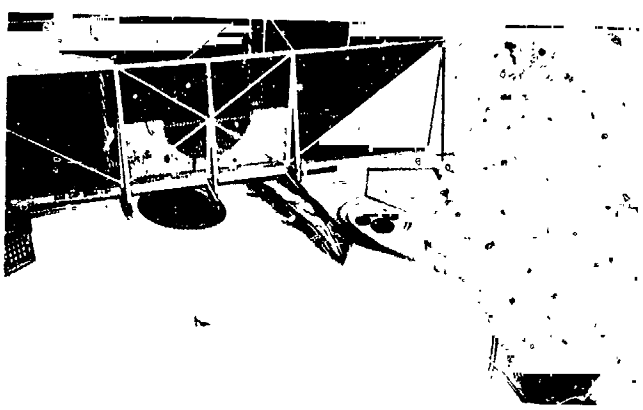
S-IC-1 stage arrival, KSC



S-IC-3 being erected in the static test stand at MSFC

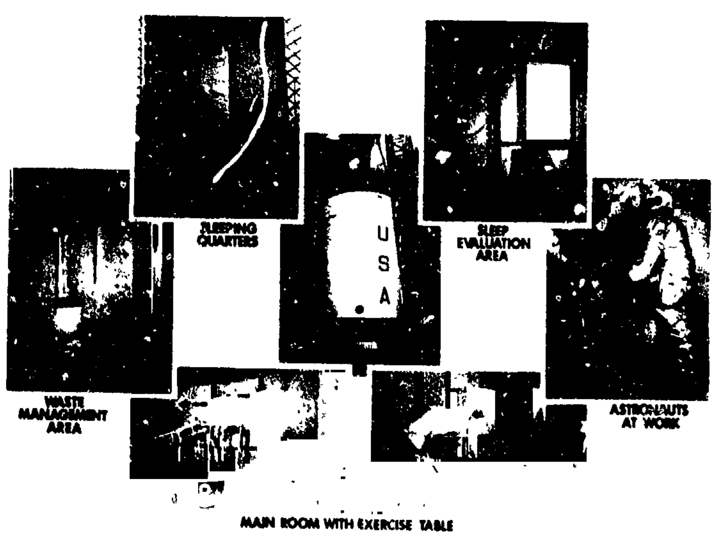


S-II-F stage being unloaded at MSFC



Cracks in the liquid hydrogen tanks for the S-II-3

Dynamic vehicle stacked in the Saturn V Dynamic Test Tower at MSFC



S-IVB Orbital Workshop

Airlock Module

MDA flight article

MDA structural test hardware

Orbital Workshop MDA mated with CSM/ATM

1967

The first flight version of a rocket stage to undergo captive firings at MTF, the S-II-1 stage, left Bay St. Louis, Mississippi, on January 16 enroute to KSC where it would become a part of the first Apollo/Saturn V flight vehicle, scheduled for launch during the second quarter of 1967 [241].

A Saturn V third stage, S-IVB-503, exploded shortly before it was scheduled to be ignited in a January 20 test at the Sacramento Test Facility. The explosion completely destroyed the stage at Test Stand Beta III. Post-accident investigation revealed that one of the eight ambient temperature helium storage spheres located on the engine thrust structure exploded because of weld weakness resulting from use of the wrong weld material [242].

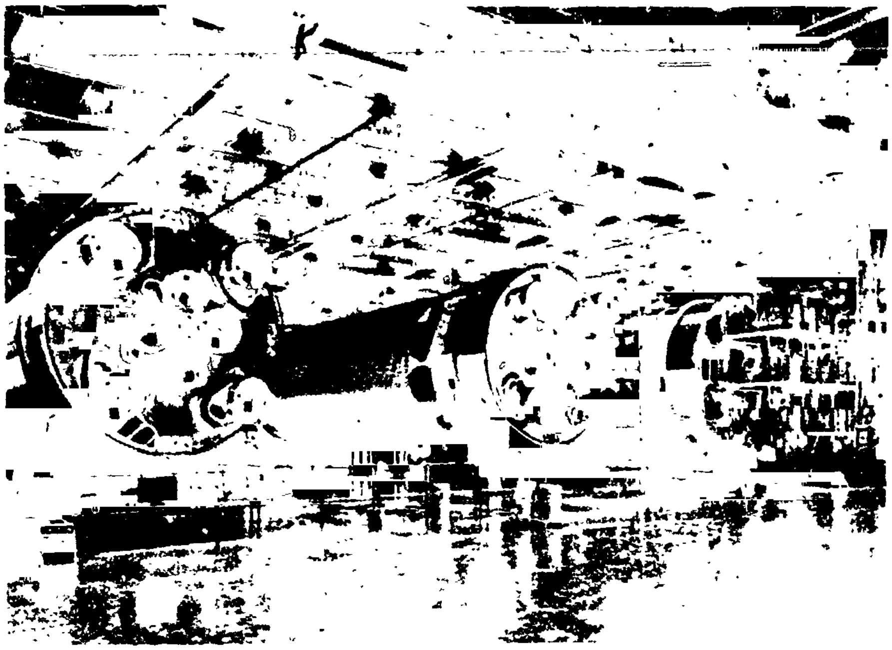
Following the loss of the S-IVB-503 stage during testing on January 20, NASA officials amended identification numbers of subsequent S-IVB stages to fill the void. The S-IVB-504 became the S-IVB-503N, S-IVB-505 became S-IVB-504N, and S-IVB-506 became S-IVB-505N. A replacement stage using an old S-IVB-507 tankage became S-IVB-506, and S-IVB-507 and subsequent stages retained the old identification [243, 244]. (The N at the end of the stage identification stood for the word "New," a designation started after an earlier stage version exploded, necessitating the use of a substitute stage.)

At KSC a flash fire swept through the Apollo I spacecraft mated to the SA-204 launch vehicle on LC-34. Three astronauts within the capsule, Virgil I. Grissom, Edward H. White, and Roger B. Chaffee, perished from smoke inhalation. It was the worst tragedy in the history of the U. S. space program [245].

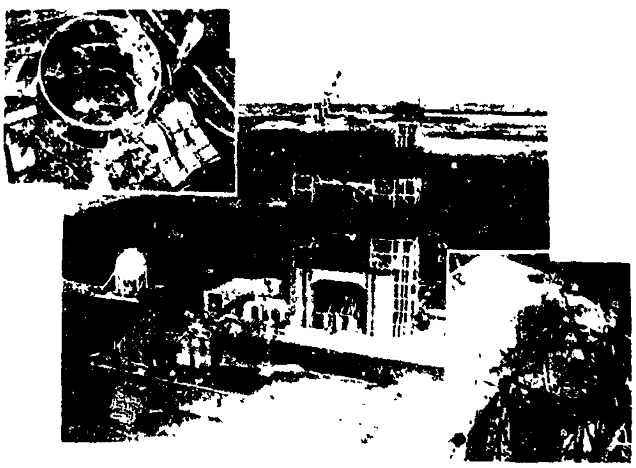
Dr. Wernher von Braun and five other MSFC officials attended memorial services on Sunday and Monday, January 29 and 30, 1967, in Texas for the three Apollo astronauts killed the previous Friday in a flash fire that had swept their spacecraft. Memorial services for Roger Chaffee were held at the Webster Presbyterian Church on Sunday and for Edward White and Virgil Grissom on Monday at the Seabrook Methodist Church, all in Texas. Some months earlier one of the three astronauts, Virgil Grissom, had said, "If we die, we want people to accept it. The conquest of space is worth the risk of it" [246].

In the first statement concerning Apollo flight missions since the AS-204 accident, NASA Associate Administrator for Manned Space Flight, Dr. George E. Mueller, announced on February 3 that NASA would proceed with launching of three unmanned Apollo flights scheduled for 1967: AS-206, AS-501, and AS-502. NASA meanwhile was postponing indefinitely manned Apollo missions pending the outcome of the Apollo 204 Review Board's investigation [247].

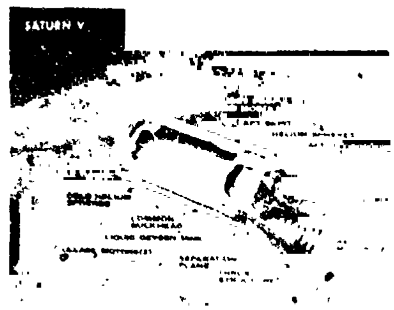
Also on February 3 NASA signed an incentive contract modification with the Boeing Company for five additional Saturn V first stages. As a result of this modification, Boeing was now under contract to fabricate and assemble 15 of the 7.5 million-pound-thrust boosters, thereby completing the S-IC stage requirements for the scheduled launching of



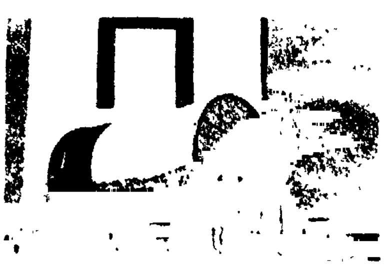
S-IB-7, S-IB-9, S-IB-5, and S-IB-6 in final assembly area, Michoud



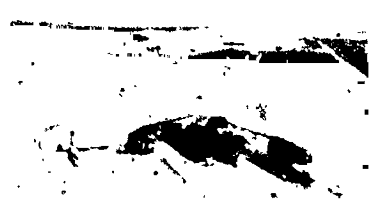
AS-503 third stage (S-IVB) explosion



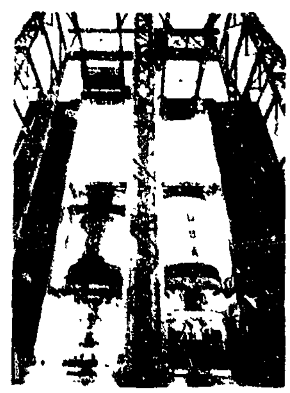
Saturn V third stage (S-IVB)



S-II stage arrival at KSC



Michoud, aerial view with plant in background



S-IVB-505 and S-IVB-211 in vertical checkout tower at Huntington Beach

15 Saturn V space vehicles in the Apollo manned lunar landing program. The $120 million supplemental agreement awarded by MSFC extended the Boeing contract through June 1970. This modification increased the total estimated value of the Boeing contract to $977 million [248].

On February 25 workmen at MTF completed construction of the S-II A-1 Test Stand, and the Corps of Engineers accepted beneficial occupancy with exceptions [249].

On March 2 NASA announced that MSFC would design and build in house a multiple docking adapter (MDA) for use in an AA payload cluster scheduled for launch in 1968-1969. Preliminary designs called for a 10-foot-diameter, 15-foot-long cylinder surrounded by five 36-inch-diameter tunnels with docking collars and sealing hatches for orbital docking [250].

On March 20 NASA scheduled use of the AS-204 booster to launch the first Apollo LM on an unmanned flight in the summer of 1967. It was the last booster equipped with full R&D instrumentation. Original plans had been to use the AS-206 booster. Purpose of the first LM mission would be to obtain data on ascent and descent propulsion systems, including a restart; verify LM structure; and evaluate staging [251, 252].

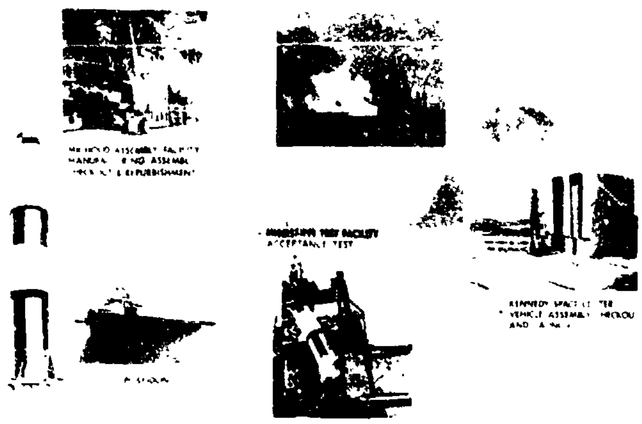
NASA decided on March 24 to add two solar array panels to its Apollo Applications Program Orbital Workshop. They would be 180 degrees apart and run the length of the OWS. This addition was deemed necessary because of the increased electrical power requirements resulting from habitation of the Workshop. Until this change in requirements, the CSM had been considered the primary power source for the cluster except for the Apollo Telescope Mount which would still have its own solar arrays and power system [253].

On April 19 a J-2 engine set a record with the completion of 103 tests lasting a total of 20 094 seconds. This length of testing was longer than for any other large rocket engine produced by the Rocketdyne Division of North American Aviation, Inc. This record-breaking series of tests was conducted on research and development engine J022-1 on test stand Delta 2A at the Santa Susana Field Laboratory between December 9, 1966, and April 19, 1967, with no major hardware changes. The total run duration was more than five times the designated qualification test time, and the number of tests was more than three times the number required for qualification. At the time of this test completion Rocketdyne had delivered 109 J-2 production model engines to MSFC, the Center responsible for technical direction of the engine development [254].

Of concern to many MSFC employees was the death of Maj. Gen. Holger N. Toftoy, 64, who died April 19 at Walter Reed Army Medical Center, Washington, D. C., after a long illness [255]

Thirteen astronauts attended a Saturn V launch vehicle systems and performance briefing at MSFC on April 27 and 28, 1967. Among the astronauts attending was Neil Armstrong, destined to become the first man on the moon [256].

Overall view of S-IVB fuel tank relief valve undergoing test at General Dynamics (subcontractor for Douglas) in San Diego

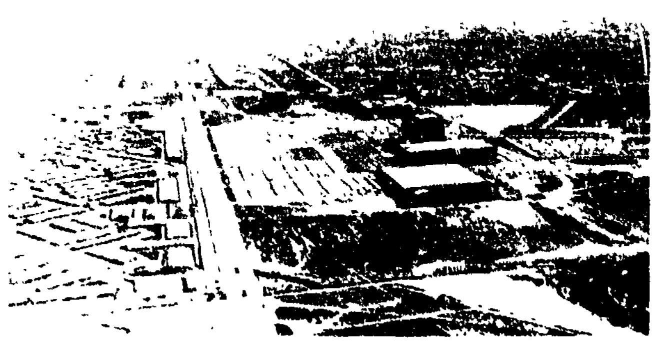


Saturn V first stage (S-IC), Boeing Co., prime contractor

Assembly area, Huntington Beach, California. S-IVB-507 left, S-IVB-506 middle, and S-IVB-212 right

Route used to transport the S-II stage from Seal Beach complex to the Seal Beach dock

S-IVB-206 on transporter in VAB, Sacramento



S-II Seal Beach Facilities, looking east

Douglas Aircraft Corporation merged with McDonnell Aircraft Corporation April 28 and became known as McDonnell Douglas Corporation [257, 258].

Twelve astronauts visited MSFC from May 2 through May 5 and evaluated modifications proposed for converting the S-IVB liquid hydrogen tank into a space station. The astronauts practiced some of the tasks they would perform while orbiting in 10 000 cubic feet of living and working space. Workmen disassembled the mockup, about 60 feet long and 22 feet in diameter, and the astronauts, dressed in space suits, practiced putting it back together in much the same manner as if they had to do it in space. Such a converted S-IVB stage would provide space in which the astronauts could live and work for an initial 28 days in space. Then the astronauts would "store" the workshop in space for reuse later for longer periods. Douglas Aircraft assembled the mockup at its Huntington Beach, California, facility and airlifted it to MSFC aboard the Super Guppy aircraft [259].

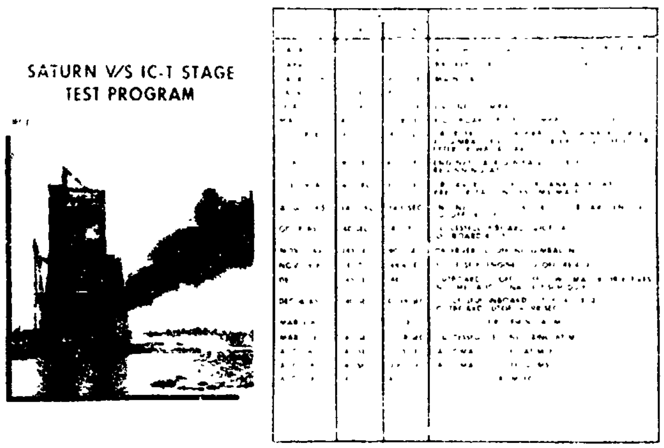
Inclement weather failed to mar the enthusiastic reception given Vice-President Hubert H. Humphrey during a visit to MSFC on Monday, May 22, 1967. After his talk in front of a shivering audience outside Building 4200, the Vice-President spent several minutes shaking hands with people before he toured MSFC via a motorcade. The Vice-President and his party later watched a static firing of an Uprated Saturn I first stage from the East Observation Bunker. The full-duration test lasted 145.6 seconds [260].

NASA announced on May 24 that the second stage of the first Saturn V launch vehicle would be dismantled at KSC to check for any hairline cracks. NASA made this decision after finding similar cracks in an identical stage of the vehicle at the North American Aviation, Seal Beach, California, plant. The space agency did not expect additional checks to delay the first Saturn V flight – an unmanned mission scheduled for mid-August – by "more than a week or so" [261].

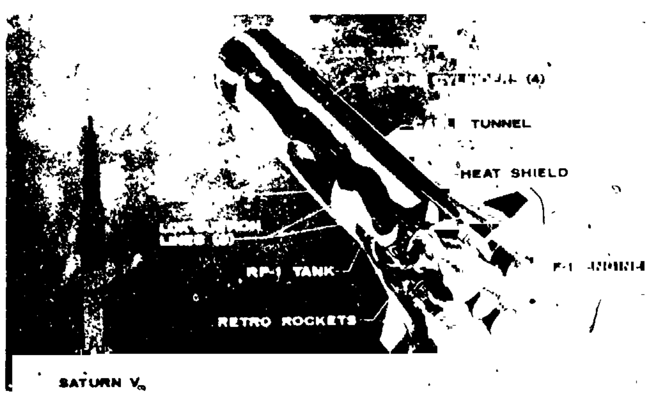
On May 24 NASA realigned its Apollo AAP launch schedules as a result of the accident in early 1967. This new AAP schedule ML-6 called for 25 Saturn IB and 14 Saturn V launches. Major hardware involved in these launches would be two Workshops flown on Saturn IB vehicles, two Saturn V Workshops, and three ATM's. Also planned were nine lunar missions and one Mars mission called Voyager. According to this new schedule the first launch of a Workshop would be in January 1969 [262].

During May the highlight of the Orbital Workshop design progress was the intensive 3-day S-IVB Orbital Workshop design review held at MSFC early in May with more than 200 engineering and management representatives participating. Organizations represented at the preliminary design review included NASA Headquarters, Manned Spacecraft Center, Kennedy Space Center, MSFC, and Douglas Aircraft Company, manufacturer of the S-IVB stage. The review featured an S-IVB mockup built by Douglas and shipped to MSFC. Made of nonflight S-IVB hardware, the mockup was outfitted according to the preliminary design of the manned Orbital Workshop [263].

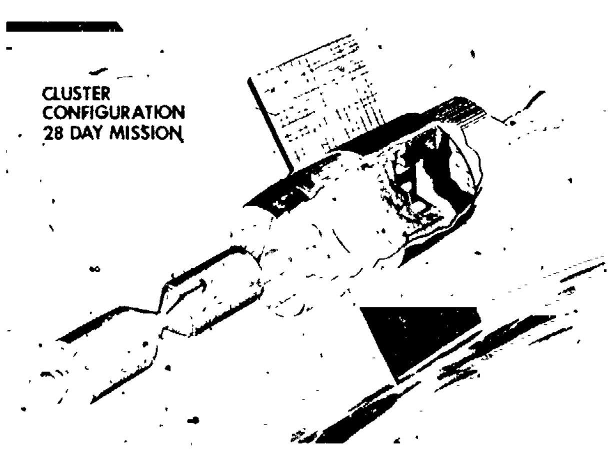
NASA changed the charter on June 8 to reflect the change of the name of the Michoud Operations to Michoud Assembly Facility [264].



Saturn V/S-IC-T stage test program



Saturn V first stage (S-IC)



Cluster with solar array wings added to Workshop

Saturn V second stage (S-II), North American Rockwell, prime contractor

S-IC-8, S-IC-4, and S-IC-6 in manufacturing building, Michoud

S-IC test stand at MTF

ATM solar wing

The Center announced on June 14 that the number of successful F-1 engine tests had reached the 4000 mark. This 4000th test occurred when an F-1 engine at Edwards Field Laboratory, California, ran 165 seconds at 1 542 000 pounds of thrust. The total of 4000 firings included 2035 engine firings and 1965 thrust chamber injection assembly firings. Rocketdyne Division of North American Aviation, Inc., developed the engine. Engine number 103-1 made the 4000th run, almost 7 years after the first F-1 firing at Edwards [265].

The first flight model of the Apollo LM arrived at KSC on June 23 aboard the Pregnant Guppy aircraft. This was the payload for SA-204, then on the pad at LC-37. The lunar module would be in KSC's industrial area for about 45 days before installation atop the launch vehicle [266].

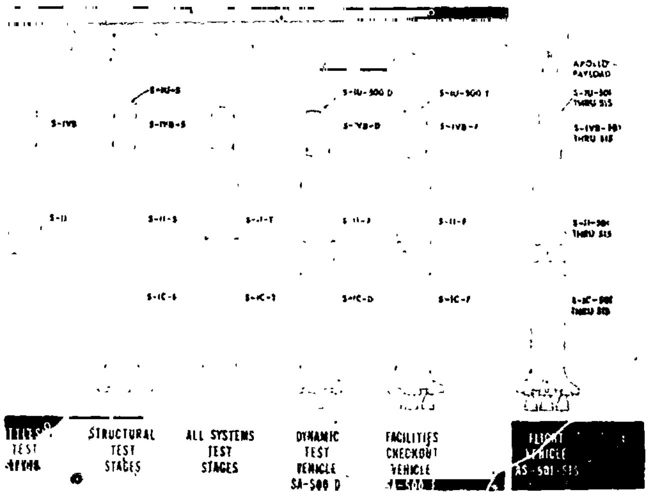
Officials at NASA's rocket engine test site at Edwards Air Force Base, California, held brief ceremonies on June 28 marking the delivery of the millionth ton of cryogenic rocket propellants and pressurants. NASA had used the liquid oxygen and liquid nitrogen to test F-1 rocket engines during the past 6 years. (The first engine test had been in 1961.) Peak testing was in 1965 when as many as 35 300 tons were delivered in a single month [267].

MSFC announced on June 30 the award by NASA of a $14 811 540 fixed-price-incentive-fee contract to North American Aviation for 60 additional H-1 rocket engines for use on first stages of Uprated Saturn I vehicles. This order increased the total number of engines purchased to 322. Delivery would continue through September 1968 [268].

During June special tests to determine the best way to recover and reuse the Saturn V first stage (S-IC) were conducted at MSFC. In these tests 1/10 scale models of the S-IC were dropped from altitudes of as much as 156 feet into a 20-foot-deep water tank to simulate descent of the stage through the earth's atmosphere and into the ocean. Purpose of the tests was to study a "soft splash" concept designed to bring back the S-IC with minimal damage. MSFC engineers said a workable recovery method would save millions of dollars in future years [269].

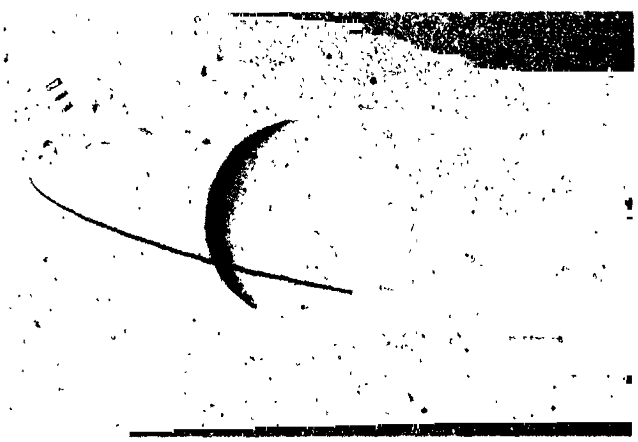
Records at the end of June indicated that during the first 6 months of 1967 Rocketdyne conducted 1838 R&D A-1 engine tests for a total firing time of 149 483 seconds. The tests were performed at Edwards Field Laboratory and at MSFC's West Area F-1 Test Stand. Rocketdyne delivered 11 F-1 production engines to Boeing during the same 6-month period: one for the S-IC-7 stage, five for the S-IC-8 stage, three for the S-IC-9 stage, and two as S-IC flight stage spares [270].

Records at the end of June also indicated that during the January to June 1967 period Rocketdyne conducted 103 J-2 engine R&D tests at Santa Susana Field Laboratory (SSFL) for a total firing time of 18 904.5 seconds; conducted 66 J-2 engine production tests for a total duration of 10 443 seconds; and continued J-2 engine environmental testing at AEDC, including S-IVB-501 verification tests proving restart capability and S-II-501 verification tests. In this same period NASA accepted 19 J-2 production engines, allocated 17 of these as Government-furnished equipment to NAA for S-II flight stages



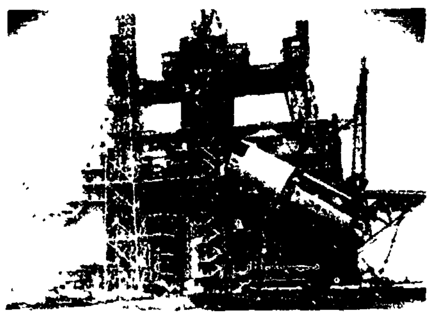
Saturn V vehicle configuration

Saturn V instrument unit

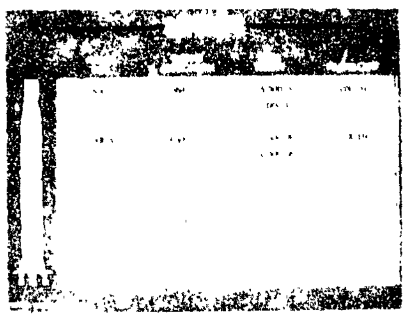


Skylab cluster on station (concept)

MTF, laboratory and engineering complex, looking north



Installation of S-IC-D in S-IC-BI test stand at MTF



Saturn V specifications

MTF, industrial complex

and one as an S-II spare, and provided the other engine to DAC as an S-IVB flight stage engine [271].

MSFC awarded McDonnell Douglas a $496 024 contract on July 1 to study advanced versions of the Saturn S-IVB Orbital Workshop. Under terms of this contract, the contractor would explore concepts for a follow-on Workshop for the Uprated Saturn I program and several more sophisticated versions of the Saturn V, with initial emphasis on uses of the stage in the Apollo Applications program [272].

MSFC announced on July 26 that NASA had awarded a $2.275 million contract to the Boeing Company for procurement of long-lead-time materials for two additional Saturn V flight boosters. The cost-plus-fixed-fee contract was the first Saturn V procurement in support of NASA's Apollo Applications program. Boeing, prime contractor for the 7.5 million-pound-thrust first stage (S-IC) of the Saturn V launch vehicle, was manufacturing 12 stages at MAF for the Apollo manned lunar exploration program. Boeing would begin acquiring such items as propellant ducts, liquid oxygen tunnels, and fuel tank components for the 16th and 17th stages. The contract would expire on January 1, 1968 [273].

On July 26 NASA selected Martin Marietta Corporation to negotiate a 27-month, $25-million, cost-plus-incentive-award fee contract for payload integration of equipment on Apollo Applications spacecraft. Tasks would be performed at NASA's three manned spaceflight centers: (1) MSFC work would involve the Orbital Workshop and Apollo Telescope Mount (ATM), (2) MSC work, the meteorological and earth resources payloads, and (3) KSC work, the test integration planning and support for launch operations [274].

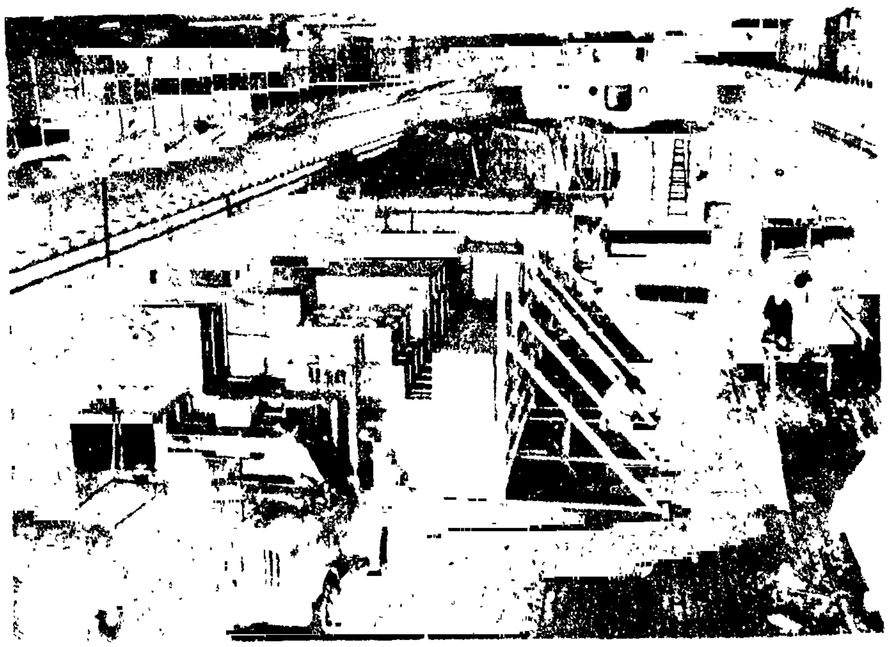
MSFC and KSC on July 31 signed a formal Memorandum of Agreement concerning "KSC Use of Selected MSFC Personnel." The agreement laid the ground rules for use of MSFC personnel by KSC to (1) support the AS-501 launch scheduled for September 1967, and (2) to support projects of mutual interest and importance to both Centers which would require additional specialized personnel for temporary periods of time [275].

MSFC announced on August 3 the successful completion of a dynamic test program of the Apollo/Saturn V, in effect giving "the green light" for the launch of the first Apollo/Saturn V later in the year as far as dynamics and structures were concerned. Boeing conducted the test program at MSFC under the direction of MSFC engineering personnel, the latter providing test criteria and monitoring of effort. Initial dynamic tests had started with the first stage of the Saturn V. Subsequent tests included the second and third stage, instrument unit, and the Apollo spacecraft. MSFC made several minor modifications to the space vehicle as a result of the dynamic program. These tests included determination of the bending and vibration characteristics of the complete vehicle. Tests were carried out in a 400-foot-high tower in the Center's Test Laboratory [276, 277].

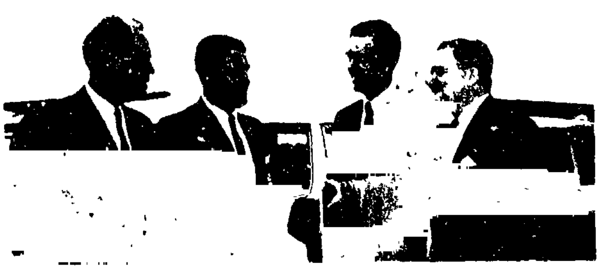
"Rollout" of AS-501 occurred August 26 at Kennedy Space Center. Representatives from MSFC and other NASA organizations, and newsmen, were present when a huge door of the Vehicle Assembly Building was raised to allow passage of this first flight vehicle. The

J-2 injector tests in Vertical Test Stand One, Santa Susana Field Laboratory

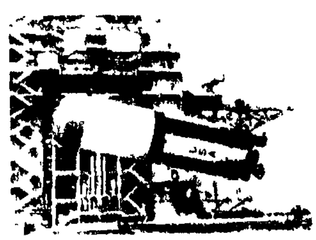
Installation of optical system in S-IVB space chamber, Huntington Beach



S-IC-3 parts inside Point Barrow



James Webb visits MSFC



Lowering S-IC-5 onto barge at MTF

rocket and its portable launch platform and tower, weighing 12.2 million pounds, crept to the launch mound 3.5 miles away at a top speed of less than 0.5 mile an hour. Workmen secured AS-501 over the flame trench within approximately 4 hours after it had reached the launch site. Then on August 28 workmen at KSC placed the 9-million-pound mobile service structure around the 363-foot-tall vehicle, providing work platforms and other access during the 7 weeks prior to launch date [278].

On September 1 MSFC returned a McDonnell Douglas-built S-IVB Orbital Workshop mockup to the contractor's Space Systems Center in Huntington Beach, California, for incorporation of a number of design changes. Following modification the mockup would represent the S-IVB stage as a manned space laboratory designed for use in the Apollo Applications Program [279].

On September 18 the NASA procurement officer executed a contract modification (supplemental agreement 813) for five additional S-II flight stages (S-II-11 through S-II-15) to become effective on October 3. Authorization and funding to procure long-lead-time hardware for these stages had been given previously, during the first quarter of 1967. This was a $159 716 477 contract modification for the fabrication of the five Saturn V second stages. Purchase of these five stages completed the S-II requirements for the 15 Saturn V launch vehicles approved for development in the Apollo program. Schedules called for the first of the stages to be delivered to NASA in February 1969. The total value of the S-II stage contract with North American was approximately $1.2 billion [280, 281].

The S-II-3 stage fired for approximately 65 seconds during its first acceptance test, September 19 [282].

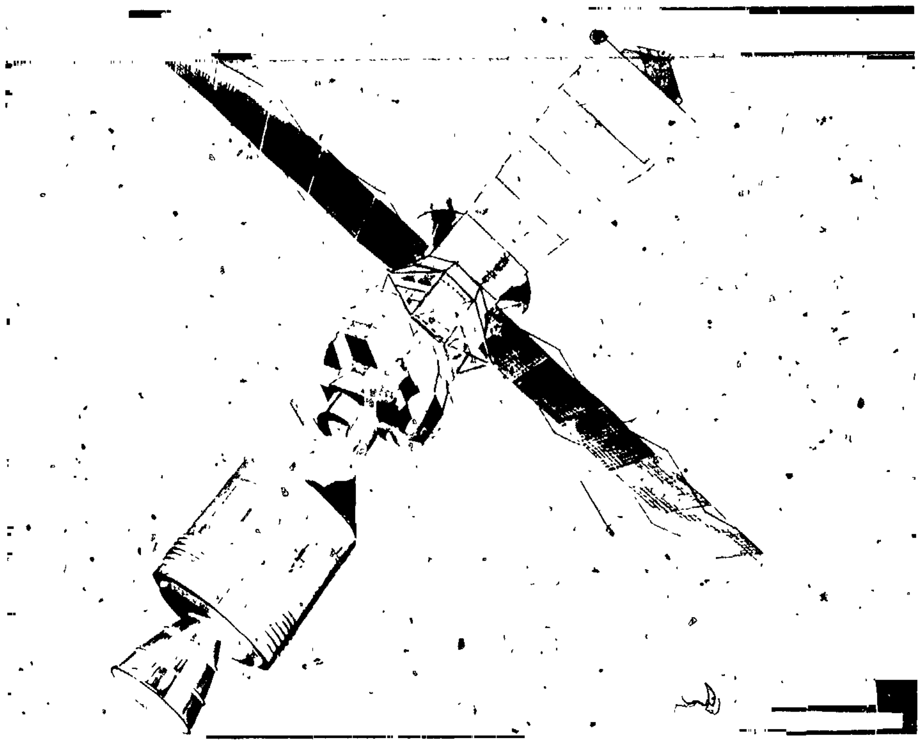
The major S-II stage contractor, North American Aviation, Inc., merged with Rockwell-Standard Corporation on September 22 to form the North American Rockwell (NAR) Corporation [283].

A branch of the Huntsville Post Office opened at MSFC on September 25, 1967 [284].

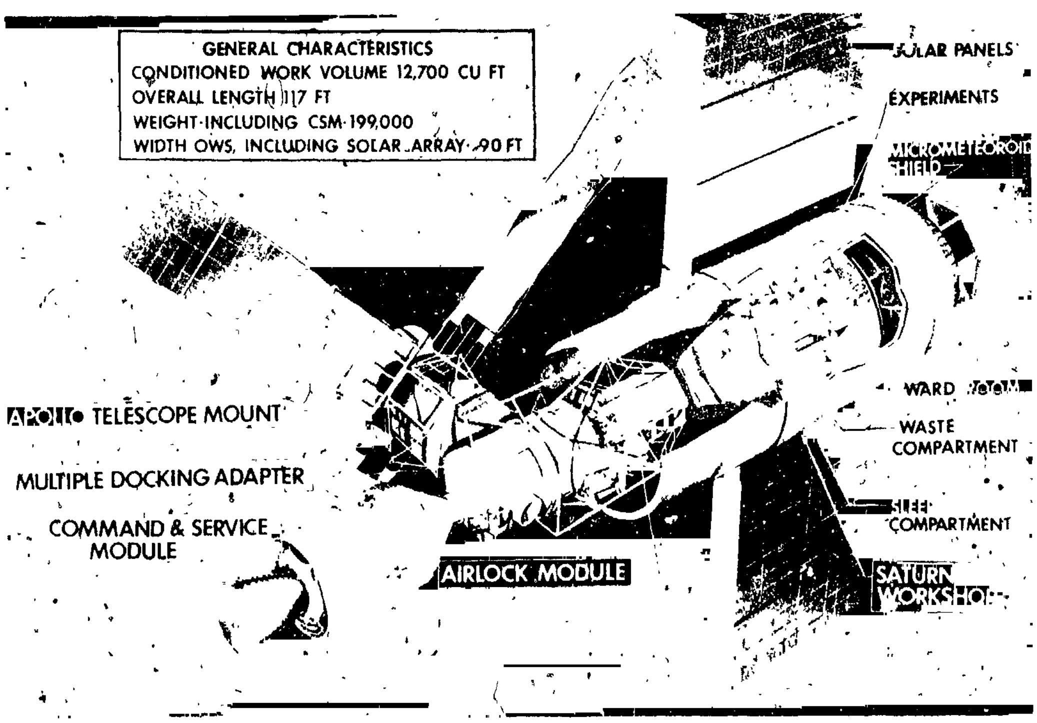
NASA Administrator James E. Webb announced on October 2 that Deputy Administrator Dr. Robert C. Seamans was resigning to return to private life on January 1, 1968 [285].

On October 3 NASA published its Apollo Applications Program schedule ML-7, a schedule that reflected current budgetary restraints. This schedule reflected the reduced Apollo Applications Program lunar activity to four missions and Saturn V Workshop activity calling for only 17 Saturn IB and seven Saturn V launches. During this program of 24 Saturn launches, there would be two Workshops launched on Saturn IB vehicles, one Saturn V Workshop, and three ATM's. Launch of the first Workshop was scheduled for March 1970 [286].

In support of the Saturn V program NASA decided on October 4 to purchase nine additional S-IVB stages from the McDonnell Douglas Corporation for $146.5 million, fulfilling requirements for currently approved 15 Saturn V and 12 Uprated Saturn I launch vehicles. Delivery would begin in April 1968 and end in May 1970. The purchase



Early CM/ATM concept using Apollo hardware



Skylab cluster

brought the total S-IVB contract value for both vehicles to $957 182 093 and the total number of stages purchased to 27 [287].

Also on October 4 NASA revealed that MSFC had used AEDC facilities to investigate preparation of a spent rocket stage for human occupancy in space. The investigation involved dumping 840 gallons of super-cold liquid nitrogen (LN) through a "dead" or inactive J-2 rocket engine. Conducted at a simulated 100 000-foot altitude, this dumping experiment would pave the way for astronauts to move inside an orbiting stage and use tanks as living quarters for a space station [288].

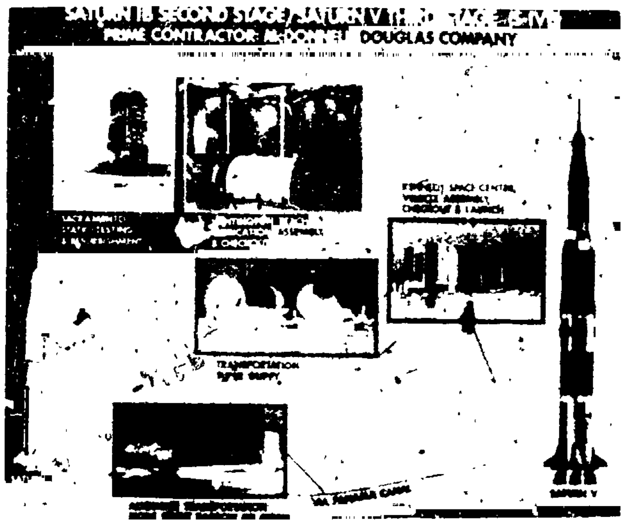
A NASA spokesman announced on October 10 that the planned launch of the Saturn V-Apollo 4 vehicle AS-501, scheduled for October 17, would be postponed until early November. Troubles with ground support equipment had stalled the countdown rehearsal. Once rehearsal was finished, engineers would evaluate results and set the date for the unmanned launch [289].

The countdown rehearsal for Apollo 4 (AS 501) ended on October 14. final flight preparations were to be completed for scheduled launch in about 3 weeks [290].

In an October 23, 1967, letter to all MSFC employees, Dr. Wernher von Braun stated that there was a possibility of a reduction in personnel if NASA's FY 1968 budget was cut as proposed by Congress [291].

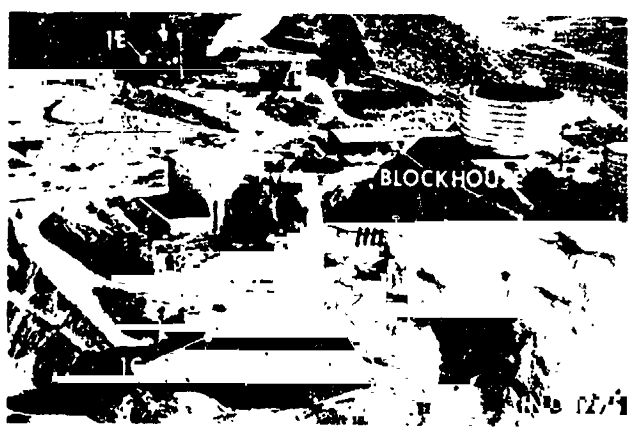
Maj. Gen. Samuel C. Phillips, Apollo Program Director, announced on October 26 that the first flight test of Saturn V, designated Apollo 4, would be scheduled no earlier than November 7. "This is a target date," he said. "We are in a very complex learning process and we are going to take all the time we need on this first launch." Key objective of the flight planned for November 7 would be evaluation of the Apollo command module heat shield under conditions encountered on return from the moon mission. The Apollo 4 flight plan would call for Saturn V to place the spacecraft and launch vehicle third stage (S-IVB) into a 117-mile circular orbit. After completing two orbits, the third stage would be reignited to place spacecraft into orbit with an apogee of 10 800 miles. After separation from the third stage, the service module propulsion system would be fired to raise the spacecraft apogee to 11 400 miles [292].

NASA Associate Administrator for Manned Space Flight, Dr. George Mueller, announced on November 4 a revised Apollo mission schedule that called for six flights in 1968 and five in 1969 using the "200-series" (Uprated Saturn I) and the "500-series" (Saturn V) launch vehicles to test and qualify Command, Service, and Lunar Modules (C&SM and LM). The schedule for 1968 would include: Apollo/Saturn 204 (AS-204), first unmanned test of LM in earth orbit; AS-502, second unmanned flight test of Saturn V and Apollo C&SM; AS-503, third unmanned test of Saturn V and C&SM; AS-206, second unmanned flight test of LM in earth orbit; AS-205, first manned Apollo flight, a 10-day mission to qualify C&SM for further manned operations; and AS-504, first manned Apollo flight on Saturn V to provide experience with both C&SM and LM, including crew transfer from C&SM to LM and rendezvous and docking. The schedule for 1969 would include five manned flights (AS-505 through AS-509) with the first four programmed as lunar mission



Saturn IB second stage/Saturn V third stage (S-IVB), McDonnell Douglas Co., prime contractor

S-IU-503 during installation of retrofit kit to umbilical quick disconnect mechanism, IBM facility, Huntsville

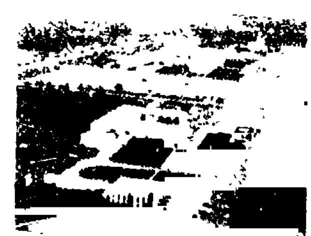


F-1 test facilities, Edwards AFB

Seal Beach, S-II facilities, looking west

Saturn V flight vehicle in VAB-KSC

MTF, meteorology lab



MTF, laboratory and engineering complex, looking north development flights or lunar mission simulations - AS-509 being that flight in which the lunar landing would be made [293, 294].

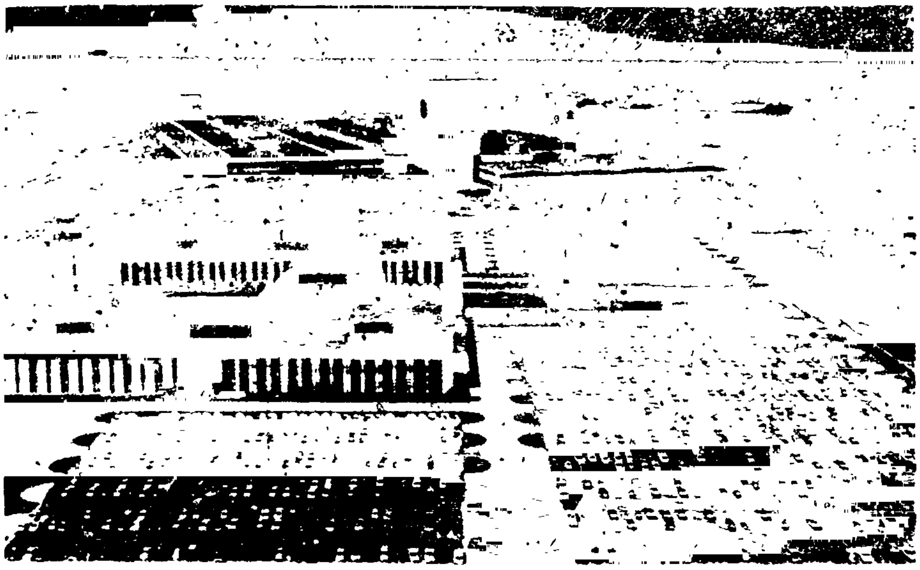
NASA reached a critical point in the Apollo Program with the Apollo 4 flight (AS-501) on November 9, an "all-up" launch from LC-39 at KSC. The flight, termed "perfect" based on evaluation of flight data, demonstrated that the spacecraft, heat shield, and lunar rocket met program requirements. S-IC stage lox depletion sensors signaled S-IC outboard engine cutoff at 150.8 seconds after launch. The second burn, lasting 300 seconds, injected the spacecraft into an orbit with an apogee of 9301 nautical miles. Spacecraft reentry occurred at 400 000 feet, at a flight path angle of -7.077 degrees with an internal velocity of 36 537 feet per second. The CM landed upright within 9 nautical miles of the planned landing point in the Pacific Ocean, 8 hours 37 minutes 8 seconds after launch. The CM was recovered by divers from the carrier *USS Bennington* 2 hours 14 minutes after splashdown. Post-launch examination revealed that the aft heat shield was heavily charred but that crew-compartment-heat-shield charring was less than expected. The spacecraft windows were undamaged, but moisture existed between the micrometeoroid and heat shield panels of the rendezvous window, and the spacecraft contained approximately 2 quarts of sea water taken in through the relief valve. Apollo 4's flight was the first of two or three missions designed to qualify Saturn V for manned flight, and the first test of the structural integrity and compatibility of launch vehicle and spacecraft. Heat shield design, S-IVB restart, structural/thermal integrity, compatibility of launch vehicle and spacecraft, and ground support had been proven [295-299].

The blastoff of Saturn V at KSC produced one of the loudest noises in history, natural or man-made, according to a November 9 announcement by Columbia University's Lamont Geological Observatory, located in Palisades, New York. Observatory physicist Dr. William Donn labeled U.S. and U.S.S.R. nuclear explosions as the only louder manmade sounds, and the 1883 fall of the Great Siberian Meteorite as the only louder natural sound on record [300].

Dr. von Braun announced by letter to all MSFC personnel on November 9, 1967, an expected cut of 700 people in the Center's authorized employment strength. He advised that the cut might become necessary because of a reduction in NASA's FY-1968 budget to be announced by the Senate Appropriations Commitee. Figured on the basis of 7183 permanent Civil Service personnel at MSFC at the start of 1967, this would be a cut of approximately 10 percent [301].

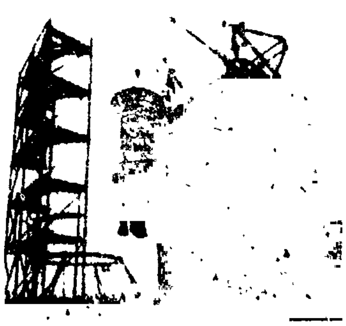
By letter and speech on November 15, 1967, Dr. von Braun gave his personal congratulations to MSFC Civil Service and contractor employees for their work in making the first Saturn V, Saturn/Apollo 501, successful in its mission. The MSFC Director stated, "... the success of 501 gives us renewed hope for meeting the original goal of landing men on the moon in 1969" [302].

On November 20 NASA named crews for the first two manned Saturn V/Apollo flights. As prime crew for AS-504 (first mission), scheduled for 1968, it names James A. McDivitt, commander; David R. Scott, CM pilot; and Russell L. Schweickart, LM pilot. Backup crew would be Charles Conrad, Jr., commander, Richard F. Gordon, CM pilot; and Alan L. Bean, LM pilot. Prime crew for AS-505 (second mission), scheduled for



Michoud, aerial view of engineering building and manufacturing area

Testing of S-II battleship test stage



Installation of S-II-4 in test stand at MTF

DATE	DURATION (SEC) PLANNED	DURATION (SEC) ACTUAL	RESULTS
*NOV 9 64	IGNITION	IGNITION	SUCCESSFUL
*NOV 21 64	TRANSITION	TRANSITION	SUCCESSFUL
*NOV 26 64	10	1.3	PREMATURE CUTOFF TEMP OVER LIMIT
*DEC 11 64	10	10	SUCCESSFUL
APR 24 65	IGNITION*	IGNITION	SUCCESSFUL
MAY 1 65	10	IGNITION	PREMATURE CUTOFF FALSE SIGNAL
MAY 5 65	10	1.2	PREMATURE CUTOFF FALSE SIGNAL
MAY 7 65	10	10	SUCCESSFUL
JUN 9 65	25	8	LOST PREP COMPLETE SIGNAL
JUN 15 65	25	5	LOST PREP COMPLETE SIGNAL
JUN 17 65	25	TRANSITION	PREMATURE CUTOFF SLAM PRESS SWITCH
JUN 26 65	25		PREMATURE CUTOFF GAS GEN OVERHEAT
JUL 13 65	25	2.86	MANUAL CUTOFF FAULTY CONNECTION
JUL 13 65	25	27	SUCCESSFUL
JUL 16 65	150	14	MANUAL CUTOFF FALSE INDICATION
JUL 20 65	150	150	SUCCESSFUL
JUL 27 65	FULL	IGNITION	IGNITION CUTOFF FAULTY PROBE
JUL 27 65	FULL	60	MANUAL CUTOFF FALSE SIGNAL
JUL 30 65	FULL	65	AUTOMATIC CUTOFF LOST H_2 CONTROL SOLENOID SIGNAL
AUG 3 65	FULL	5	PREMATURE CUTOFF OVER TEMP #2 ENG
AUG 9 65	FULL	FULL	SUCCESSFUL 392 SEC
AUG 12 65	150	104	MANUAL CUTOFF ENGINE FIRES
DEC 22 65	15	1.03	AUTOMATIC CUTOFF FAULTY INDICATION
DEC 28 65	15	1.08	AUTOMATIC CUTOFF FAULTY WIRING
DEC 29 65	15	5.1	MANUAL CUTOFF OBSERVER ERROR
DEC 29 65	15	18	SUCCESSFUL
JAN 12 66	350	354	SUCCESSFUL
FEB 3 66	350	14	AUTOMATIC CUTOFF FAULTY GENERATOR
FEB 7 66	200 350	335	SUCCESSFUL
FEB 22 66	350	69	AUTOMATIC CUTOFF FAULTY GENERATOR
FEB 24 66	350	360	SUCCESSFUL
MAR 4 66	150	150	SUCCESSFUL
MAR 15 66	350	360	SUCCESSFUL

TOTAL ACTUAL FIRING 2766.87 SEC

*SINGLE ENGINE TEST

Test results of S-II battleship test stage

1969, would be Frank Borman, commander; Michael Collins, CM pilot; and William A. Anders, LM pilot. Backup crew would be Neil A. Armstrong, commander; James A. Lovell, CM pilot; and Edwin E. Aldrin, LM pilot. A three-astronaut support team was named for each flight crew: for AS-504 – Edgar D. Mitchell, Fred W. Haise, Jr., and Alfred M. Worden; and for AS-505 – Thomas F. Mattingly II, Gerald P. Carr, and John S. Bull [303].

The S-II-4 stage, more powerful and somewhat lighter than previous S-II flight stages, arrived at MTF on November 26 from the NAR Corporation, Seal Beach, California. Each J-2 engine of this stage had been uprated to produce 5000 more pounds of thrust than had been developed by previous J-2 engines. The lighter weight resulted from the use of thinner propellant tank walls and lighter weight structures [304, 305].

In a November 29, 1967, speech to all MSFC employees, Dr. von Braun told of the official administrative decisions necessary because of a reduction in NASA's FY 1968 budget and also because of the changing nature of MSFC as development of Saturn launch vehicles neared completion. He stated that NASA had directed MSFC to: (1) reduce personnel by 700, to be effective January 13, 1968; (2) reduce travel by 10 percent; and (3) reduce all other administrative costs by 15 percent. Personnel reduction would include 345 wage board and technicians, 120 clerical, 145 business and professional, and 50 engineering positions. Dr. von Braun also stated that the reduction in civil service personnel would be accompanied by a proportionate reduction in support contractor personnel, effective also by January 13, 1968 [306].

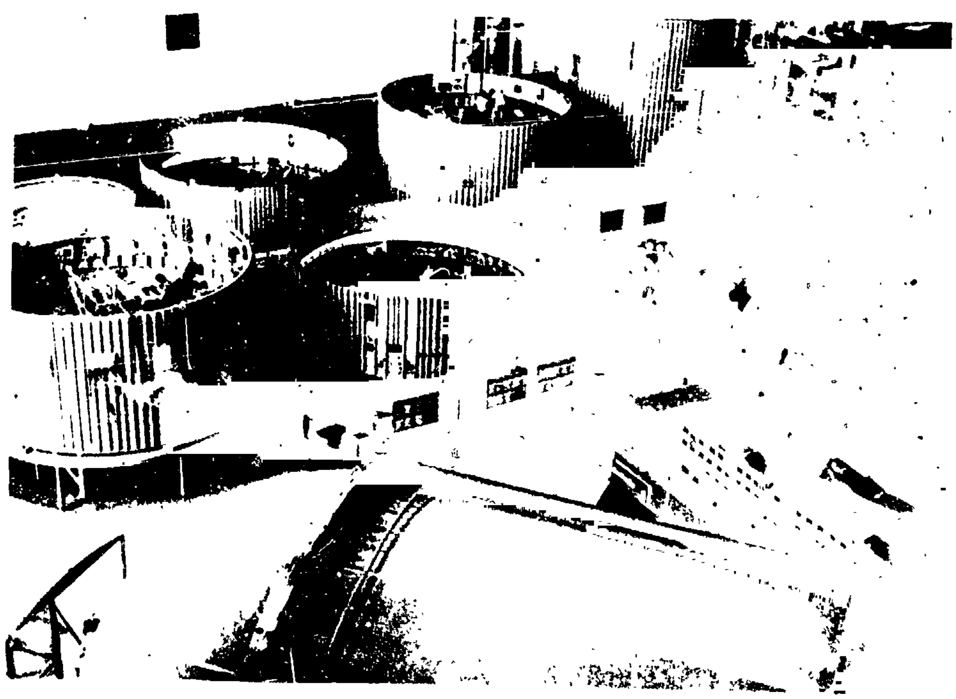
Special personnel notices were delivered to approximately 1200 MSFC employees on December 6, 1967, informing them of reduction-in-force and reassignment actions made necessary by the personnel cut announced the previous week by Dr. von Braun. MSFC was reducing its personnel by 700, 630 employees being laid off, with attrition and other personnel actions accounting for the remainder [307].

Approximately 100 representatives of Government and industry attended an Orbital Workshop design meeting at MSFC December 11-14 to discuss structures, mechanical systems, propulsion, instrumentation, communications, crew station, and electrical systems. At this meeting members formulated plans for a 5-day Orbital Workshop mockup review to be held in late January 1968 with a McDonnell Douglas Corporation mockup containing the most recent design concepts on display [308].

President Lyndon B. Johnson, accompanied by NASA administrator and Mrs. James E. Webb, other officials from NASA Headquarters, MSFC officials, and Louisiana's Governor John J. McKeithen, toured the Michoud Assembly Facility on December 12. While at MAF the President spoke to some 2600 spectators, stating: "We Americans are the first to really enter and the first to understand the Twentieth Century. We will never evacuate the frontiers of space to any other Nation. We will be – we must be – the pioneers who lead the way to the stars" [309].

NASA Administrator James E. Webb and other officials of NASA stopped briefly at MSFC on their return to Washington, D.C., from Michoud. During his stopover Webb

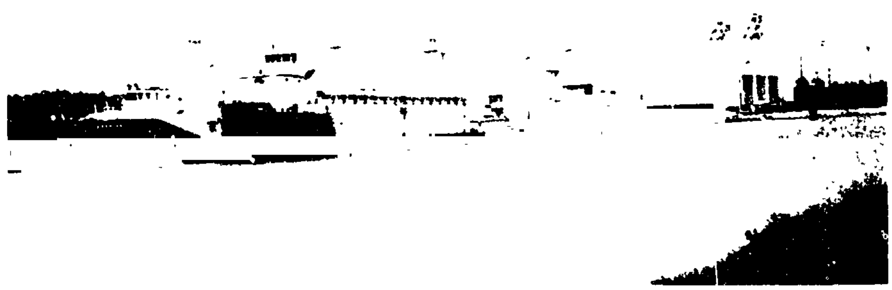
S-IC flight stage, Huntsville



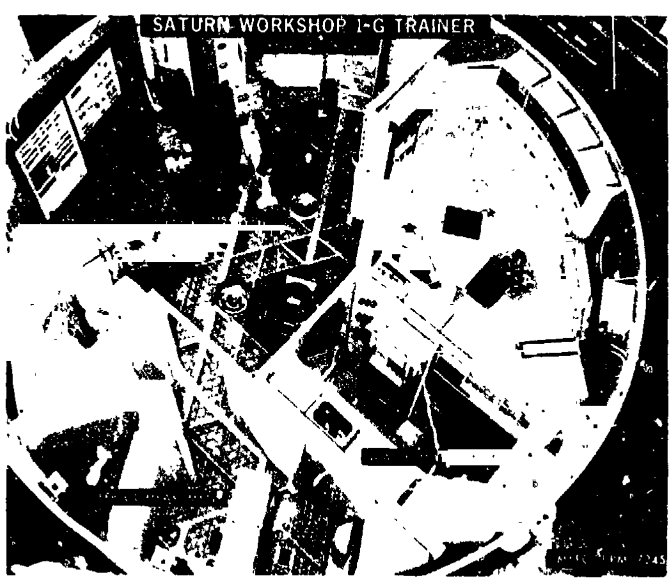
S-IVB production area, Huntington Beach toured the AAP mock area and was briefed by Dr. von Braun and other MSFC executives [310].

On December 29 MSFC announced start of negotiations with CCSD for an extension to the S-IB stage contract to cover four additional S-IB flight stages and related services at an estimated cost of $2.5 million. This would bring to 16 the total number of S-IB flight stages to be developed by CCSD for MSFC [311].

NASA announced on December 31 that, in the final 6 months of 1967, Rocketdyne conducted 100 J-2 engine R&D tests accumulating 14 675 seconds firing time at SSFL and also conducted 35 production engine tests having a total firing duration of 4449 seconds [312]. During this same time Rocketdyne conducted 122 R&D F-1 engine tests at Edwards Field Laboratory (EFL) for an accumulated firing time of 13 254 seconds and at MSFC's West Area Test Stand eight tests that totaled 340 seconds of firing time. Rocketdyne meanwhile conducted 36 production engine tests at EFL totaling 2983 seconds firing time and delivered 11 production engines to NASA [313].

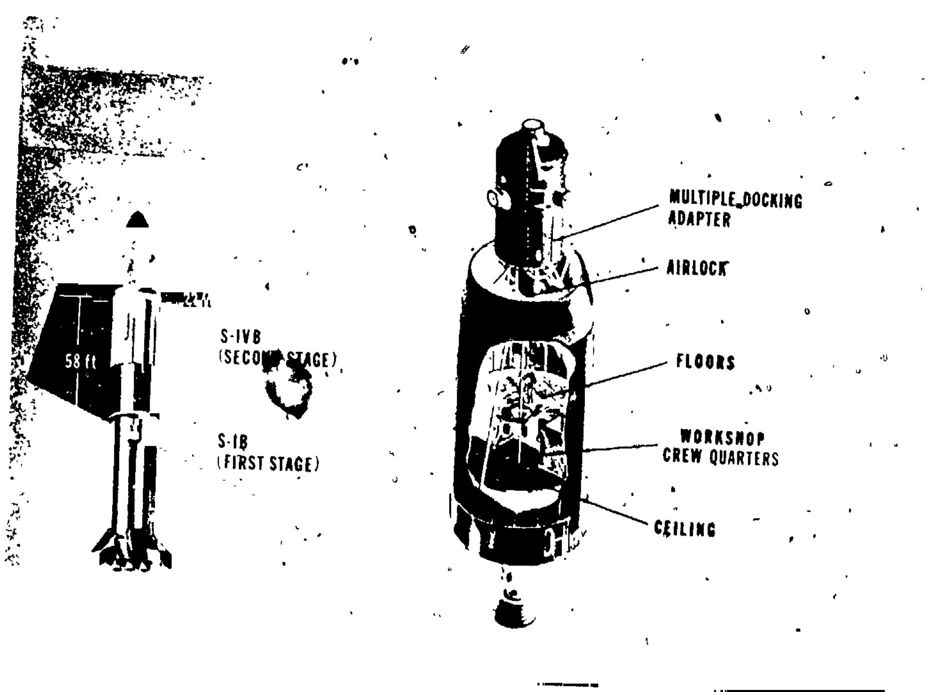


MTF, barges – hurricane precautions



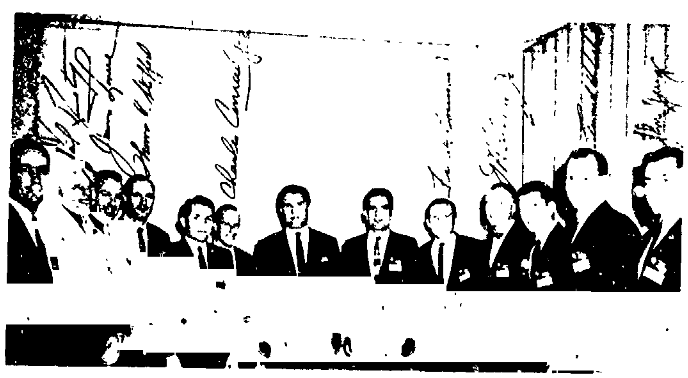
Saturn Workshop 1-g trainer

MTF, Saturn V test complex, looking northwest

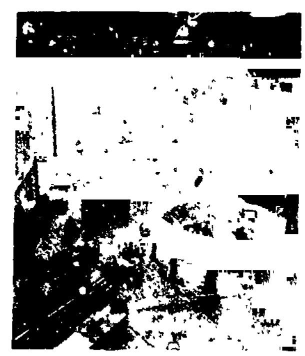


Interior of Orbital Workshop showing common floor – artist's concept

Seal Beach complex

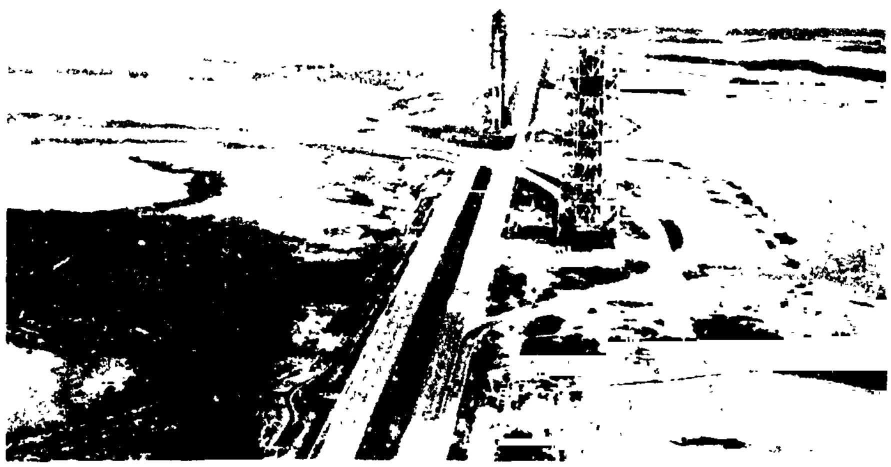


Astronauts assembled at MSFC with Dr. von Braun

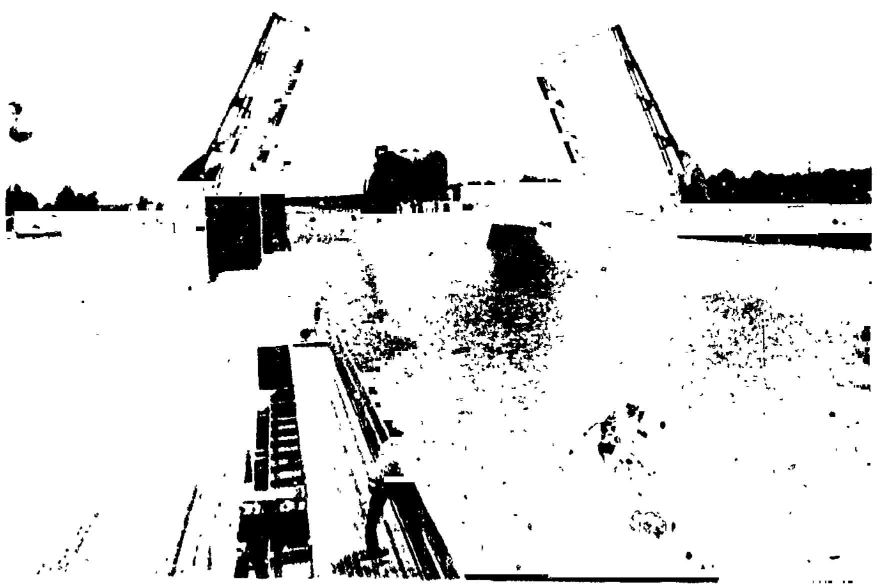


Overall view of high bay east, IBM Huntsville, S-IU-210 in fabrication, S-IU-504 in assembly, S-IU-503 in storage, and S-IU-209 in systems test

S-IU-503 leaving IBM facility, Huntsville

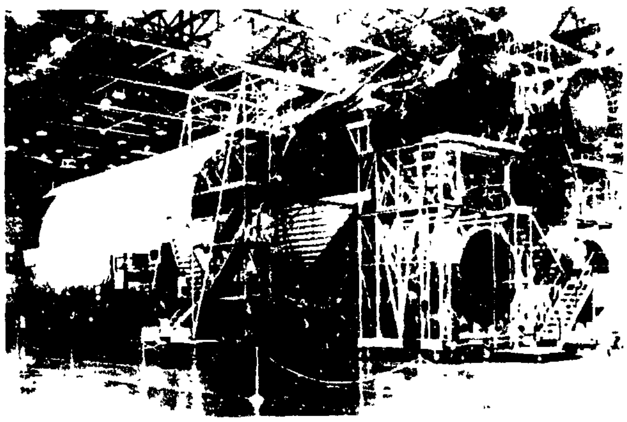


Apollo Saturn V, AS-501 rollout, transfer from VAB to LC 39A

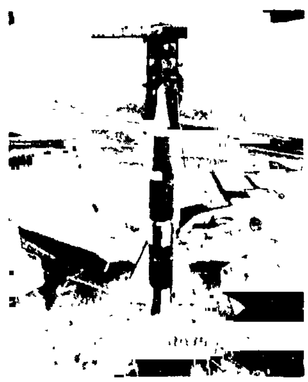


S-IC-5 passing through Bascule Bridge leaving MTF

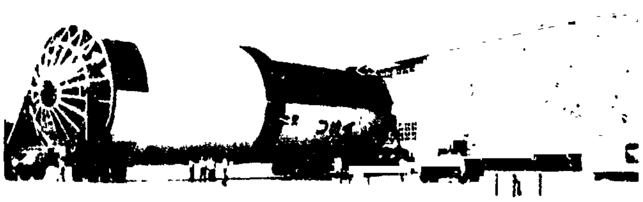
S-IC-5 on Pearl River



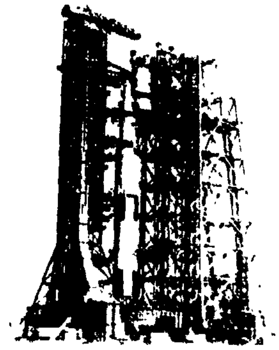
S-IC-8 horizontal installation at Michoud



Saturn 501 from top of mobile service structure, Pad 39A

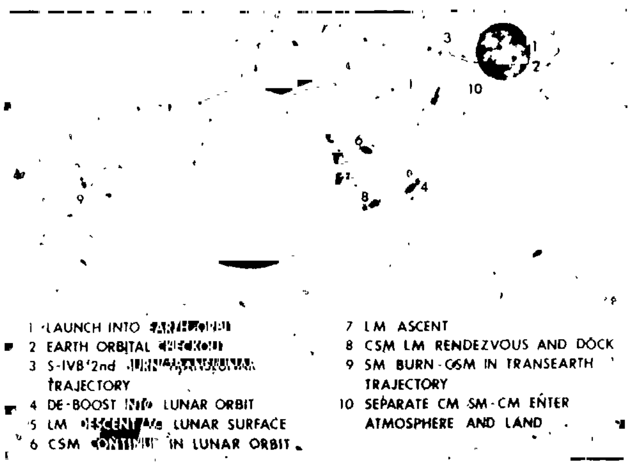


S-IC stages in horizontal area, Michoud

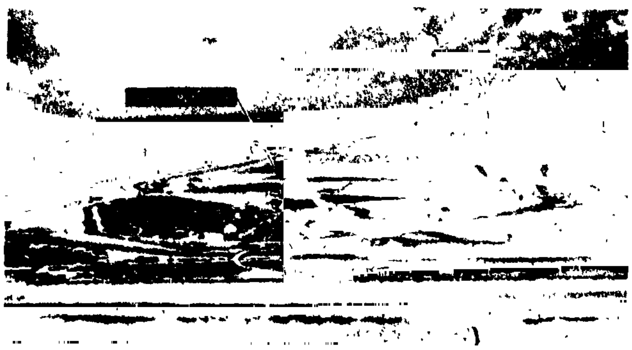


Mobile service structure arriving at LC-39A for Apollo Saturn 501

S-IVB-211 in storage, S-IVB-507 being painted, background; S-IVB-510 aft skirt, S-IVB-510 forward dome, and S-IVB-506 aft interstage, left/right foreground – Huntington Beach assembly building

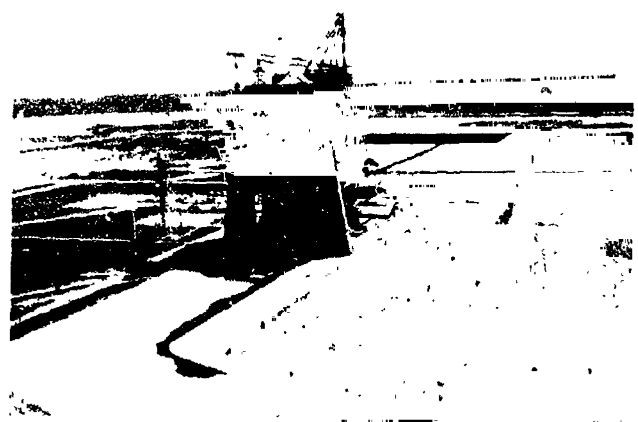


Apollo lunar landing mission, typical profile

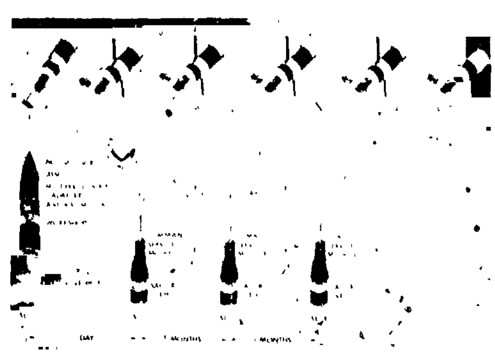


Aerial view of LC-39, KSC

S-IVB-211, Huntington Beach fabrication area



S-II-5 in S-II A-2 test stand at MTF



Skylab activation and operation

1968

On January 5 NASA exercised the second of three 1-year renewal options with the Range Systems Division of Ling-Temco-Vought (LTV) to provide computer services for the major contractors operating at the NASA-Michoud Assembly Facility in New Orleans. The new $2 704 349 extension of LTV's basic cost-plus-award-fee contract was awarded by MSFC for Michoud. The contract, to continue in force until January 8, 1969, would increase the total value of LTV's contract to $7 641 584. NASA had originally selected the Dallas-based firm in December 1965 to provide computer services at the Michoud installation in New Orleans and at its Computer Operations Office in nearby Slidell, Louisiana [314].

On January 9 NASA budgetary restraints required an additional cut in AAP launches. The reduced program called for 12 Saturn IB and 3 Saturn V launches, including one Workshop launched on a Saturn IB vehicle; one Saturn V Workshop; and one ATM. Two lunar missions were planned. Launch of the first Workshop would be in April 1970 [315].

An indication of NASA's varied activities in the Saturn Program is in the Saturn V Weekly Report for January 10 as follows: AS-502 Flight Vehicle (final package) was scheduled for delivery to KSC January 26, 1968; also for the AS-502 flight the final LVDC (flight program tapes) and SLCC (ground tapes) were scheduled for delivery to KSC by February 5, 1968. Status of the AS-503 Flight Vehicle was as follows: all three stages were in the VAB-KSC undergoing inspection and checkout; as for the S-IU-503 for AS-503, adverse weather conditions and mechanical problems with the Super Guppy had delayed the delivery of the IU on-dock KSC from December 29, 1967, to January 4, 1968. Status of the AS-504 Flight Vehicle was: S-IC-4 Stage was in test cell at Boeing-Michoud undergoing modification; the stage was scheduled on-dock at KSC April 15, 1968; S-II-4 Stage for AS-504 was at test stand at MTF undergoing modification work prior to lox/LH_2 tanking test with captive firing scheduled for January 26, 1968, and then the stage was scheduled on-dock KSC March 31, 1968; the S-IVB-504 stage for AS-504 was in the VCL-SACTO and the stage was scheduled for transfer onto Beta I Test Stand for deferred post-firing checkout after completion of Korotherm rework, after which the stage was scheduled on-dock KSC March 31, 1968; the S IU-504 Unit for AS-504 was in storage at IBM-Huntsville, scheduled on-dock KSC April 15, 1968. Status of AS-505 Flight Vehicle was: S-IC-5 Stage was in storage at Boeing-Michoud, scheduled on-dock KSC June 29, 1968; S-II-5 Stage for AS-505 was undergoing shakedown inspection preparation at NAA/SD-Seal Beach, prior to on-docking MTF February 9, 1968, and then on-docking KSC June 29, 1968; S-IVB-505 Stage for AS-505 was in storage at VCL-SACTO, scheduled for on-dock KSC June 29, 1968; and S-IU-505 Unit for AS-505 was in component assembly at IBM-Huntsville, scheduled on-dock KSC June 29, 1968.

NASA announced on January 11 that it would negotiate with CCSD, New Orleans, for assembly and delivery of four additional S-IB stages at a rate of two per year. Earlier NASA had contracted with Chrysler for production of long-lead-time materials, parts, and components for these stages. Work related to this effort would be performed at New

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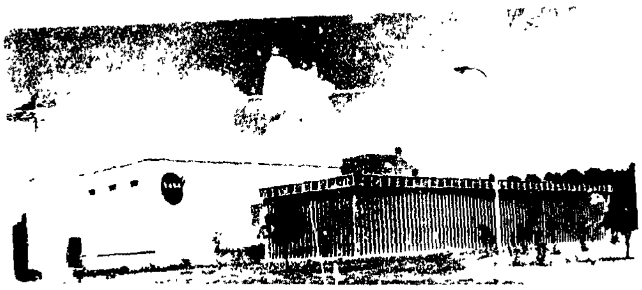
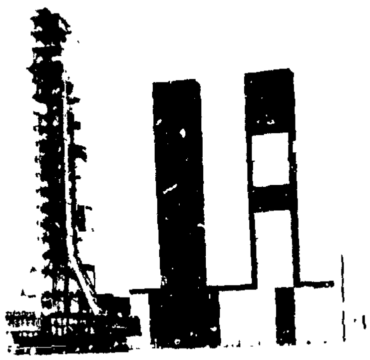


Slidell computer complex

S-IC stage load test at MTF

Vehicle Assembly Building at KSC



Saturn V and mobile launcher on crawler emerging from VAB at KSC

Project Apollo three missions

Orleans under the direction of MSFC. Chrysler presently was under contract with NASA to furnish 12 Saturn IB flight stages [316, 317].

On January 11 NASA began negotiation with McDonnell Douglas, Huntington Beach, California, for assembly and delivery of four additional Uprated Saturn I launch vehicle second (S-IVB) stages at a rate of two per year. The negotiations were expected to result in a contract valued at more than $48 million. Earlier NASA had contracted with Douglas for production of long-lead-time materials, parts, and components for these stages. Work related to this effort would be performed at Huntington Beach under direction of MSFC [318, 319].

NASA awarded Rocketdyne Division, North American Rockwell Corporation a contract on January 11 valued at $14 796 400 for engineering support services for H-1 engines. The H-1 engines would be used to power the first stage of the Saturn IB launch vehicles. Under this cost-plus-incentive-fee agreement, Rocketdyne would be responsible for engineering support services for engine manufacturing, testing, delivery, application, reliability, and flight performance evaluation. The major portion of the work would be at Rocketdyne's Canoga Park, California, plant. Minor segments would be performed at MAF, where the H-1 engines would be installed on the Saturn IB's first stage, and at the Kennedy Space Center's launch complex. The contract would cover the period July 1967 through June 1971 [320, 321].

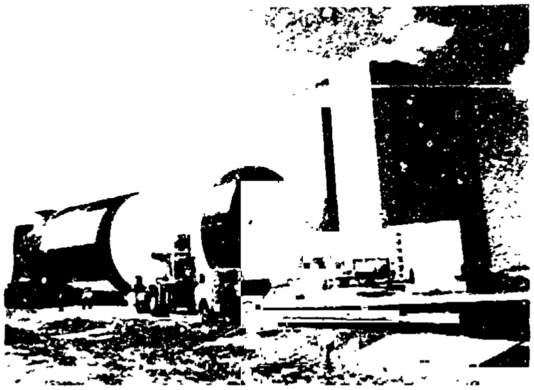
The Federal District Court in Washington, D.C., issued a January 11, 1968, temporary restraining order which postponed the effective date of personnel action in a reduction in force (RIF) at MSFC. The RIF, announced December 6, 1967, had been scheduled to take effect January 13, 1968 [322]. Copies of the order were distributed on January 16 to all MSFC employees [323]. On the same day a five-man committee from NASA Headquarters arrived at MSFC to confer with Center officials on the effect of the order. Lt. Gen. Frank Bogart, Deputy Associate Administrator, Office of Manned Space Flight, was head of the visiting group [324].

On January 16 NASA awarded a letter contract to Martin Marietta for the payload integration effort on the Apollo Applications Program [325].

Also on January 16 MSFC combined the Saturn IB Office and Saturn V Office as a Saturn Program Office under the direction of Lee B. James [326].

NASA announced on January 17 that the Apollo 5 flight, the first test in space of an unmanned lunar module, was being rescheduled for no earlier than Monday, January 22. Reason for the rescheduling was that some launch operations being done for the first time required more time than expected for completion, including the loading of hypergolic propellants aboard the spacecraft. The new schedule would be dependent upon the success of several additional ground tests, including the launch countdown demonstration test, scheduled for completion on January 19 [327].

On the same day the Boeing Company made the final presentation of a study entitled "Saturn V Vehicle With 260-Inch Diameter Solid Motor." The 8-month study investigated

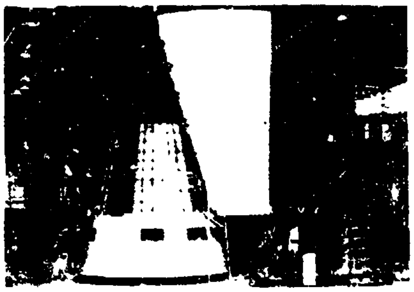


S-IC stage arrival at KSC

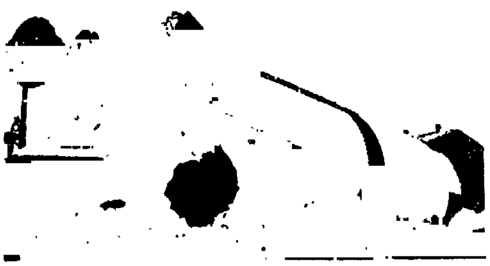
S-IC thrust structure shear webs, Michoud

S-IC engine installation, Michoud

S-IC tank ring baffles, Michoud



S-IC engine fairing fitup, Michoud



First S-IC flight stage – Huntsville

S-IC lox and fuel tanks in assembly building at MSFC the feasibility of using four 260-inch solid rocket motors for a strap-on boost assist to increase Saturn V payload capability [328].

Also on January 17 a mockup of the S-IVB stage to be used as a manned Orbital Workshop was flown to MSFC. The full size model arrived from the West Coast aboard the giant Super Guppy aircraft. The mockup would be used later in the month for a crew station design review. NASA plans called for launching the flight Orbital Workshop as the second stage of the Saturn IB launch vehicle. Once in space, astronauts would convert the stage's large fuel tank into living and working quarters for a 28-day stay. The Orbital Workshop mockup had recently been modified by McDonnell Douglas, manufacturer of the Saturn upper stage for MSFC. This was the mockup's second trip to MSFC; the previous spring engineers had used the model at MSFC in its original configuration for design studies [329, 330].

The director of the 5th Civil Service Region at Atlanta, Georgia, notified MSFC on January 19, 1968, that he had received a total of 416 appeals from MSFC employees involved in the RIF. The MSFC Manpower Office began contacting all personnel who had separated prior to the January 11 injunction to determine whether they wished to have their separation orders cancelled [331].

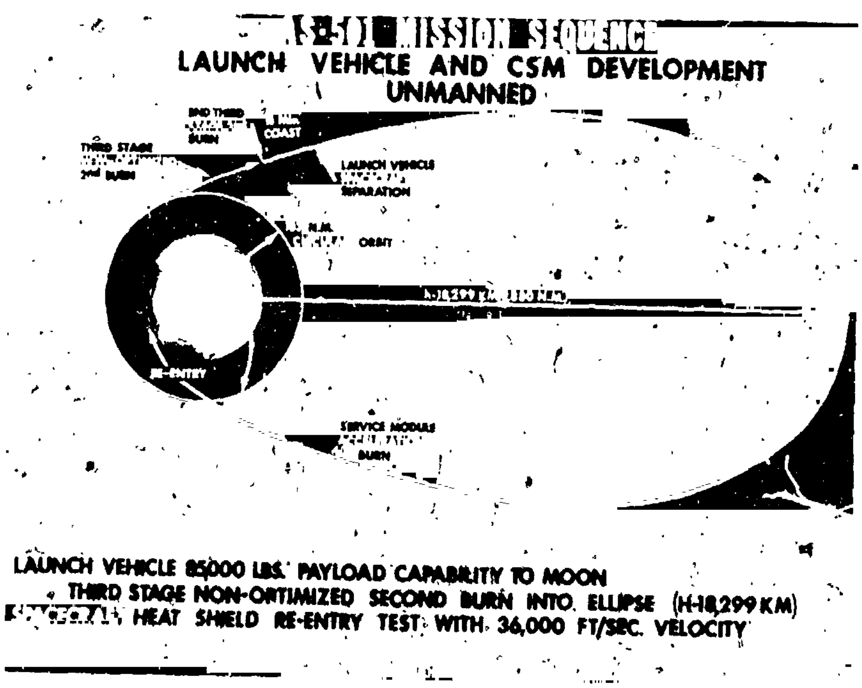
On January 20 Dr. von Braun invited Dr. Gilruth of MSC to send MSC representatives to a long-life hardware symposium at MSFC on March 17-19, 1969. Dr. von Braun stated that he "would like to encourage strong participation from personnel at MSC who are concerned with long duration missions such as the AAP-2/4 and future space stations. Such a meeting should benefit both our centers" [332].

The Saturn IB (AS-204) launch vehicle and the lunar module it orbited on January 22 performed satisfactorily. This Apollo 5 mission began at 4:48 p.m. CST January 22 when the Saturn lifted off Launch Complex 37 at Cape Kennedy after ground support equipment caused a delay of 3 hours 50 minutes. The lift-off came at sundown on a day so clear that both stages were visible to the unaided eye long after stage separation. The S-IB could be seen falling and the S-IVB going on toward orbit when tracking equipment indicated that the second stage was almost 90 miles up and 168 miles downrange. The Saturn hurled the lunar module into space to begin a series of tests of the LM's ascent and descent propulsion systems, the first such test in the vacuum of space [333].

The Post Apollo Advisory Committee, authorized by the NASA Administrator to evaluate and make recommendations on post-Apollo space activities, held a meeting at MSFC on January 25. The committee, headed by Dr. Floyd Thompson, Special Assistant to the Administrator, held three additional meetings – February 15, 1968, at MSC; March 12, 1968, at Headquarters; and March 25 and 26, 1968, at KSC. The report by this committee confirmed the basic objectives of the Apollo Applications Program and played a deciding role in its later evolution [334].

NASA announced on January 30 that shipment of the second Apollo spacecraft lunar module and fifth Saturn IB rocket to KSC would be postponed pending further evaluation of Apollo 5 mission results. Initial evaluation of the first lunar module flight on January 22-23 had indicated that a second unmanned flight, launched by the Saturn

MTF, S-IC, S-II booster storage and harbor area



AS-501 mission sequence

IB, might not be required to qualify the spacecraft for flight with men aboard. Further detailed review of flight data and deliberations by a NASA design certification review board in March would determine the final decision. Meanwhile the Lunar Module 2 and the Saturn IB rocket stages would be maintained ready for shipment to KSC on 3- and 14-day notices, respectively. Refurbishment of LC 37B would proceed for a second unmanned lunar module flight. The Mission Control Center, Houston, and tracking ships *Coastal Sentry Quebec* and *Rose Knot Victor* would maintain the operational capability to support another unmanned lunar module flight [335].

By the end of January an Orbital Workshop engineering mockup simulating the flight vehicle had been readied for an extensive 5-day crew station review February 12-16 at MSFC. During the review several astronauts were scheduled to "walk through" many tasks on the ground that would later be done in orbit under zero gravity conditions. These tasks would include experiment installation and operation. Lighting tests were being conducted during the week in the Orbital Workshop mockup by engineers of the MSFC Propulsion and Vehicle Engineering Laboratory. P&VE was the lead laboratory for the development of the Workshop [336].

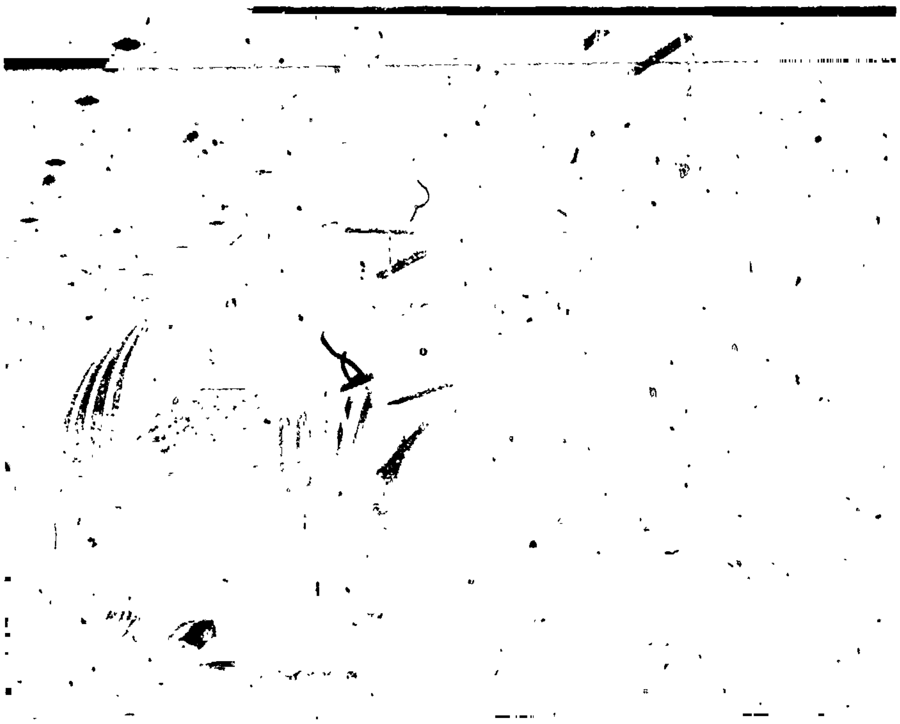
During January NASA Headquarters affirmed several project name changes. The intermediate Saturn launch vehicle formerly called "Uprated Saturn I" was officially designated IB. The ground-outfitted Orbital Workshop, sometimes called the "dry workshop," would henceforth be known as the Saturn V Workshop. The Workshop to be launched by the Saturn IB, formerly referred to as "Orbital Workshop" and "wet workshop," would be officially named Saturn I Workshop [337, 338].

During January NASA and Rocketdyne decided to move the site of H-1 engine production from Air Force Plant No. 65 at Neosho, Missouri, to Canoga Park, California [339].

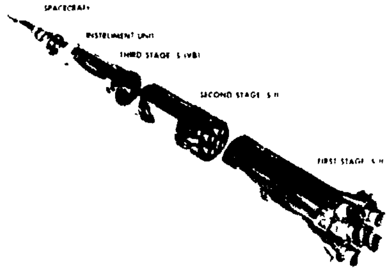
The S-II stage for the fifth Apollo/Saturn V mission left Seal Beach, California, on February 2 aboard the *USNS Point Barrow* enroute to the MTF, where the stage would undergo static testing before shipment to KSC. Also on board the ship was an F-1 rocket engine. This combination load saved an estimated $6000 in transportation charges. The F-1 would be unloaded for inspection at MAF, where the stage would be transferred to a barge for the remainder of the trip to MTF [340].

The AS-502 transfer to Pad A of Launch Complex 39 occurred on February 6 at KSC. However, the scheduled transfer of the Mobile Service Structure (MSS) to the pad was delayed for 3 days because of high winds [341].

Also on February 6 NASA negotiated an additional 1-year contract with the Boeing Company for operation of the Saturn V Development Facility at MSFC. The $5 782 750 incentive contract would continue through September 1968. The original award was made in September 1964. The Saturn V Development Facility, often called the "Saturn V breadboard," would electrically simulate the operation of the Saturn V and its ground and electrical support equipment. Each step at the launch site, through lift-off and flight of each stage, could be computer-simulated at the facility [342].



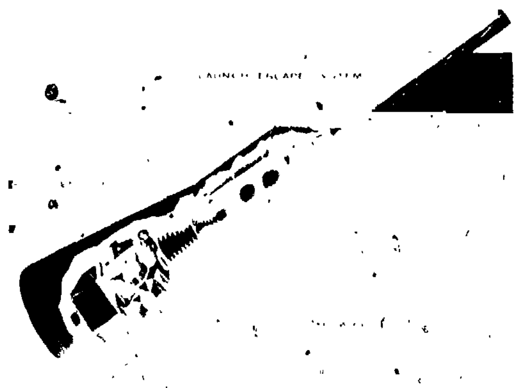
S-IC flight stage, Michoud



Artist's concept of Apollo/Saturn V launch vehicle

S-IC in transit – MTF

Skylab crew quarters layout



Apollo spacecraft

On the same day the Senate confirmed the nomination of Dr. Thomas O. Paine as NASA Deputy Administrator, to succeed Dr. Robert C. Seamans, Jr. [343].

On February 7 NASA added a \$3 226 374 supplemental clause to the Boeing Company's Saturn V systems engineering and integration contract. The contract extension would be effective through December 1969. Under this contract Boeing would be responsible for providing NASA with Saturn V propulsion systems preflight and postflight performance analysis for the first 10 Saturn V launch vehicles. Boeing would study all of the propulsion system data recorded during the vehicles' test firings and launches for a complete analysis of Saturn V propulsion system performance. All work would be conducted at Boeing facilities in Huntsville. This extension brought the systems engineering and integration portion of Boeing's three-part Saturn V contract to a total of \$194 845 024. Meanwhile, under separate agreements, Boeing remained responsible for Saturn V booster production at MAF and for launch support services at KSC [344].

Transfer of the Mobile Service Structure for AS-502 to the pad, delayed on February 6 because of high winds, occurred on February 9 [345].

As of February 9 MSFC Civil Service employee strength was 6685, or 299 above the 6386 ceiling authorized by NASA Headquarters [346].

The first full-duration captive rocket firing at MTF in 1968 was successfully completed on Saturday, February 10, ushering in the busiest year to date for the rocket testing center. Space engineers and technicians static-fired the fourth flight version of the Apollo/Saturn V second stage (S-II-4) for its full duration of 6 minutes. The huge liquid-hydrogen-fueled rocket developed an equivalent thrust of more than 1 million pounds. A North American Rockwell crew conducted the captive firing with the rocket locked in a 200-foot-tall tower. The captive firing was one of a series of special checkouts the stage would go through at the Mississippi proving ground before it would be certified for later flight from KSC in the manned lunar landing program. NASA engineers and scientists would carefully evaluate approximately 1000 separate measurements taken from the rocket before a flight worthiness certificate would be issued. MTF was scheduled to test-fire, check, and flight-certify eight more Apollo/Saturn space vehicles in 1968 – four of the S-II second stages and four S-IC first stage rockets [347].

During February 12-14 a group of 12 scientist-astronauts, appointed to the space program 6 months earlier, visited MSFC. Purpose of the visit was to acquaint the new group with Marshall Center work, including development of the Saturn vehicles. They also saw an engineering mockup of an Orbital Workshop - a vehicle that would some day house astronauts for extended stays in space. The astronauts who visited the Center, all of them with doctoral degrees, were Robert A. Parker, Brian T. O'Leary, and Karl G. Henize, astronomers; John A. Llewellyn, chemist; Joseph P. Allen, Philip K. Chapman, and Anthony W. England, physicists; William B. Lenoir, engineer; F. Story Musgrave, physiologist; and William E. Thornton and Donald L. Holmquest, medical doctors [348].

The Office of Manned Space Flight at NASA Headquarters issued a teletype on February 20 authorizing MSFC to proceed with procurement of long-lead items for S-IC-16 and S-IC-17, the boosters for Saturn V vehicles beyond the approved 15 vehicle production program [349].

S-II-4 removal from vertical checkout building at MTF

Saturn V

Simulated weightlessness activity in S-IVB Orbital Workshop mockup at Huntington Beach

S-II flight stage erection at MTF

Congressman George Miller of California, Chairman of the House Committee on Science and Astronautics, headed a Congressional group visiting MSFC on February 22, 1968. The group received a briefing on the Apollo Applications Program and presented to the Center a portrait of Dr. Wernher von Braun painted by Victor Lailier [350].

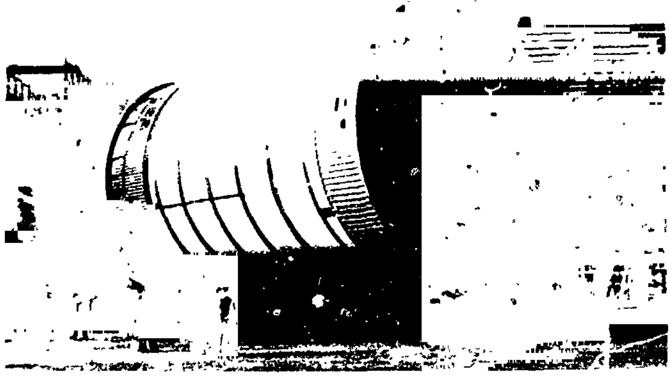
By the middle of February NASA had announced that the first Americans on the moon would land in one of five 3-by-5-mile landing areas selected by NASA's Apollo Site Selection Board. Each of the areas would satisfy criteria in which astronaut safety was the paramount consideration. The first two sites selected by NASA were in the Sea of Tranquility, the third in the Central Bay, and the fourth and fifth were in the Ocean of Storms. The sites were selected from eight under study from a choice of 30 original sites. Selection of the five permitted scientists and engineers to concentrate on fewer areas in preparing data on the specific sites. The site selection board studied material obtained by unmanned Lunar Orbiters and soft-landing Surveyor spacecraft. Lunar Orbiter returned high resolution photographs of all the sites, and Surveyor provided close-up photos and surface data of the general areas in which they were located. The criteria considered by the board included smoothness of the area, desirability in terms of amount of propellant necessary for the lunar module propulsion systems, lighting as it concerned the best visibility by astronauts, and the general slope of the landing area [351].

Near the end of February minor problems necessitated the rescheduling of Saturn flights. Discovery by MSFC officials of tiny weld flaws in the Saturn V second stage prompted scheduling of a new test series before the flight could be manned. Although none of the flaws was considered serious enough to cause failure, it was decided to conduct cryogenic proof testing on March 18-25 with the Saturn V "fourth flight version." Meanwhile delays in the normal test and checkout procedures in the Apollo 6 space vehicle being prepared for launch at KSC resulted in a slippage of the launch date from March 21 to March 25. Problems encountered, none of which were major, included such items as modification of the spacecraft service module propulsion tanks, problems with replacing the inertial measurements unit in the spacecraft guidance and control system, and changing the eight actuators on the first stage outboard engines and resulting interactions with normal test activities. No one item could be exclusively identified as being the major delaying factor, but the accumulated effect of the corrective actions resulted in a 4-day delay in the checkout schedule [352, 353].

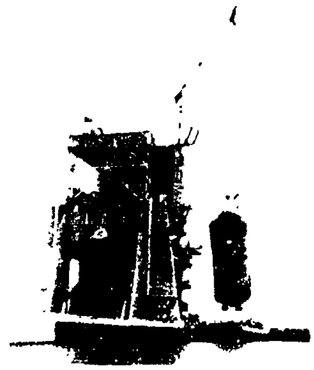
Dr. von Braun commented on March 12: "If AS-502 is successful, there will be no need for a third unmanned Saturn V flight" [354, 355].

By the middle of March all three static test stands at the Mississippi Test Facility were filled with Apollo/Saturn V flight stages for the first time. Two of the stands contained second stages for the fourth and fifth Apollo/Saturn V rockets. A third was holding the 7.5 million pound thrust booster that would lift the sixth Apollo/Saturn V off its KSC launch pad [356, 357].

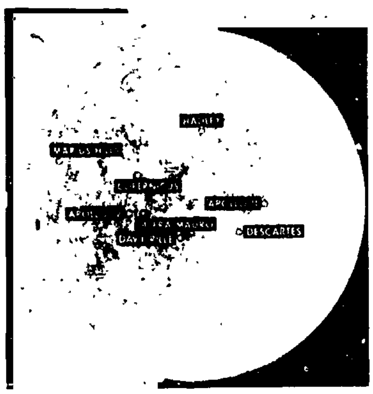
On March 19 NASA released the findings of an Investigating Board appointed to examine and report on the June 8, 1967, rupture of a test tank at MSFC in Huntsville which resulted in the deaths of two employees of Brown Engineering Company of Huntsville, a NASA subcontractor. NASA's release said in essence that the rupture of the test tank was apparently caused by internal pressure which exceeded the tank limits [358].



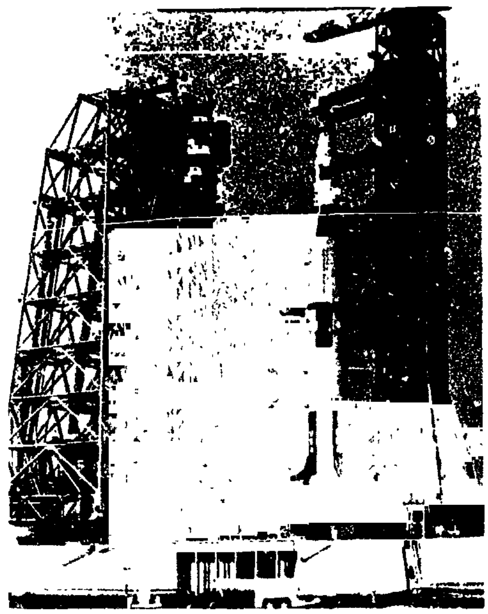
S-II stage on transporter, Seal Beach



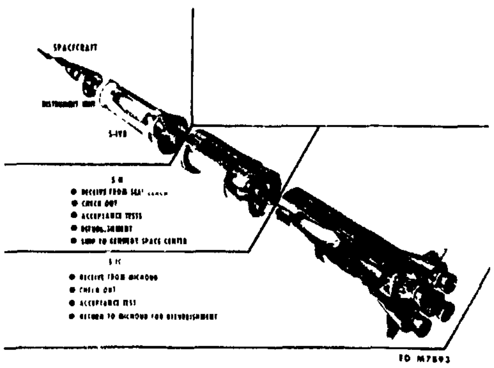
Removal of S-II-4 from A2 stand at MTF



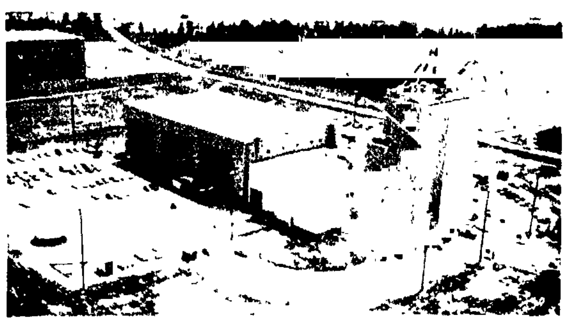
Lunar exploration sites



Mobile service structure moving onto Pad 39A at KSC



Apollo/Saturn vehicle assignments



S-II stage storage and vertical checkout facility at MTF

On March 19 and 20 more than 100 engineers and scientists participated in a 2-day Saturn I Workshop design review board meeting at MSFC. The engineers discussed results of previous Workshop reviews including the original engineering design review in May 1967, a documentation study in December, and a week-long crew station review February 12 16 at MSFC. Meeting participants represented the Manned Spacecraft Center, Kennedy Space Center, NASA Headquarters, and the McDonnell Douglas Corporation, manufacturer of the Saturn S-IVB stage. A Workshop mockup had been used at MSFC for earlier design work. Chairman of the design review board was Leland Belew, manager of Marshall's Saturn/Apollo Applications Office [359].

After a two month's delay caused by the temporary restraining order issued by the Federal District Court in Washington, MSFC began issuing RIF notices, at a much lower rate than its December 6 RIF action. That action had involved approximately 1200 MSFC employees in reduction-in-force and reassignment roles. The new action involved less than one-sixth that number [360].

On March 27 test personnel at MSFC mounted an ST-124M Saturn V guidance platform in the F-1 Engine Stand and subjected the test article to a 30-second F-1 engine static firing. The objective was to measure the vibrational and acoustical effects of this exposure on the ST-124M. Similar tests in the F-1 Engine Stand had also occurred on March 12 and March 19 [361].

NASA decided during the third week in March that a second unmanned flight of the lunar module would not be necessary. The first manned LM flight would be made later in the year, launched by a Saturn V vehicle. The decision to cancel the repeat flight of an unmanned LM followed a detailed evaluation of the first LM flight, flown January 22 atop a Saturn IB launch vehicle. Data from a comprehensive examination of the LM's structural and ground test results were also thoroughly analyzed [362, 363].

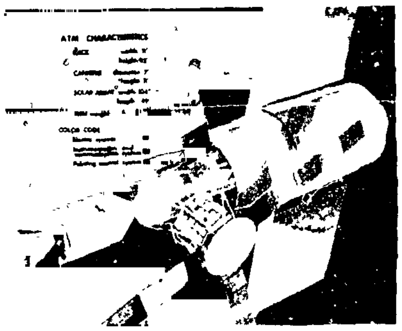
On March 28 MSFC decided that "it would be in the best interest of the space program to transfer S-IC and S-IB stage procurement responsibilities from the Michoud Assembly Facility to Huntsville [364, 365].

The schedule for launch of the AS-502 vehicle slipped 13 days during March, primarily because of a problem with the A7-64 propellant disconnect. Two days of slippage were attributed to problems with the S-II-2 stage [366, 367].

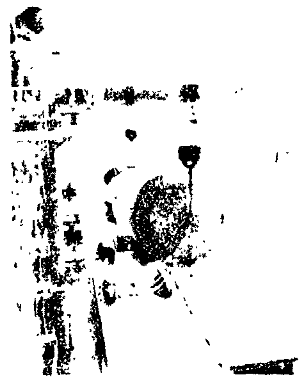
During March workmen completed structural assembly of the 75-foot-diameter Neutral Buoyancy Tank in Huntsville and filled the tank with water. Also completed were the recompression chamber, the diving belt, the airlock system, and the breathing air system. Installation of instrumentation and cabling was in process [368].

On April 1 MSFC transferred from MAF to Huntsville the administration of the Chrysler and Boeing prime contracts involving the Saturn IB and Saturn V programs, respectively [369].

The AS-502 (Apollo 6) launch countdown began at LC-39A at KSC on April 3 [370].

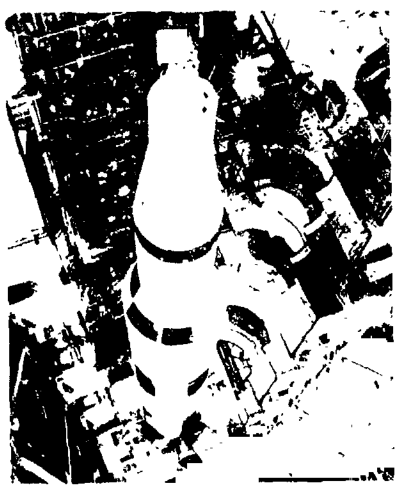


Skylab concept

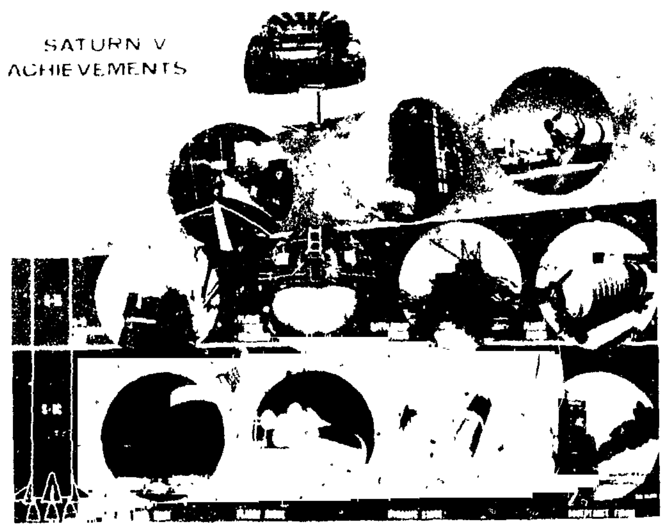


Installation of S-IC-6 in test stand at MTF

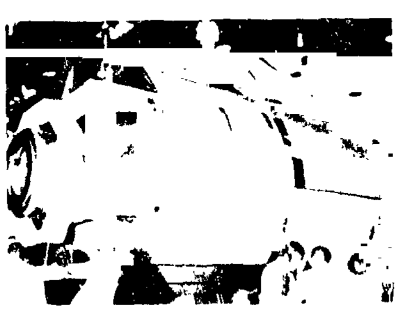
Installation of S-II 5 into A-1 stand at MTF



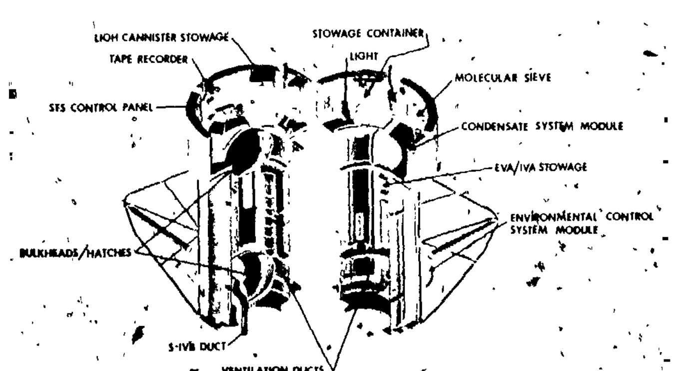
Saturn V in high bay area VAB at KSC



Saturn V achievements



MDA dynamic test article – Denver



Airlock Module internal arrangement

On April 4 NASA successfully launched Apollo 6 from KSC's Complex 39A at 7:00 a.m. EST on a mission to qualify the Saturn V launch vehicle for future manned space flights. Primary objectives were to demonstrate structural and thermal integrity and compatibility of launch vehicle and spacecraft; confirm launch loads and dynamic characteristics; demonstrate S-II/S-IC and S-IVB/S-II stage separations; verify operation of propulsion (including S-IVB restart), guidance and control (optimum injection), and electrical systems; evaluate performance of Emergency Detection System (EDS) in closed-loop configuration; and demonstrate mission support facilities and operations required for launch, mission conduct, and CM recovery [371] The launch vehicle second-stage performance was near nominal, but two of the five second stage J-2 engines shut down prematurely, causing the remaining second- and third-stage engines to burn longer than planned [372]. As a result, the spacecraft and third stage entered elliptical parking orbit with a 223.1 mile (395.1-kilometer) apogee, 107-mile (172.1-kilometer) perigee. When the third stage failed to re-ignite on command after two orbits as planned, NASA switched to an alternate mission, firing the Service Propulsion System (SPS) to place the spacecraft into trajectory with a 13 823-mile (22 225.4-kilometer) apogee [373]. Since insufficient propellent remained after the extended burn, a second SPS burn was not attempted, and the CM reentered at 22 376 miles per hour, just under the planned 25 000-mile-per-hour rate. The spacecraft splashed down 50 miles off target in the Pacific Ocean 9 hours 50 minutes after launch and was recovered in good condition by the *U.S.S. Okinawa*. Preliminary assessment indicated that four of the five objectives were attained, even though the launch vehicle performance of the S-IVB restart and guidance control (optimum trajectory) were not fully successful [374].

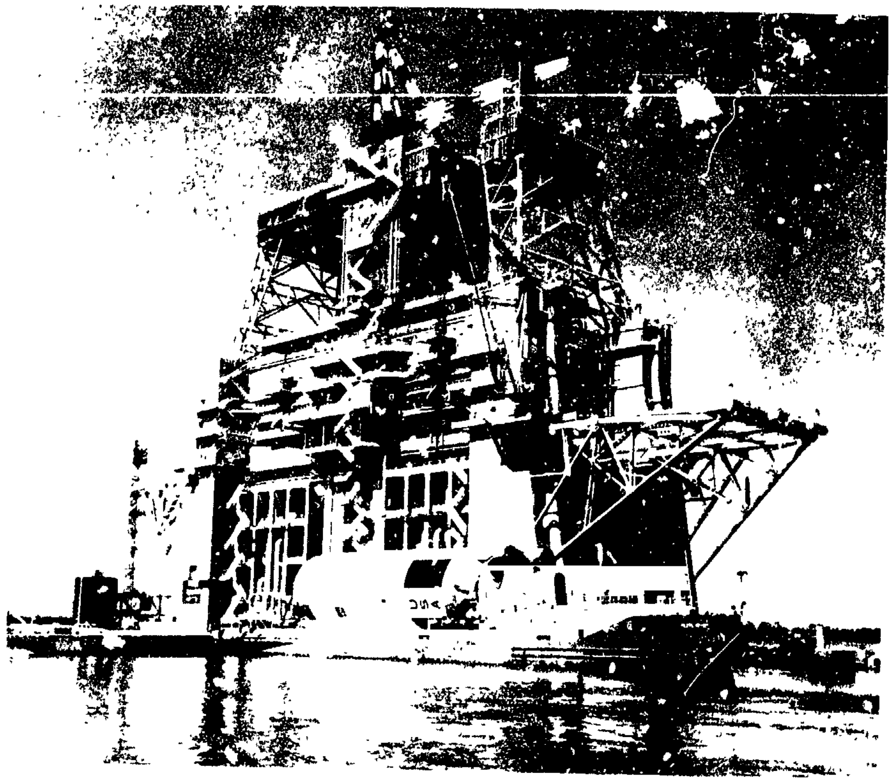
At the third in a series of monthly meetings, on April 4, the MSFC Manpower Utilization and Administration Office staff and administrative officers of MSFC heard a presentation of a summary of final RIF actions at the Center. The actions included 57 terminations, 68 reassignments in the same grade, and 49 changes to lower grade, for a total of 174 actions [375].

MSFC announced on April 4 that launch damage to LC-39A facilities, subsequent to the launch of AS-502, was less than expected, indicating the effectiveness of modifications subsequent to the AS-501 launch. Service arm damage, however, was more extensive than experienced in the AS-501 launch [376].

On April 17 MSFC awarded a 9-month, $99 000 contract for habitability studies of Saturn I and Saturn V Workshops. The contract award went to Raymond Loewy/William Snaith, Incorporated [377].

A technical review of Saturn launch vehicles, attended by about 140 scientists, engineers, and administrators, was held at MSFC April 20-21. The participants investigated the status and flight schedule of Saturn launch vehicles [378, 379].

On April 22, 23, and 24, Dr. Thomas O. Paine, newly appointed Deputy Administrator of NASA, visited MSFC and its subsidiary facilities, MAF and MTF, with a party of NASA Headquarters and MSFC officials. Dr. Paine toured the facilities, heard briefings on the functions and programs of the Center, and witnessed a static firing of an S-IB stage [380, 381].



Stage at base of S-IC stand at MTF

S-IC firing at MTF

During the week of April 22 MSFC directed Boeing to delay static firing of S-IC-6 until modifications could be incorporated into the stage to alleviate the pogo effect oscillations experienced in the AS-502 launch [382].

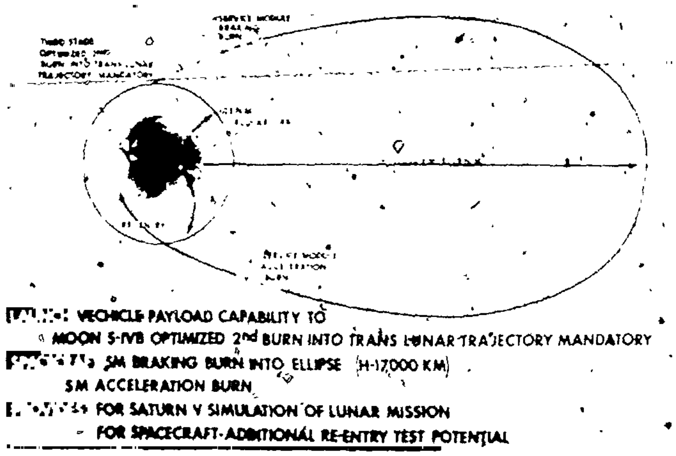
On April 23 S-IB-12, the last of the Saturn IB flight boosters, was shipped from MAF to Huntsville aboard the NASA barge *Palaemon*.

NASA announced on April 27 that the AS-503 launch vehicle would be manned and that the launch would be scheduled for the fall. The manned flight would occur in the fourth quarter of 1968. Two previous flights of the Saturn V had been unmanned, but on the basis of data thus far obtained from the second unmanned flight, on April 4, NASA decided to plan and work toward a manned flight with the third Saturn V vehicle. "However, we will retain the option of flying another unmanned mission if further analysis and ground testing indicate that it is the best course," said Maj. Gen. Samuel C. Phillips, Apollo program director. Before NASA made its decision, NASA and industry engineers worked virtually around the clock to determine the causes, effects, and solutions of several problems experienced in the April 4 flight. These included: premature shutdown of two J-2 engines in the second stage (S-II) of the Saturn V; failure of the third stage J-2 engine to re-ignite in orbit; a longitudinal oscillation, or pogo effect, caused by synchronous vibration of the five F-1 engines in the first stage; and an indication that some material fell away from the area of the spacecraft/lunar module adapter. Information developed by the time of the NASA April 27 announcement indicated that the early shutdown of the two second stage engines began with the failure of a small fuel line in the Number 2 engine ignition system. "We are confident that we know the cause, effects, and solutions involving the J-2 engine failure and the launch vehicle longitudinal vibration problems," said Gen. Phillips. "Analysis and ground testing will continue to achieve an even more complete understanding of all aspects of Saturn V performance and operation [383].

NASA Director of the Apollo Applications Program, Charles W. Mathews, on April 25 assigned responsibility for overall systems engineering activities to MSFC, responsibility for the implementation of all flight operations and recovery activities to MSC, and responsibility for the implementation of all launch operations to KSC. In terms of Center responsibilities for flight hardware elements he assigned to MSFC the Saturn IB; Lunar Module Ascent Modifications; Workshop, Airlock, and MDA; ATM; and assigned experiments, including Workshop habitability experiments. He assigned MSC the responsibilities for Command and Service Modules, and any required modifications thereto; Crew Systems (pressure suits, EVA equipment, etc.); Medical Equipment; Food; and Assigned Experiments, including medical experiments [384].

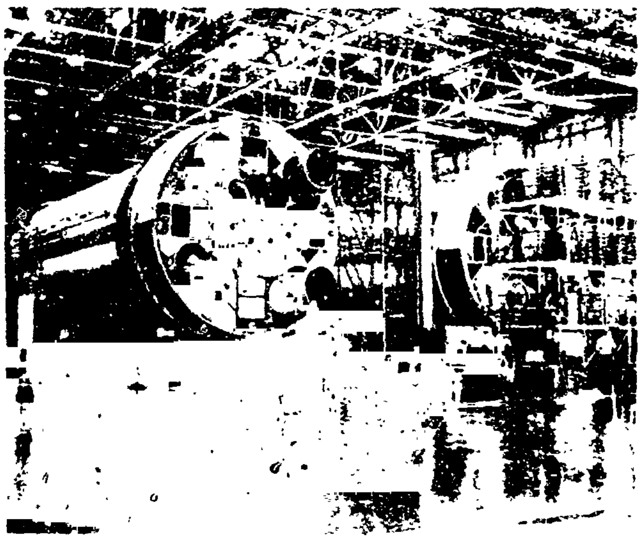
On April 29 NASA awarded a $23.8-million, 1-year, cost-plus-fee contract to Bendix Field Engineering Corporation for continued maintenance and operation of the major portion of NASA's Manned Space Flight Network, including 11 facilities of the 14-station, unified S-band network for Apollo. The contract extended the original 2-year agreement [385, 386].

During April Rocketdyne personnel began a test program designed to overcome the J-2 engine failures experienced on the S-II and S-IVB stages of the AS-502 flight vehicle

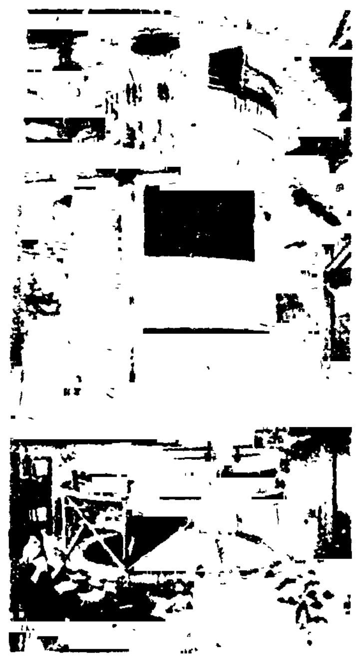


AS-502 mission sequence

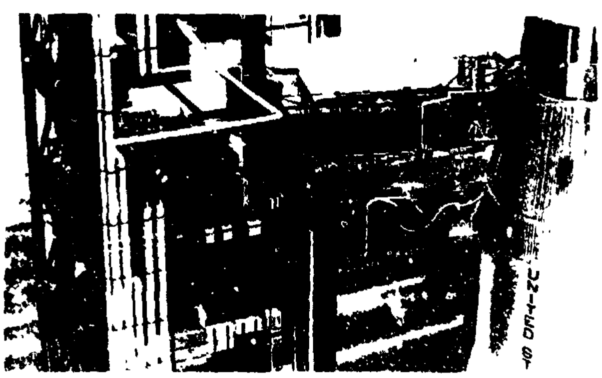
Underwater view of Neutral Buoyancy Simulator at MSFC



S-IB-6 in preparation to ship area at Michoud



Orbital Workshop flight unit at Huntington Beach



Mobile launcher service arms for S-II and S-IVB stages — artist's concept

Remote control MTA

during the flight period. They fired R&D J-2 engines 30 times. Three production engine tests totaled 315 seconds. At AEDC 21 S-IVB firings occurred under simulated environmental conditions [387].

Rocketdyne completed assembly of J-111, the first full configuration J-2S development engine, and shipped the engine to the Santa Susana Firing Laboratory for testing. Tests there were delayed for basic J-2 engine testing to resolve AS-502 flight problems [388].

During April an exhaustive test program to solve the S-IC stage problem of pogo longitudinal vibrations experienced on the AS-502 flight delayed the acceptance test schedule of S-IC-6 at MTF. On April 4 in preparation for static testing, Boeing test personnel turned power on the stage in the Test Stand. Subsequent to the AS-502 launch that same day, program officials and engineers began work to isolate the causes, using S-IC-6 in an effort to determine corrective action [389, 390].

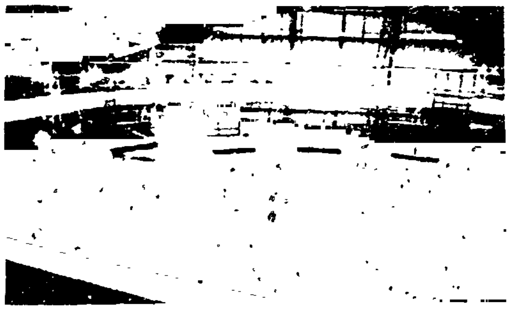
During the second week in April MSFC completed a report containing preliminary results of the Apollo 6 flight. Although the basic source of the difficulties had not yet been determined, scientists and engineers speculated that wires carrying cutoff commands to the malfunctioning engines were interchanged. The first stage had performed as planned and stage thrust was near that predicted during the first portion of flight. The second stage had performed satisfactorily through the first-stage boost, second-stage ignition, and early portion of second-stage powered flight. First indications of anomaly were the decreasing temperatures on the main oxidizer valve and its control line on the fifth engine and steady decrease in second engine's yaw actuator pressure. The third stage performed satisfactorily through the first burn and orbital coast. Investigations were continuing on longitudinal oscillation of the vehicle. Guidance and other instrumentation functions, telemetry performance, and onboard TV camera operation were satisfactory. Considerable damage, and not typical, involved both Mobile Launcher (ML) elevators in the Apollo Emergency Ingress/Egress System (PAD & ML). The damage occurred at ignition and/or during lift-off [391, 392].

Mr. Harold T. Luskin was appointed Director, Apollo Applications, in the Office of Manned Space Flight on May 1. Luskin came to NASA in March of 1968 as Deputy Associate Administrator for Manned Space Flight (Technical) [393].

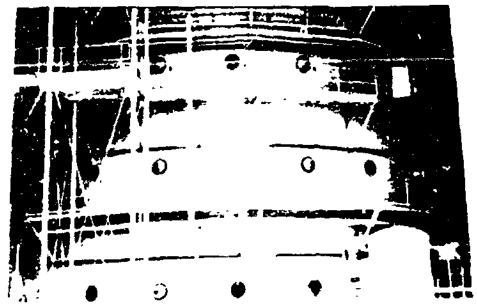
On May 3 NASA completed contract negotiations with Boeing for technical integration and evaluation in support of the Apollo program. The $73 million cost-plus-fixed-fee contract would continue through December 31, 1968, with provisions for extensions [394].

At a May 7 Management Council meeting at MSFC, participants agreed to assign to MSFC the overall systems integration responsibility for individual stacked vehicles as well as the previously assigned systems integration responsibility for the cluster and to increase management responsibility by MSFC in the Apollo Applications Program [395].

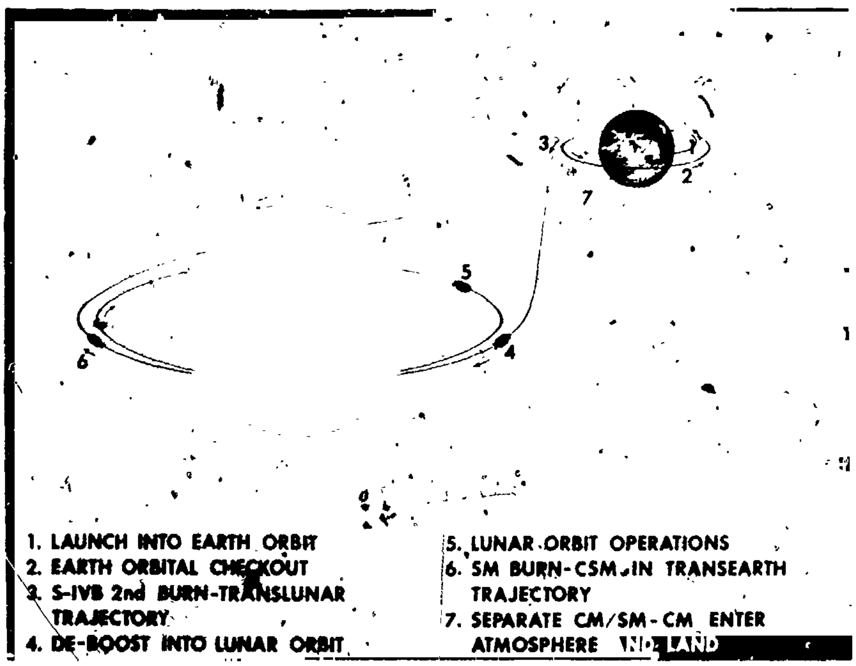
On May 13 Dr. Wernher von Braun announced the impending retirement of Dr. Arthur Rudolph as Saturn V Program Manager and the gradual assumption of his duties by Lee



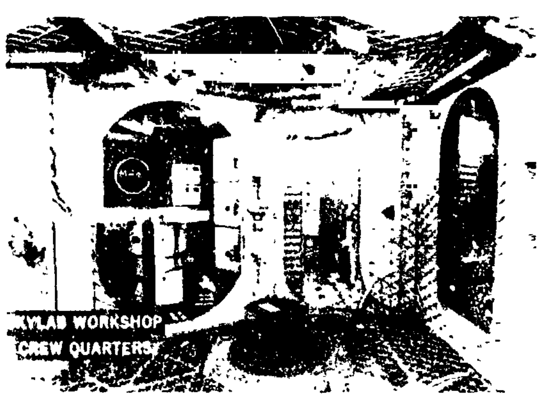
Top view of Neutral Buoyancy tank at MSFC



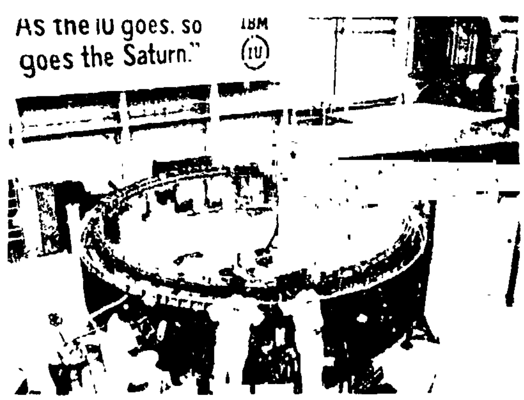
Neutral Buoyancy Simulator exterior



Apollo 8 lunar mission sequence, orbital mission (AS-503)



Skylab Workshop crew quarters



S-IU-507 in component assembly

B. James. A veteran of 38 years in rocket development, Dr. Rudolph had managed the Saturn V program at MSFC's Industrial Operations for 4½ years [396].

After extensive testing, MSFC and Rocketdyne engineers concluded on May 20 that the J-2 engine failures on the S-II and S-IVB stages of AS-502 resulted from broken augmented spark ignition fuel lines. The findings led officials to prescribe solid-wall lines for both lox and fuel in place of the flexible lines formerly used [397].

On May 20 NASA increased the capability of the Skylab Multiple Docking Adapter (MDA) to provide for crew habitation and to perform certain biomedical experiments in the event the Orbital Workshop could not be made habitable upon reaching orbit [398].

On May 21 MSFC personnel completed rework of the Saturn I Workshop crew quarters section which would adapt the structure for use in neutral buoyancy simulation [399].

MSFC announced on May 22, 1968, that NASA had notified elements of the agency to hold permanent employment to the onboard strength as of the close of business May 13, 1968 [400].

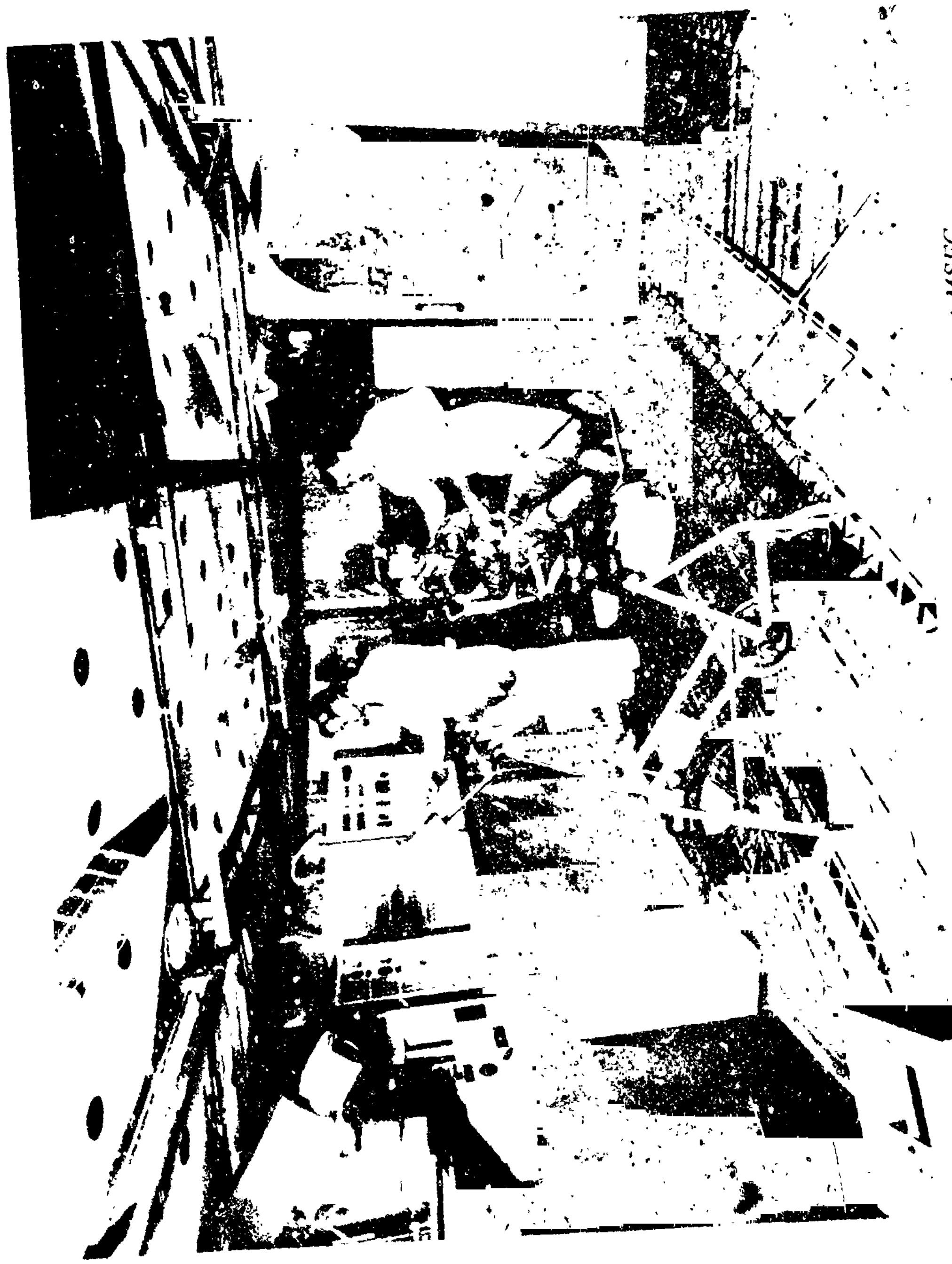
Also on May 22 MSFC received NASA Headquarters approval of the modification extending RCA Service Company's Management Services Office support contract for 1 year, and awarded the $6.4 million contract extension. RCA's support of management services ranged from housekeeping projects to MSFC's medical facilities [401].

On June 4 NASA released it's Apollo Applications Program, "Launch Readiness and Delivery Schedule ML-14A." This new schedule decreased the number of Saturn flights to 11 Saturn IB flights and one Saturn V flight. It called for three Workshops, one of the which would be launched by a Saturn IB and another which would serve as a backup. The third Workshop would be launched by a Saturn V. Schedule ML-14A also included one ATM. Launch of the first Workshop would be in November 1970. Lunar missions were no longer planned in the AAP.

A June 7 memorandum cited the general Apollo Applications Program efforts assigned to MSFC as of that date as follows: (a) Saturn I Workshop. (b) Multiple Docking Adapter, (c) Apollo Telescope Mount, (d) Payload Shroud for the Workshop and ATM, (e) Assigned Engineering Experiments, (f) Saturn IB and Saturn V Launch Vehicles [402].

On June 7 the *Point Barrow* which had left Seal Beach May 25, arrived at the Michoud Assembly Facility with a cargo of an S-II stage (S-II-6), five F-1 engines, and seven large F-1 engine components. It was the first time F-1 engines were shipped in quantity by water. The engines would be unloaded at MAF for installation on an S-IC stage. The S-II stage was destined for the Mississippi Test Facility, where it would undergo captive firing and tankage proof pressure testing [403].

During June Rocketdyne completed assembly and test of the first H-1 engine since transfer of production capability from Neosho to Canoga Park. MSFC observed that the production transfer appeared to be "completely satisfactory" [404].



Technicians working in the Saturn I Workshop mockup at MSFC

On July 1, 1968, MSFC, established on July 1, 1960, with 4400 employees and facilities valued at $100 million, celebrated its eighth anniversary as NASA's largest center. Current work force was 6500 and plant value was $400 million [405].

On July 15 the Special Studies Subcommittee of the House Committee on Government Operations ordered NASA to try to cut the escalating cost of its June 16, 1967, contract with Boeing for technical integration and evaluation in the assembly of the Apollo spacecraft with the Saturn V launch vehicle. The contract, awarded after the January 27, 1967, Apollo fire, in an effort to improve safety, had been listed tentatively as costing $20 million dollars. NASA now placed the cost of continuing the contract through 1968 at $73.4 million dollars [406].

A by-product of the Saturn program would be the Mobility Test Article (MTA). An MTA test program began at MSFC on July 15. Test Laboratory provided personnel and equipment for the three MTA vehicles on the test course. The three vehicles were built by Bendix, General Motors, and Brown Engineering [407].

On July 18 MSFC announced the completion of tests to determine a solution to the pogo longitudinal vibrations of the Saturn V first stage during the Apollo 6 (AS-502) flight and a means of preventing subsequent oscillations. Tests had revealed that the natural frequency of the vehicle structure and the propulsion system coincided, multiplying oscillation amplitude. Such a problem would be corrected by using small gas reservoirs as an "accumulator" in the lox prevalves in order to change the frequency of the propulsion system. This solution would be verified in the test-firing of a stage early in the following month [408].

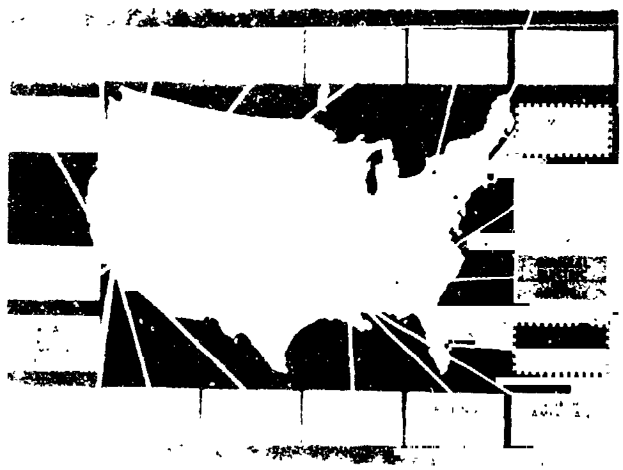
The last captive firing of S-IB flight stages in Huntsville occurred on July 25 when Chrysler personnel at MSFC conducted a 145.4-second static firing of S-IB-12, the second and final firing of this stage. All systems performed satisfactorily [409].

The MSFC Manpower Utilization and Administration Office reported on July 26, 1968, that of 130 RIF appeals heard by the Civil Service Commission, NASA's action was sustained in 129 cases. The commission also ruled that NASA's support contractor policies were "not appealable." NASA procedures during the RIF were upheld in every case, the report said [410].

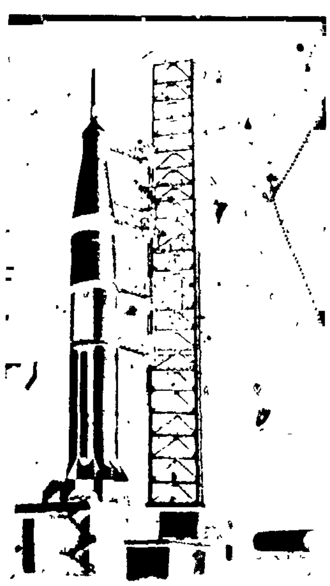
On August 2 NASA announced the halt of work on Saturn IB vehicles No. 215 and 216. The agency also instructed contractors to discontinue work on Saturn V follow-on vehicles 516 and 517. Such a curtailment was an economy move [411].

On August 7 Chrysler removed S-IB-12 from the Static Test Tower East at MSFC and prepared it for shipment to MAF. S-IB-12 was the final Saturn IB booster, and this operation completed Chrysler's activities at Static Test Tower East [412].

MSFC's share in a reduction outlined in a new NASA Operating Plan, announced August 7, would be 459 people. Personnel strength that had been 6440 on July 1 must be down to 5981 on June 30, 1969, to meet guidelines set by the new plan. However, this 459

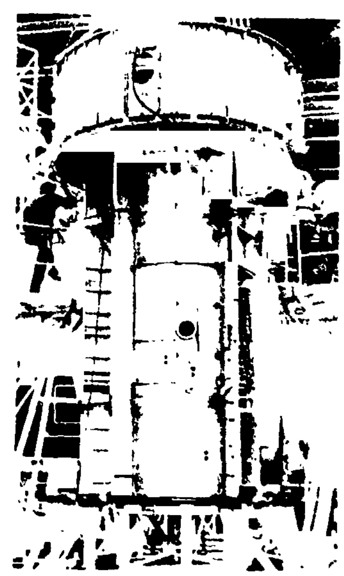


Saturn V major contractors



AAP manned launch configuration

S-IC fuel tank assembly at Michoud



Airlock flight article no. 2 – St. Louis reduction was expected to be absorbed by attrition if conditions remained the same as anticipated [413].

On August 13 an S-IC-6 static firing occurred at MTF on the first attempt and continued successfully for 125.1 seconds. All indications were that the newly instituted pogo suppression system performed as expected [414].

On August 30, following receipt of NASA direction to limit Saturn V production to vehicle 515, MSFC completed studies and began terminating production of engine hardware for the Apollo and AAP programs. The termination action involved 27 H-1 engines, eight F-1 engines, and three J-2 engines [415].

Fabrication and assembly of the last approved Saturn V booster, S-IC-15, began at the Michoud Assembly Facility in August [416].

In August Rocketdyne personnel at Santa Susana Field Laboratory ran nine R&D J-2 engine tests and four production J-2 engine tests. J-2 engine tests at Arnold Engineering Development Center numbered 16 [417].

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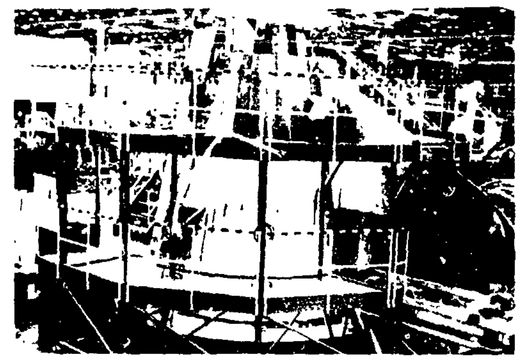
Because of LM processing delays at KSC and problems experienced in the LM development program, NASA decided not to use the lunar module LM-3 on the AS-503 (Apollo 8) flight. Instead, NASA decided to fly the AS-503 vehicle with the Lunar Test Article LTA-B to simulate the structure and weight of LM-3. This decision not to use LM-3 on AS-503 resulted in a change in mission assignments. NASA officials redesignated the mission: Instead of a "D-type" (CSM-LM operations) mission it became a "C prime" CSM operations mission. The primary objectives of C missions were to demonstrate CSM/crew performance and CSM rendezvous capability [419].

On September 4 Dr. von Braun performed a full-pressure suit test in the Saturn I Workshop mockup immersed in the Neutral Buoyancy Tank. He reported that the upgraded seals used in the aft dome penetration sealing study were "very good." Dr. von Braun recommended additional handholds and tether points [420].

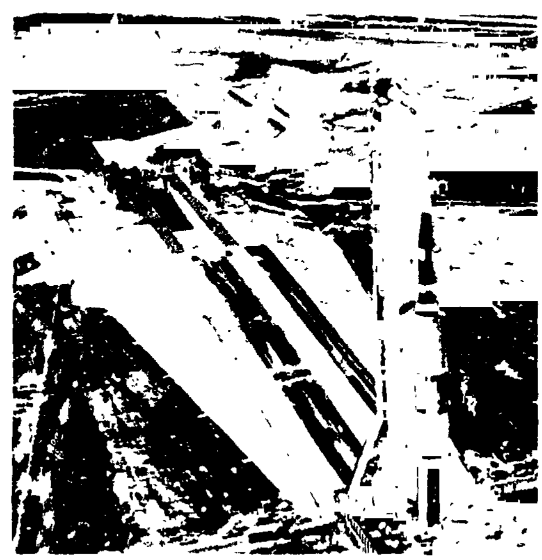
On September 5 NASA terminated production of H-1 engines under its contract with Rocketdyne. Of 60 engines being produced for the Saturn IB vehicle, Rocketdyne had completed delivery of 32 [421].

NASA Administrator James E. Webb announounded on September 16 that he would resign effective October 7. Deputy Administrator Thomas Paine would become Acting Administrator at that time. Webb was named NASA Administrator February 14, 1961, by President Kennedy [422].

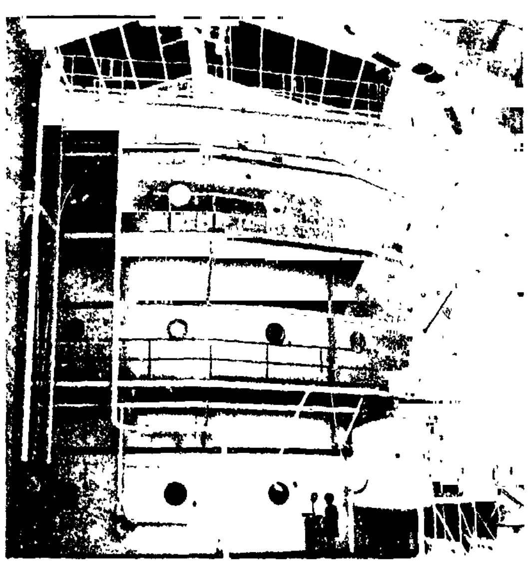
This is an aerial view of the storage, waterway, and testing area at the Mississippi Test Facility. The 13 424 acre test facility was used for static tests of the first and second stages of the Saturn V launch vehicle. Because of the extensive waterway around the area, Saturn stages and propellants could be barged into and out of MTF on convenient river/canal systems.



S-IC fin and fairing assembly at Michoud



Hard stand at Area A Complex 39 at KSC



MSFC Neutral Buoyancy Facility

Saturn IB launch complex at KSC

S-IB in service structure at KSC

On September 16 and 17, KSC launch crews completed both "wet" and "dry" Countdown Demonstration Tests (CDDT's) for the Apollo 7 (AS-205) space vehicle. The wet test, with propellants aboard, lasted the normal 102-hour countdown and ended at T-0. The dry test picked up at T-5 hours [423].

In a September 17 letter to General Samuel C. Phillips, Col. Lee B. James wrote: "During the NAR/SD cost reduction presentation to General Bogart's committee on August 20, SD proposed, as a significant cost reduction item, the deletion of cryoproof testing effective with S-II-7. MSFC had stated a position at the initiation of the cryogenic proof test program that the testing was not considered essential in man-rating the S-II structure . . . MSFC would be willing to accept the NAR/SD proposal to delete cryogenic proof testing at cost savings."

On September 18 NASA assigned to MSFC the management responsibility for the Airlock Module and the modified Lunar Module Ascent Stage. MSC formerly managed these AAP activities. NASA officials explained that this reassignment was made for the purpose of establishing a satisfactory balance between Apollo and AAP and in order to place a design integration under a single NASA Center [424].

On September 23 the General Accounting Office reported to Congress that the Bendix Corporation had agreed to a downward adjustment of $106 000 in fees it would have received under its $57 million dollar contract for development of the ST-124 Saturn V inertial guidance platform. Effective date of the contract modification was August 22, 1968 [425].

An estimated 25 000 persons visited MSFC for Family Day and Open House, on September 28 and 29, 1968. The program included an address by Dr. von Braun, an awards ceremony, and displays in laboratories and shops all over the Center. The event marked the 10th anniversary of NASA's establishment [426].

During September North American Rockwell assessed the structural failure repair requirements for S-II-TS-C, damaged in an August 21 test at MSFC. The recommended 31-week-repair plan was not acceptable to MSFC. Officials decided to repair local areas of damage and accept minor configuration deviations [427].

On October 6 MTF held Open House to observe the 10th anniversary of NASA. An estimated 3500 persons toured the facility [428].

On October 8, 1968, the Huntsville Board of Education approved the naming of three new city schools for the three astronauts who died in the Apollo 204 flash fire at Cape Kennedy January 27, 1967. A new high school would be named for Virgil I. Grissom, a junior high school for Edward H. White II, and an elementary school for Roger B. Chaffee. All three schools were scheduled to open in the fall of 1969 [429].

On October 9 NASA released its AAP, "Launch Readiness and Delivery Schedule ML-15," which slipped the first launch of Workshop into August 1971. This new schedule called for eight Saturn IB's but no Saturn V launches. According to this

MSFC Director Wernher von Braun "suits up" in a pressurized space suit and diving gear before entering the Center's Neutral Buoyancy Simulator. The big water tank – 75 feet in diameter and 40 feet deep – was designed for simulated astronaut activities.

schedule there would be one Workshop launched on a Saturn IB, one backup Workshop; no Saturn V Workshop scheduled; and one ATM with a backup.

On October 11 Apollo 7 (AS-205) rose from KSC LC-34 at 11:02 a.m. This was the start of the first manned mission in the Apollo Lunar Landing Program, the fifth in a series of Saturn IB launch vehicle flights. Primary mission objectives were to demonstrate CSM/crew performance and crew/space support facilities performance during manned SCM missions, and CSM rendezvous capability. All launch events occurred as planned. The S-IB stage propulsion system performed satisfactorily. Inboard engines cut off at 140.64 seconds range time; outboard engines cut off 3.68 seconds later. The S-IB stage separated from the S-IVB/IU/CSM at about 146 seconds. The S-IVB's J-2 engine ignited at approximately 147 seconds. Jettison of ullage motors and the launch escape tower followed. The S-IVB engine cutoff came at 616.75 seconds, and 10 seconds later the S-IVB/IU/CSM was inserted into an earth parking orbit with 177.8/mile apogee and 138.2/mile perigee. Aboard the spacecraft for this historic journey were Astronauts Walter M. Schirra, Jr., Donn F. Eisele, and R. Walter Cunningham. Live color telecasts at several intervals during the flight featured the astronauts and the spacecraft interior, as well as cloud and earth views. The crew also photographed Hurricane Gladys in the Gulf of Mexico. On the final day of the flight, CM/SM separation, parachute deployment, and other reentry events were normal. The CM splashed down in the Atlantic near the recovery ship *Essex* at 7:11 a.m. EDT on October 22. All primary mission objectives had been achieved [430].

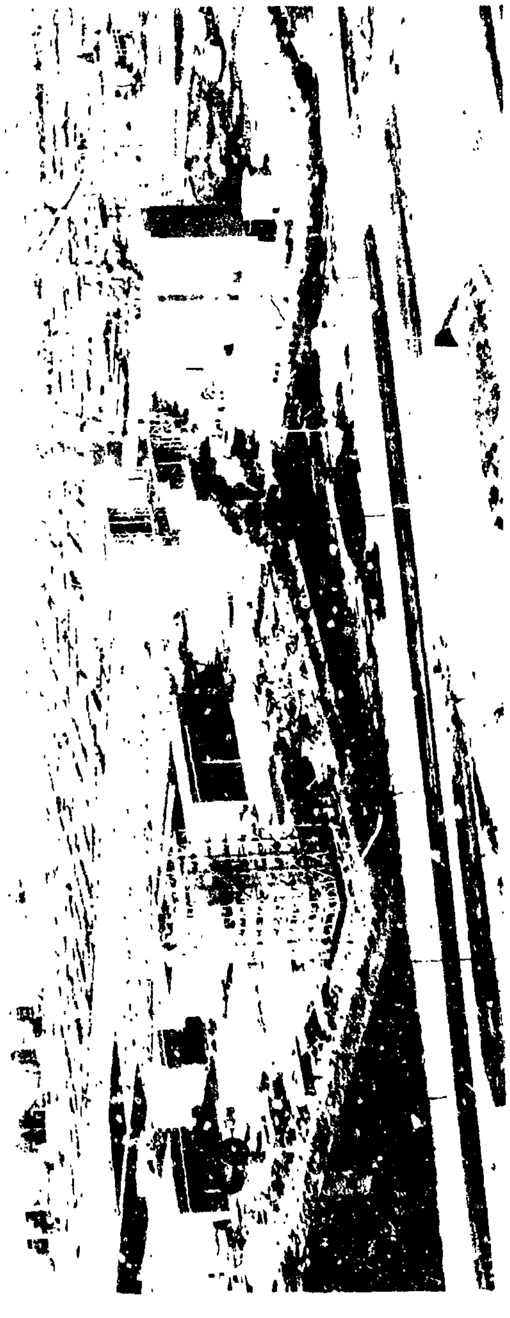
A pioneering concept in the substitution of the "dry" for the "wet" Workshop program was the B-Zero project generated at MSFC in October 1968. B-Zero (meaning least sophisticated) was proposed as a standby S-IVB stage stripped of existing hardware and on substitute standby as needed for a "wet" S-IVB stage [431].

On November 4 NASA issued a contract to the Boeing Company for a 10-month study to define a two-stage derivative of the Saturn V launch vehicle. The proposed vehicle, consisting of S-IC and S-IVB stages and instrument unit, would place a payload of 158 000 pounds into low earth orbit. MSFC would administer this $239 500 contract [432].

On November 6 a definitive engineering summary of data findings showed that the powered phase of the Apollo 7 (AS-205) flight was extremely close to predictions. In that October 11 launch the first stage performed with accuracy within 0.2 percent of predictions. The second stage also performed as planned. Launch vehicle instrumentation systems attained a reliability of 99 43 percent [433].

The first meeting of the AAP Mission Evaluation Panel was conducted at MSFC on November 7. Representatives from KSC, MSC, NASA Headquarters, Goddard Space Flight Center, and MSFC participated [434].

On November 20 Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight, made his annual staff visit to MSFC [435].



Shown at Seal Beach, California, is the North American Rockwell manufacturing facility for S-II stages

In November MSFC technicians fired an H-1 engine at the Power Plant Test Stand. The engine had been in storage since October 1963. All engine parameters appeared normal, and there were no discrepancies during checkout. Purpose of the test program was to investigate gear-box preservation requirements during extended storage. The engine later would be torn down and inspected for damage caused by age, corrosion, or wear [436].

In November Rocketdyne conducted a J-2 engine test program at Santa Susana Field Laboratory to explore the effects of the loss of fuel tank pressure during flight period. As a result of this testing program, officials decided to recommend against aborting flights because of loss of fuel tank pressure [437].

On December 15 the launch countdown for AS-503 (Apollo 8) began at 7:00 p.m. EST at KSC's LC-39A [438, 439].

On December 18 NASA announced the appointment of William C. Schneider, Apollo Mission Director, as Director of the Apollo Applications Program. He succeeded Harold T. Luskin, who died November 25, 1968 [440].

On December 20 NASA approved a supplemental agreement to a Boeing contract extending the maintenance and operation of the Saturn V SDF at Huntsville and providing support to MSFC for the Saturn V mechanical ground support equipment. This agreement, costing $8 429 047, called for performance from October 1968 through March 1970 [441].

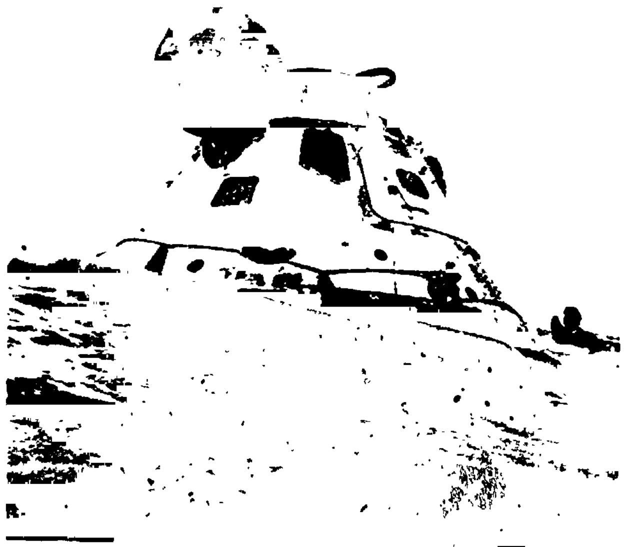
Also on December 20 an explosion during a test completely destroyed the S-II-TS-B specimen and caused extensive fires in the test area at Santa Susana Field Laboratory. Space officials conjectured that the explosion occurred when the LH_2 forward bulkhead collapsed because of negative pressure, causing a tank rupture that introduced air to the tanks [442].

NASA's Apollo 8 (AS-503), the second manned mission in the Apollo lunar landing program and the first manned mission to orbit the moon, rose from KSC Launch Complex 39 at 7:51 a.m. EST, December 21, atop a Saturn V booster. Aboard Apollo 8 were Astronauts Frank Borman (commander), James A. Lovell, Jr. (CM pilot), and William A. Anders (LM pilot). At 10:42 a.m. EST a second burn of the third stage injected the spacecraft into a lunar trajectory and the astronauts began their journey to become the first men to leave the earth's gravitational field. A second midcourse maneuver, scheduled for the second day, was canceled because the trajectory was already so accurate that a burn would have required a velocity change of only 0.7 foot per second. The crew took navigation sightings and conducted the first TV transmission, showing the spacecraft interior and the earth from a 138 690-mile altitude, and they demonstrated food preparation and movements in a state of weightlessness. A second transmission, on the third day, showed excellent pictures of the earth from an altitude of 201 365 miles, including a view of the Western Hemisphere in sunlight. On the fourth day, Christmas Eve, communications were interrupted as Apollo 8 passed behind the moon and the astronauts became the first men to see the moon's far side. In their third TV telecast Anders described the lunar surface as "whitish gray, like dirty beach sand

Mission Control Center

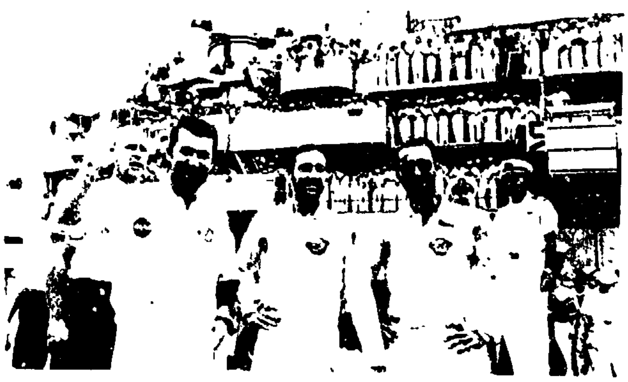
Launch Control Center at KSC

Apollo 7 astronauts



Apollo 7 Atlantic recovery area – pararescuemen attach flotation collar to Apollo 7 spacecraft

Recovery of Apollo 7 astronauts



Apollo 7 Astronauts Schirra, Eisele, and Cunningham aboard USS Essex following their recovery

with lots of footprints on it. Some of these craters look like pick-axes striking concrete, creating a lot of fine dust."

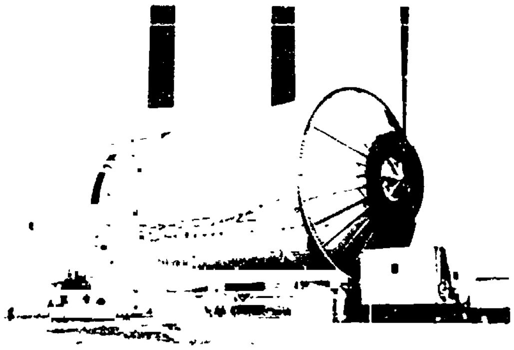
After their spacecraft had passed from behind the moon, Lovell said that the astronauts had "a grand view" of the lunar surface and confirmed that prospective landing sites were satisfactory. They conducted a communications experiment which showed that a radio signal from the earth to Apollo 8 and back to earth took 3 seconds to make a 460 000-mile round trip. Their third TV transmission during their ninth revolution showed heavily impacted mountains described by Anders as "a vastness of black and white, absolutely no color." The moon is "a very dark and unappetizing place . . . ." Then the crew further electrified their earth-ground fans by reading versus from the first chapter of Genesis and wishing viewers a Merry Christmas. On the fifth day the Apollo 8 headed back toward the earth. A fifth TV transmission showed the spacecraft interior, controls, and food preparation. A sixth TV transmission showed the earth from an altitude of 112 125 miles. On the sixth day the crew prepared for reentry, and the SM separated from the CM on schedule. Parachute deployment and other reentry events were nominal, and the Apollo 8 splashed down in the Pacific about 5100 yards from the recovery ship *USS Yorktown* at 10:51 a.m. EST, December 27, 147 hours after launch and precisely on time. As scheduled, helicopters and aircraft hovered over the spacecraft, and pararescue personnel were not deployed until local sunrise, 50 minutes after splashdown. The crew was then picked up and reached the recovery ship at 12:20 p.m. EST. All primary Apollo 8 mission objectives had been met. Apollo 8 had been the fifth Apollo mission to date, the second manned Apollo mission, the first manned mission on a Saturn V launch vehicle, and the first manned operation of the Apollo system under conditions for which it was designed [443-445].

On December 21 a preliminary analysis at MSFC of the AS-503 (Apollo 8) launch indicated that all propulsion systems of the vehicle performed normally. The pogo suppression system performed as scheduled, and there was no evidence of longitudinal vibrations on the S-IC stage. The J-2 engines on the S-II and S-IVB stages operated satisfactorily, and there were no problems with the modified augmented spark ignition fuel lines [446].

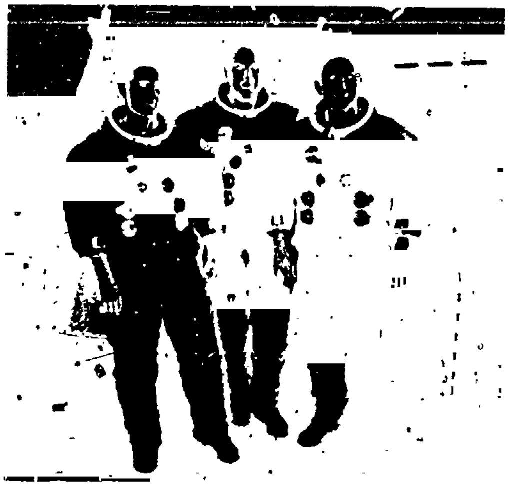
On December 27 MSFC awarded a $173 000, 11-month contract to the Boeing Company for the study of cost-reduction methods in future space vehicle logistics systems, including expendable and reusable systems [447].

Personnel strength at MAF at the close of 1968 was 6095. The total was divided as follows: Boeing 3736; Chrysler, 1336; Mason-Rust (support contractor), 618; NASA civil service, 158; and Service Technology Corporation 247. Ling-Temco-Vought, the computer service contracto at Slidell, Louisiana, had 245 employees, a reduction of 41 persons during the year.

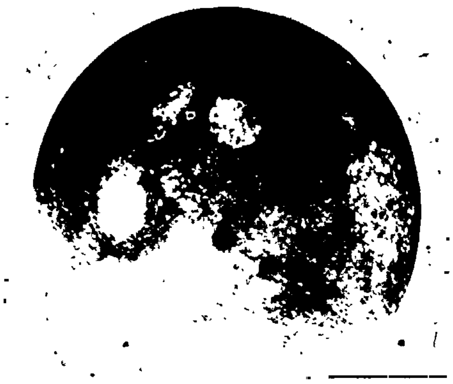
At MTF personnel at the end of the year totaled 2775, including all government and contractor employees. This was a reduction of 6.4 percent from the 2967 at the site when the year began. Year-end employment included: Government, 190; General Electric Company, 1197; subcontractors of General Electric, 356; stage and engine contractors, 1028; and construction employees, 4 [448].



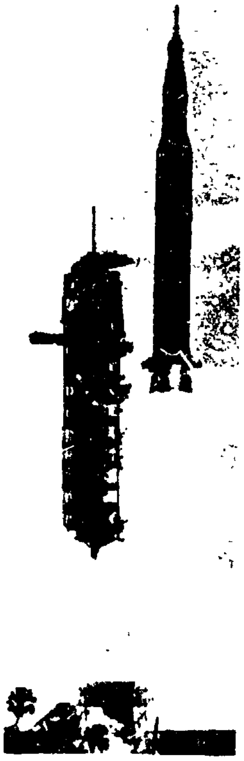
S-II stage arrival at KSC



Apollo 8 crew – Astronauts Anders, Lovell, and Borman



Moon as seen from Apollo 8



Launch of Apollo 8

Recovery of Apollo 8 astronauts

The moon (foreground) and earth as viewed from Apollo 8

At MSFC personnel at the end of this year totaled more than 13 000, including all government and contractor employees [448].

NASA ended the year 1968 with a record of four Saturn flights. These consisted of two manned and two unmanned missions. Both the Saturn V and Saturn IB launch vehicles were manned for the first time in 1968. The Saturn V sent Astronauts Frank Borman, James Lovell, and William Anders aloft in Apollo 8. The Saturn IB vehiclesplaced the first manned spacecraft, Apollo 7, into earth orbit on October 11, with Astronauts Walter Schirra, Donn Eisele, and Walter Cunningham aboard. The first unmanned Saturn mission in 1968 occurred on January 2 when a Saturn IB carried an unmanned lunar module spacecraft into orbit as Apollo 5. The second unmanned Saturn mission, Saturn V, came with the launching of Apollo 6 on April 4 [449].

In December Convair Division of General Dynamics Corporation received a $200 000 contract from MSFC to study the feasibility of experimental television broadcast satellites for the 1972-1977 period. The study would consider use of the Saturn V vehicle, both manned and unmanned [450].

In December there were seven drop-tests in a continuing series of tests being conducted at MSFC in the Zero Gravity Drop Tower located in the Saturn V Dynamic Stand. MSFC's Test Laboratory conducted the tests in order to assist the Propulsion and Vehicle Engineering Laboratory in a study of low gravity fluid mechanics and thermodynamics phenomena [451].

1969

The year 1969 began with varied activity in the Saturn program. As the Apollo 8 crew underwent debriefings and medical checks prior to their January 9 visit with the President at the White House to receive Distinguished Service Medals, workmen at KSC rolled the Apollo 9 space vehicle out to its pad, on January 3, with no hitches. Traveling between 0.5 and 0.8 mile per hour the huge vehicle and its mobile launcher and transporter made the 3.5-mile trip in almost 9 hours. The 5.5-million pound transporter moved its 12.5-million-pound load to the top of the ramp at Launch Complex 39. Meanwhile, the Apollo 10 launch vehicle (Saturn/Apollo 505) was stacked inside the Vehicle Assembly Building. Schedules called for the Apollo 106 spacecraft to arrive at KSC the second week of January and for the AS-505 spacecraft to undergo altitude chamber runs [452].

On January 9 NASA named Astronauts Neil A. Armstrong (commander), Michael Collins (CM pilot), and Edwin E. Aldrin, Jr. (LM pilot) as the prime crew of the Apollo 11 lunar landing mission scheduled for the summer of 1969. The backup crew would be Astronauts James A. Lovell, Jr. (commander), William A. Anders (CM pilot), and Fred W. Haise, Jr. (LM pilot) [453].

Near the start of 1969 several hundred MSFC employees changed their physical location at MSFC. This began with a shift of 400 in Program Management, formerly Industrial Operations. The movement of office workers was being made to reflect an organizational change announced in January by Dr. von Braun. In another change MSFC telephone numbers were converted to a single centrex system. The new MSFC prefix was being changed to 453 [454].

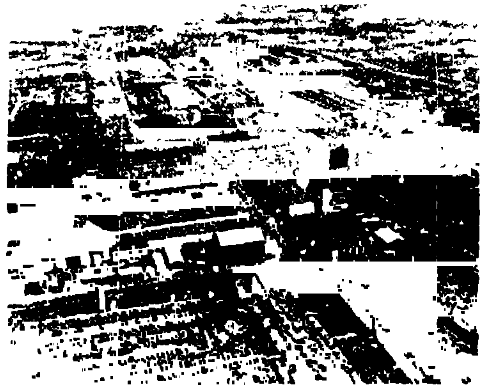
Telephone exchange equipment valued at almost $1 million, permitting MSFC's phone exchange to utilize a single Centrex system, was placed in operation on February 2 [455].

The MSFC Medical Program qualified at the start of 1969 for the Certificate of Health Maintenance awarded by the Occupational Health Institute. The certificate indicated that the MSFC medical organization was among those U. S. organizations achieving distinction for the quality and quantity of constructive health maintenance service for employees [456].

The second stage (S-II-6) for the Apollo 11 mission arrived at KSC on February 5. It had been test-fired at the Mississippi Test Facility before arriving at KSC aboard the *Orion*. Meanwhile, NASA announced that the first stage (S-IC-6) of the AS-506 launch vehicle would be shipped from the Mississippi test complex on February 10 and would arrive by barge at KSC on February 16. Schedules also called for the instrument unit (IU-6) to leave Huntsville on February 20 aboard the Super Guppy cargo aircraft and to arrive at KSC the same day. The third stage of the AS-506 vehicle had arrived at the Kennedy launch site on January 19, after being shipped by Guppy aircraft from California [457].

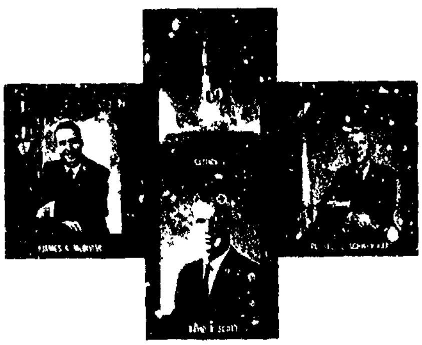
As of February 10 acting NASA Administrator Dr. Thomas O. Paine was expressing concern at NASA's inability to develop an attractive Space Station plan which would be

Apollo 8 Commander Frank Borman thanked MSFC employees in the spring of 1969. From the left are C. M. Smith, Joyce Taylor, Robert Wilcox, Lloyd Marks (in background), Forrest Wells, Tom Arnold, Wesley F. Hammer, and Carmine DeSanctis.



An aerial view of a portion of the Marshall Center showing the Quality and Reliability Assurance Laboratory, the Manufacturing Engineering Laboratory, and the vertical assembly building.

Artist's concept showing commonality of design for Shuttle and Orbiter



Apollo 9 astronauts

Launch of Apollo 9

Astronaut Schweickart during EVA of Apollo 9 flight

Dr. Thomas O. Paine became NASA's third Administrator on Mar. 5, 1969 bold and aggressive yet reasonable and, more importantly, one that would demonstrate a "united attitude." Relative to Space Station activities. Dr. Paine considered two major NASA in-house problems to be: (1) where should we be going and what is the nature of the program? (i.e., size, timing, mode of operation, and systems desired for the Space Station program); (2) how do we organize NASA to undertake such a program? [458]

An indication of retirement trends was a trial retirement program offered for the first time at MSFC and a 3.9 percent cost of living increase promised those retiring on or before February 28, 1969 [459].

On February 17 the legal affairs office at MTF reported that members of the Lee Town Community (approximately 9 to 11 miles north of the S-IC test stand) were circulating petitions requesting that MTF static testing be stopped or that much stricter safety criteria be utilized [460].

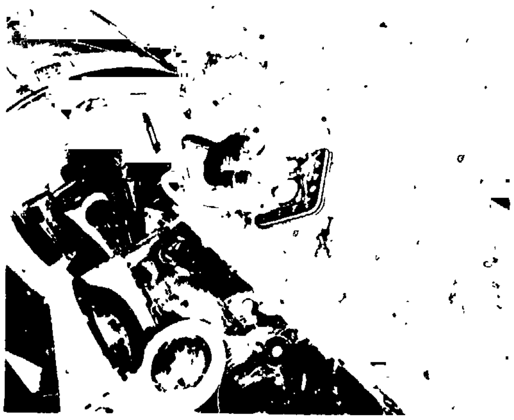
The Apollo 9 Countdown Demonstration Test (CDDT), last major test before the scheduled February 28 launch date, ended on February 19 at KSC. Meanwhile, the "wet" portion of the CDDT ended on February 18 after minor problems. Astronauts James A. McDivitt, David R. Scott, and Russell L. Schweickart took part in the February 19 phase of the test. Schedules called for the Apollo 9 precount to begin on February 22 and continue through the launch. The mission would be the first in-space test for the lunar module [461].

On February 27 MSFC signed an agreement with North American Rockwell Corporation's Rocketdyne Division for extension of J-2 engine production through April 30, 1970, at the reduced rate of one engine per month instead of three. The engines would not be used as rapidly as originally planned because of overall extension of the launch vehicle production schedule. The modification amounted to $8 423 454 [462].

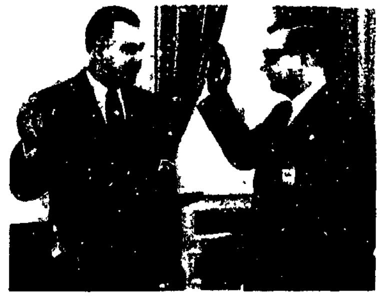
As an indication of the local interest in MTF activities, MTF announced that visitors who viewed the static firings of S-IC-9 numbered approximately 12 000 [463].

One week before the launching of Apollo 9, human factors seemed on the verge of sidetracking all the technical preparations. The three Apollo 9 astronauts developed sore throats and nasal congestion, and project officials said that the illness could delay the launch. In a phone conversation with the astronauts' physician, Dr. Charles Berry, Dr. von Braun inquired about the astronauts' conditions. Dr. Berry replied that things were not going very well because of astronaut James McDivitt's "real acute upper respiratory problem" that had not cleared up. Dr. Berry added that if the problem was not better soon, the launch would have to be postponed because Dr. Mueller would prefer to delay the launch for a short while rather than go with backup personnel [464].

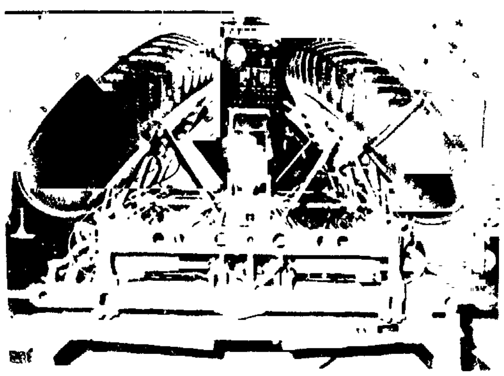
A Saturn V booster successfully launched NASA's Apollo 9 (AS-504) at 11:00 a.m. EST on March 3. This launch, from Launch Complex Pad A at KSC, was the first manned flight of an Apollo lunar module. The flight would not continue to the moon, but instead the mission was for extensive lunar module tests, extravehicular activity, and command/service module-lunar module separation, rendezvous, and docking to simulate activities after a lunar landing. The launch had been postponed 3 days because the crew



Astronaut Scott during EVA of Apollo 9 flight



Dr. Thomas O. Paine, right, is sworn in as administrator of the National Aeronautics and Space Administration by Vice-President Spiro T. Agnew. The ceremony took place April 3, 1969, in Washington.



LRV in folded configuration

Skylab ATM solar array deployment – concept had viral infections in their respiratory systems. Physicians feared that the illnesses and lack of rest might hinder the men's performance. During the 3-day hold the astronauts studied mission procedures and worked in a mission simulator. They also got some rest prescribed by their doctors. They took medication until March 1, and by March 3 the doctors had said the colds were clear. The primary objectives of the mission included demonstration of crew, space vehicle, and mission support facilities performance during a manned Saturn V mission with the command/service module and the lunar module. The launch events occurred as planned as the spacecraft carried Astronauts James A McDivitt (commander), David R. Scott (CM pilot), and Russell L. Schweickart (LM pilot). After post-insertion checkout the crew successfully docked with the LM, and the docked spacecraft was separated from the third stage. Two S-IVB burns placed the stage on an earth-escape trajectory. On the third day, McDivitt and Schweickart entered the LM through the docking tunnel, evaluated the LM systems, transmitted the first telecast, and conducted the first manned firing of the LM descent propulsion system (DPS). They then returned to the CSM.

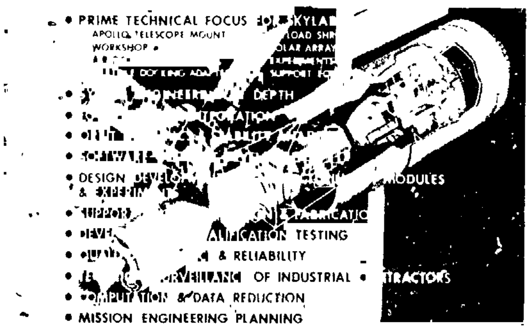
McDivitt and Schweickart reentered the LM on the fourth day and transmitted a second telecast. Schweickart spent 37 minutes outside the spacecraft, walking between the LM and CSM hatches, maneuvering on handrails, and standing in "golden slipper" foot restraints. Then he and McDivitt returned to the CSM. McDivitt and Schweickart reentered the LM on the fifth day to perform the CSM-LM rendezvous. By the end of the fifth day 97 percent of the Apollo 9 objectives had been successfully accomplished. On the sixth through the ninth days the crew accomplished tasks that included taking multispectral photographs of earth, tracking landmarks, and then preparing for reentry. On the 10th day there was some concern because of unfavorable weather in the planned landing area, but the CM-SM separation, parachute deployment, and other reentry events were normal. The spacecraft reentered during the 152nd revolution and splashed down in the Atlantic east of the Bahamas at 12:55 p.m. EST on March 13 within sight of the recovery ship *USS Guadalcanal.* The helicopter picked up the crew and flew it to the recovery ship within 1 hour after splashdown. This first manned flight of the lunar module had qualified the last major component for a lunar landing mission.

Apollo 9 was the sixth Apollo mission and the third manned Apollo mission. Earlier unmanned Apollo flights had yielded all spacecraft information possible without a crew on board. Apollo 4 (launched November 9, 1967) and Apollo 5 (launched January 22, 1968) had both been highly successful, completing inflight tests of all major pieces of Apollo hardware. Apollo 6 (launched April 4, 1968), despite launch vehicle problems, had attained four of five primary objectives with the spacecraft recovered in excellent condition. The first manned Apollo mission, Apollo 7 (October 11-22, 1968), had achieved all primary objectives and verified operation of spacecraft for lunar-mission duration. The second manned mission, Apollo 8 (December 21-27, 1968), had proved the capability of Apollo hardware and systems to operate out to lunar distances and return through the earth's atmosphere [465-468].

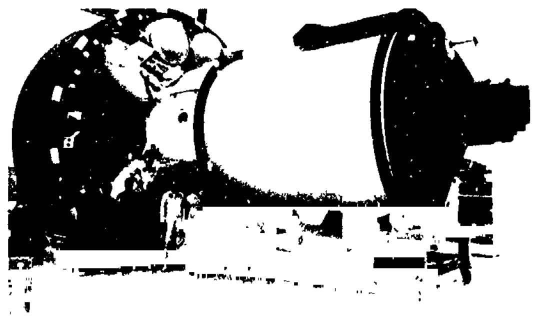
President Richard M. Nixon named Dr. Thomas O. Paine as the new NASA Administrator effective March 5, 1969. The President made the announcement at the White House during ceremonies March 5 honoring the Apollo 8 crew [469].

ATM solar array development, wing deployed

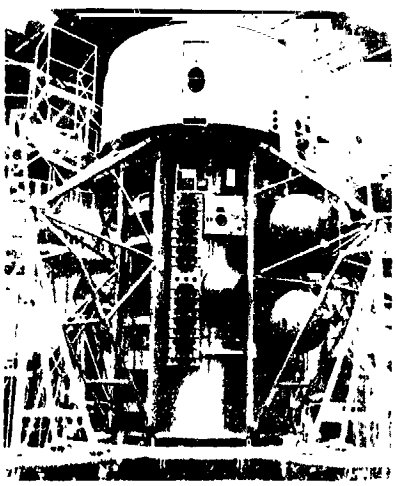
Workshop solar array wing being deployed



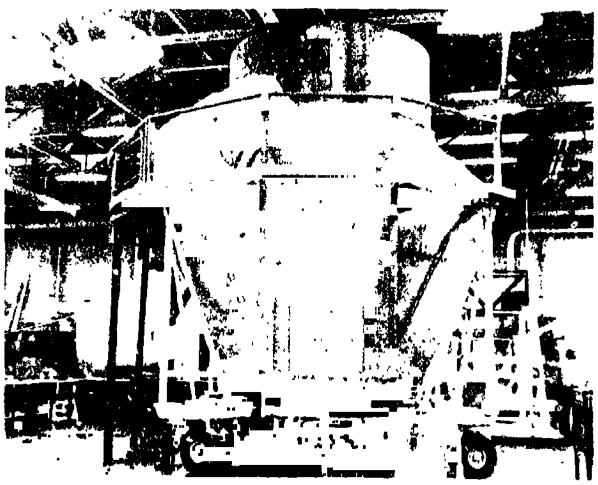
The Skylab Program



Skylab Airlock/MDA trainer



Airlock test article on production line



Airlock flight article no. 1 during fitting of thermal curtain pattern – MSFC

Personnel at the Kennedy Space Center moved the Apollo/Saturn V launch vehicle for the Apollo 10 mission to Launch Complex 39B on March 11. Launch of the fifth Saturn V vehicle from Complex 39B would mark the first use of this portion of the facility. Apollo 9 and three previous Saturn V flights had been from nearby 39A [470].

On March 13, ten days after the launch of Apollo 9, the MSFC Mission Operations Office submitted its final summary report. The report stated, "Launch of the payload into orbit and post-burn checkout was accomplished successfully, but the crew experienced some vibration during S-II at about 8 minutes GET (ground elapsed time). S/C guidance data was lost for one orbit, but was recovered by ground station computer reprogramming." Among lesser problems was a master alarm that was received when the docking probe first engaged the LM drogue. This anomaly was unexplained but had been experienced before with other vehicles [471].

On March 18 MSFC awarded a contract for additional work on an aerospike engine system to the Rocketdyne Division of North American Rockwell Corporation. The new contract amounted to $1 142 924. Work would be done at Rocketdyne's Canoga Park, California, facility and at the company's Nevada Field Laboratories. The aerospike engine (also called a plug-nozzle) was a ring-like engine with many tiny throats along its circumference that discharged engine exhausts down the sides of the plug. By the aerospike's action, the performance characteristics of a full-length nozzle were permitted without any increased weight and length [472].

A second group of MSFC astronauts participated in full pressure-suit test operations in the Neutral Buoyancy Simulator at MSFC to evaluate ATM hardware configuration changes and to suggest further changes to facilitate ATM extravehicular activity [473].

After reviews by top NASA officials, Administrator Thomas O. Paine announced on March 24 that Apollo 10, scheduled for launch May 18, would be a lunar orbit mission in which two astronauts would descend within 50 000 feet of the moon's surface. As Dr. Paine made the announcement, the Apollo/Saturn V 505 vehicle waited at Launch Complex 39B to lift astronauts Thomas P. Stafford, John W. Young, and Eugene Cernan on their 8-day flight. The manned lunar module would approach twice to within about 10 miles of one of the preselected Apollo landing sites during the 3-day trip to the vicinity of the moon. While there would be no actual landing, the mission plan would be the same as for the lunar landing mission [474].

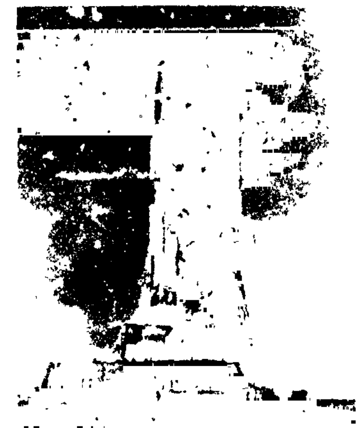
General of the Army Dwight D. Eisenhower, 34th President of the United States, died March 28, 1969. He had dedicated the Marshall Center on September 8, 1960 [475].

On March 28 MSFC and Rocketdyne signed a $38 340 000 contract modification covering production support on J-2 engines for upper stages of Saturn IB and Saturn V launch vehicles. Provisions included work to simplify the engine, make it more versatile, and modify it for a reduced restart time [476].

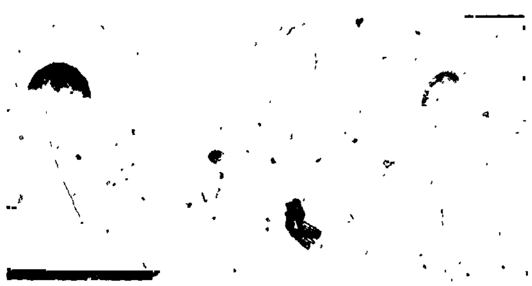
In response to Dr. von Braun's concern about the oscillation problems in the 504 flight, Lee B. James wrote Dr. von Braun, "We recognize the 504 problem must be worked separately and quickly. We are engineering an early center engine cutoff in case it is

1969

Apollo 10 astronauts

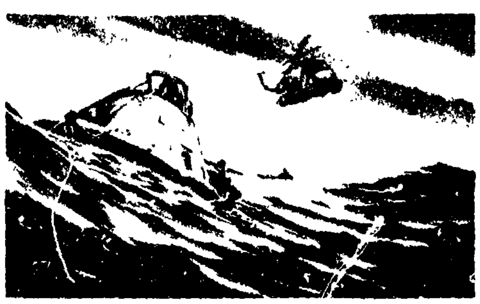


Lift-off of Apollo 10

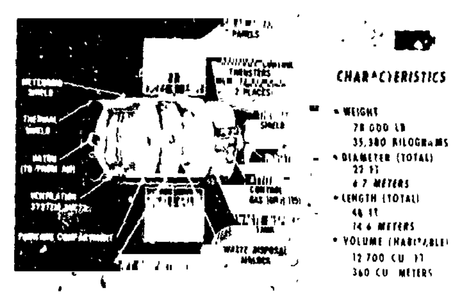


Earth and the moon as viewed from Apollo 10 spacecraft

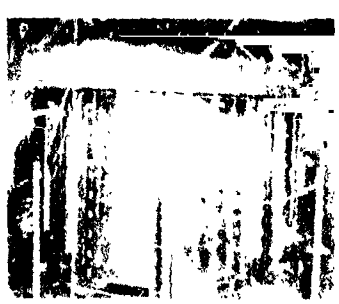
Lunar landing maneuver – artist's concept



Artist's concept of spacecraft recovery



Orbital Workshop



ATM flight unit canister at MSFC

LRV 1-g trainer at MSC

needed. In summary, I believe everyone recognizes the problem which must be solved. We are all working best approached to a long-term solution" [477].

A few days before Apollo 9 astronauts McDivitt, Schweickart, and Scott prepared to splashdown in the Pacific, other astronauts were splashing down at MSFC. Three astronauts from the Manned Spacecraft Center, who were involved in Apollo Applications Space Exploration, worked inside the Neutral Buoyancy Simulator at MSFC. The three were Dr. Edward G. Gibson, Lt. Comdr. Joseph Kerwin (a medical doctor) and Lt. Comdr. Paul J. Weitz. Inside the large water tank the astronauts were able to maneuver inside and around a full scale replica of an Apollo Telescope Mount and Saturn I Workshop. [478].

When Dr. Thomas O. Paine became the new administrator of NASA on April 3, NASA's program of Apollo/Saturn space flights was about one-third accomplished. There had been 10 flights in the Apollo/Saturn series [479].

On April 8 MSFC engineers tested one solution to the worrisome problem of longitudinal oscillation (pogo effect) or vibration which had occurred on both Apollo 8 and 9 flights and the S-II center engine and thrust structure. Since oscillations on both flights occurred 30 to 40 seconds before the S-II engines shut down, one solution to the problem might be to shut down the center engine early. With this in mind, test engineers intentionally shut down the center engine nearly 1½ minutes early during a captive firing of a Saturn V second stage (S-II-8) at the Mississippi Test Facility. This was the first time such an experiment occurred. If data obtained from the test should prove satisfactory – and on first look it appeared to be – the center engine might be cut off early during the flight of Apollo 10, scheduled May 18. A test of the eighth S-II vehicle laster 385 seconds, with only the four "outboard" engines functioning the final 86 seconds during this April 8 experiment. Should the early engine shut down be carried out in order to forestall the oscillation problem, there would be a sacrifice of about 500 pounds of the 3000-pound payload reserve on the Apollo 10 mission. However, by cutting the engine off early, engineers would simply be using the vehicle's engine-out capability in a planned mode. Guidance system of the rocket would treat it as an engine loss and make the necessary corrections [480].

On April 8 NASA released its AAP, "Launch Readiness and Delivery Schedule ML-16." This new schedule called for the same number of Saturn IB and Saturn V launches as ML-15, but moved the launch of the first Workshop 3 months to November 1971.

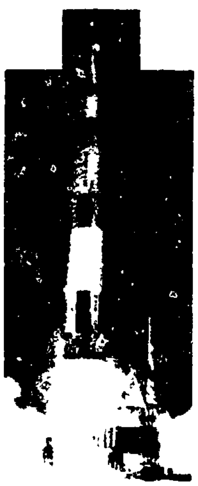
On April 9 MSFC awarded two 8-month identical $400 000 contracts, one to Grumman Aircraft Engineering Corporation and one to Bendix Corporation, for preliminary design and definition studies of dual-mode lunar roving vehicles (DLRV's) to be included in the cargo lofted from earth by Saturn vehicles. The DLRV would provide mobility for one astronaut on the lunar surface and could be operated by remote control from earth while making automated, long-range traverses of large lunar areas. The DLRV would be delivered to the moon aboard Apollo LM [481].

On April 10 NASA announced the prime crew for the Apollo 12 mission: Astronauts Charles Conrad, Jr. (commander), Richard F. Gordon, Jr. (CM pilot), and Alan L. Bean

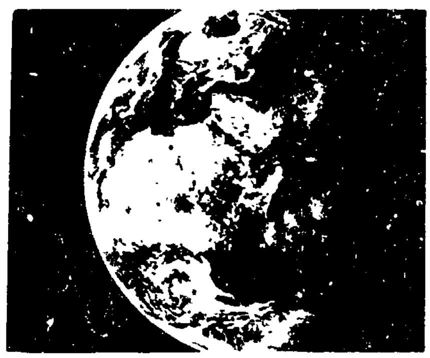
This 700-yard-long rocket caravan moved on June 28, 1969, from the Marshall Center to the Alabama Space and Rocket Center located on Alabama Highway 20 in Huntsville.

Apollo 11 crew

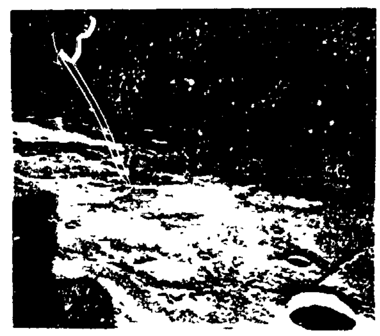
Apollo 11 Lunar Module



Lift-off of Apollo 11



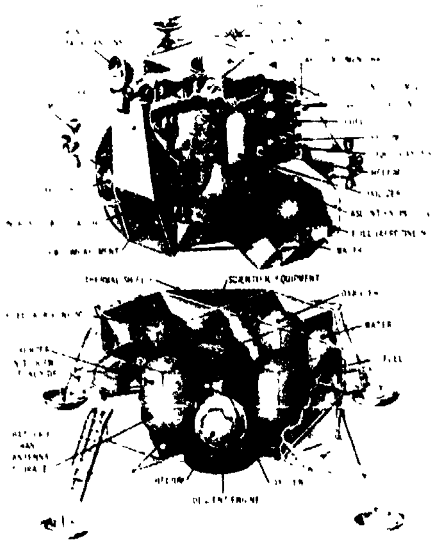
Earth as viewed from Apollo 11



Approach of Apollo 11 to lunar landing site

Flag deployment at Tranquility Base

Astronaut on lunar surface at Tranquility Base



Lunar Module

(LM pilot). The backup crew would be Astronauts David R. Scott, Alfred M. Worden, and James B. Irwin. The Apollo 12 would land on the moon 4 to 6 months after the July 1969 Apollo 11 mission [482].

On April 18 MSFC announced that it had issued Requests For Proposals for assistance in producing 320 completed solar arrays to convert solar energy into electrical power to operate the Saturn I Workshop. A preproposal conference was scheduled at MSFC May 1 [483].

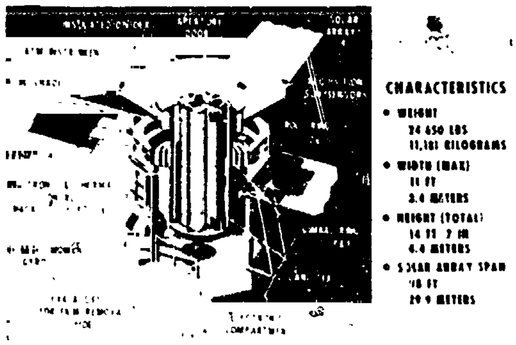
Expressing appreciation to Saturn Program employees who helped assure the success of his flight to the moon and back, Astronaut Frank Borman, Commander of the Apollo 8 crew, visited MSFC on April 24. Borman greeted and shook hands with MSFC workers at several locations [484].

On April 27 several thousand gallons of fuel drained from the Apollo 10 first stage; this resulted in an extensive series of checks at KSC to determine if any damage occurred. The RP-1 fuel flowed out when the prevalves in the S-IC stage opened while a leak was being repaired in the nitrogen pressurization system on the mobile launcher at Pad B in preparation for the countdown demonstration test (CDDT). Inspection of the forward section of the fuel tank included a series of dye penetrant checks to assure that no cracks were present. Entry into the stage for further inspection also was planned [485].

In proposing to build a Space Station NASA had to make a major decision concerning whether or not to build a Space Station utilizing a zero g (gravity) or an artificial g. An indication that the decision might be in favor of zero g was contained in an April 28 note from Dr. Mueller to Dr. Paine in which Dr. Mueller stated that as a result of a review of a meeting with representatives of Loewy/Snaith and Astronaut Walter Schirra, "Loewy/Snaith is developing new habitability concepts based on the freedom of movement afforded by a zero g environment."

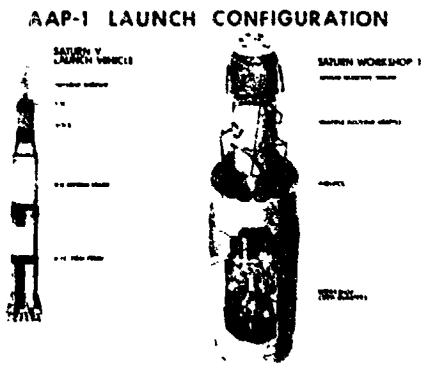
In a subject area related to orbiting space laboratories some 250 scientists and engineers from universities, government, and industry attended a Workshop on optical telescope technology at MSFC April 29 through May 1. The purpose of the Workshop was the exchange of technical information related to the design of future space telescopes and identification of the research and technology efforts needed to support future missions. NASA's Office of Advanced Research and Technology (OART) and its Office of Space Science and Applications (OSSA) sponsored the workshop. Speakers discussed the use of space telescopes and the instrumentation necessary for selecting astronomy tasks [486].

MSFC announced on April 30 that proposals for two design and planning studies of a Space Station program for the mid-1970's, one of which would be directed by MSFC, had been requested by NASA. Major effort of the studies would be preliminary design and planning of a 12-man, earth-orbital Space Station which could be developed by 1975. It would be designed to have an operational life of 10 years, subject to resupply of expendables and rotation of crews with logistic vehicles. The Space Station would be envisioned as the initial element of a large space base. The work would include a conceptual design of a 50-man space base made up of specialized modules assembled in

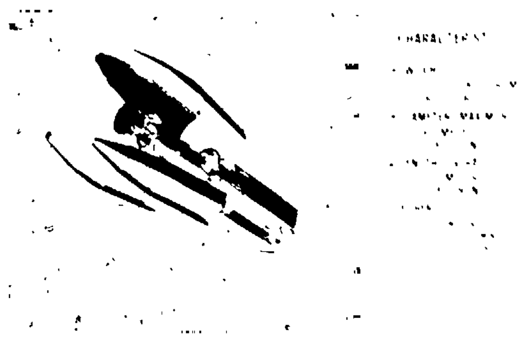


Apollo Telescope Mount

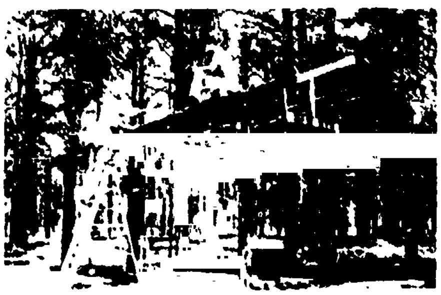
Wet Workshop detail



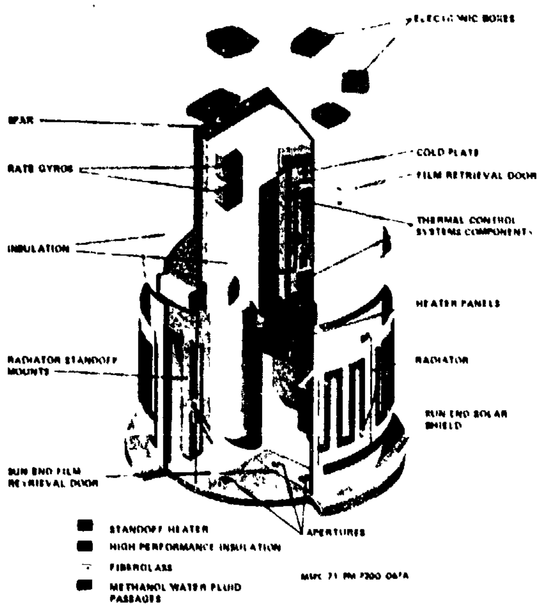
Saturn V Workshop



Artist's concept of Skylab



On July 9 workers prepared certain portions of a 10 acre area for a Lunar Landing Celebration at the Marshall Center. Shown here are debarked trees used as shelters.



ATM experiment canister

low earth orbit in the late 1970's and early 1980's. The space base would be a centralized facility in orbit, comparable to a scientific and technical research, development, and operations center on earth [487].

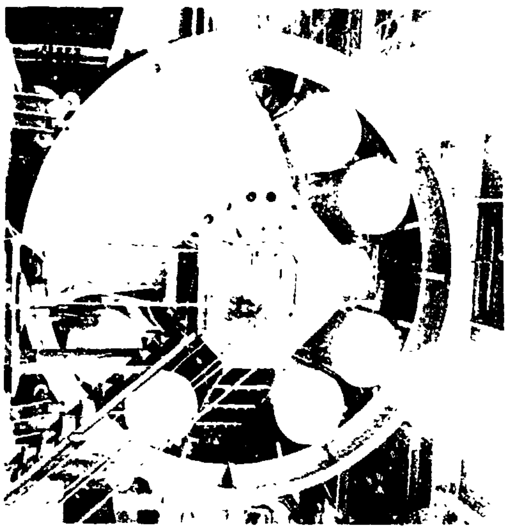
MSFC's official weekly newspaper, the *Marshall Star* stated in a headline on April 30 that "Saturn V Propellants Cost 23.4c A Mile For Moon Trip." The paper went on to add, "When the NASA's Apollo/Saturn space vehicle makes its long-awaited journey to a lunar landing this year, it will travel more than 655 000 statute miles – at a cost in propellants of 23.4 cents a mile. The estimate is based on the historic Apollo 8 flight to the moon last December. The space vehicle that makes the actual moon-landing flight will follow very closely the space trail blazed by Apollo 8. Total fuel bill for Apollo 8's Saturn V launch vehicle and Apollo spacecraft was slightly more than $153 000, an average of just under 16 cents a gallon for propellants. The Apollo/Saturn space vehicle got 0.68 mile per gallon on its Apollo 8 trip, much less than the average automobile, but the Apollo/Saturn is not of course the average automobile" [488].

Immediately following the successful S-II-8 firing, MSFC issued Change Order 1643 to NAR, authorizing incorporation of early S-II center-engine cutoff. The Change Order approved modification of stages S-II-5, S-II-6, and S-II-7 pending alternate solutions to the excess oscillation problem [489].

MSFC announced on May 2 the issuance of requests for proposals for experiment modules to be used with a proposed manned Space Station to orbit the earth in the 1970's. This study, under an 8-month contract, would analyze the scientific and engineering need for experiment modules and would develop concepts for the least number of modules needed. These study tasks included further definition of candidate experiment groupings, development of preliminary module concepts, definition of minimum number of concepts, development of preliminary design and cost analysis for each module concept, and the making of a proposed plan schedule. Proposals would be due May 22, 1969 [490].

On May 2 NASA unloaded an 8-ton airlock at MSFC for ground testing to qualify it as part of an orbiting Space Station. The airlock was part of the Apollo Applications Program cluster to be launched in the mid-1970's. NASA flew the 65-inch-diameter, 17-foot cylindrical unit from McDonnell Douglas Corporation's St. Louis plant to be joined to the multiple-docking adapter. It would provide an interconnecting passageway between the S-IVB rocket stage and the multiple-docking adapter in flight, condition environmental gases, and provide instrumentation, data management, intercommunication, and other services [491].

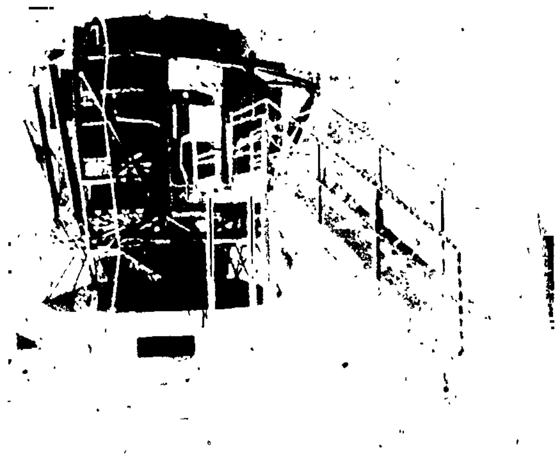
After overcoming problems, most of which were considered routine, workmen at the Cape successfully completed the "wet" portion of the CDDT for Apollo 10 on May 5. One problem not considered routine had been the occurrence on April 21 when several thousand gallons of fuel drained from the Apollo 10 first stage. But after a series of dye penetrant checks gave assurance that no cracks were present, the countdown continued on schedule, the launch schedule remaining the same, with none of the problems causing impact on the launch schedule through the May 5 countdown [492, 493].



Airlock trainer viewed from OWS end – MDAC-E

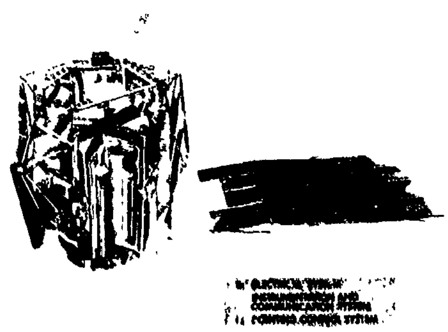
Skylab OWS concept

CSM/Skylab docking



ATM mockup at MSFC

Coleman Street was the main business area of Waveland, Miss., before Hurricane Camille leveled the town. Several hundred people, including 14 civil service employees of the Mississippi Test Facility, once lived here.



ATM canister

Charles W. Mathews, NASA's Deputy Associate Administrator for Manned Space Flight, sponsored a May 5 meeting in Washington to discuss management of the Space Station study. Representing MSFC was Dr. William R. Lucas [494].

On May 7 NASA announced the establishment of two new groups. One of them was a "Space Station task group" under Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight. The other was a "Space Shuttle task group" under Charles W. Mathews, Deputy Associate Administrator for Manned Space Flight. Reporting to Dr. Mueller would be LeRoy E. Day, former Director of Apollo Test. His group would develop NASA material for a report on Space Shuttles to the President's Space Task Group by June 15. Frank Borman, former Deputy Director of Flight Crew Operations at MSC and Apollo 8 commander, would report to Mathews as Field Director for the Space Station effort [495].

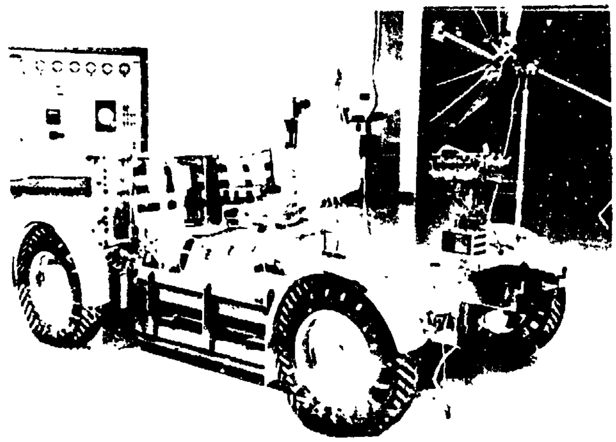
On May 16 MSFC awarded a $4 620 310 contract modification to Chrysler Corporation Space Division for vehicle systems engineering and integration on Saturn IB vehicles scheduled for NASA Apollo Applications program flights. Work begun on January 1, 1969, would extend through March 31, 1970 [496].

On May 18 another Saturn V booster successfully lifted an Apollo on its way toward the moon. NASA's Apollo 10 (AS-505), first lunar orbital mission with complete Apollo spacecraft, was launched successfully from KSC Complex 39, Pad B, at 12:49 p.m. EDT. Heading the list of VIP's for the launch were Vice-President and Mrs. Spiro Agnew. Vice-President Agnew had dinner with the crew the night before the launch. NASA Director Dr. Paine and the Vice-President co-hosted a luncheon at KSC the day of the launch.

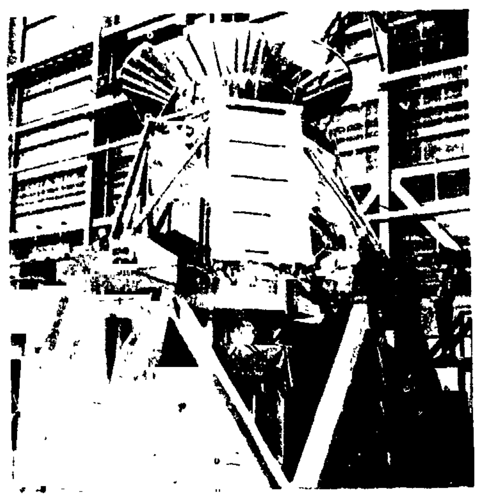
Primary objectives of the AS-505 mission were to demonstrate crew, space vehicle, and mission support facilities during a manned lunar mission with the CSM and the LM and to evaluate the LM performance and cislunar and lunar environments. Launch events occurred as planned, and the spacecraft, carrying Astronauts Thomas P. Stafford (commander), John W. Young (CM pilot), and Eugene A. Cernan (LM pilot), entered initial parking orbit with a 118.1-mile apogee and 114.6-mile perigee. The astronauts did not report any vertical oscillations or pogo during the second stage burn. Such oscillations had been experienced on the two previous Saturn V flights. Stafford did comment that when the Saturn V passed through maximum dynamic pressure, or "max Q," that "Things are beginning to shake in here." The astronauts reported oscillations during the third stage burn, describing the situation as "worse than on Titan." Lee James, Saturn Program Manager, said that engineers were aware that such oscillations could be expected and that "we have some more work to do" in this connection. After lunar trajectory insertion and checkout the CSM, code-named "Charlie Brown," separated from the Saturn V third stage (S-IVB) and the LM, code-named "Snoopy."

Excellent quality color television coverage of the docking sequences was transmitted to the Goldstone tracking station and was seen on worldwide commercial TV. The spacecraft entered the moon's sphere of influence on the fourth day, May 21. On the fifth day Stafford and Cernan entered the LM and checked out all the systems before firing the SM reaction control system thrusters to separate the CSM and the LM about 30

Refugees await evacuation beside NASA vehicles that brought hospital and Civil Defense equipment and supplies into the striken town of Pass Christian in the wake of Hurricane Camille. The refugees are in front of a school that served as hospital and communications center. Inside the school, more homeless people line up for inoculations from MSFC doctors and nurses.

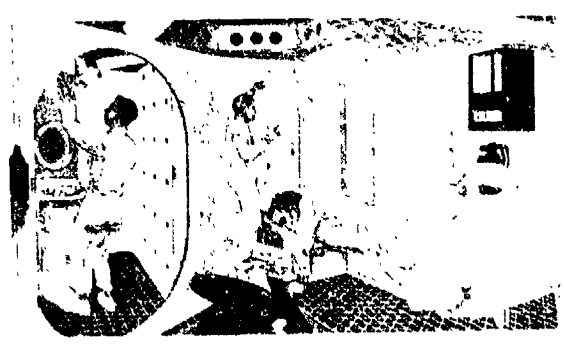


LRV flight unit



ATM in vibration test fixture at MSFC

Hand controller on LRV no. 2



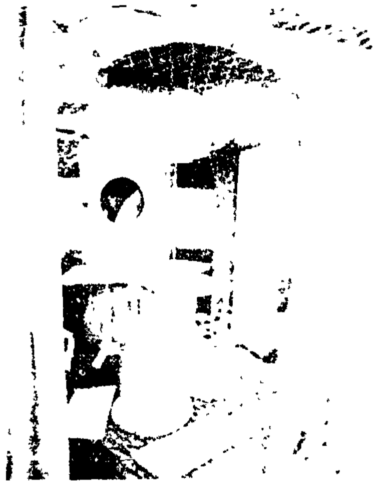
View of Workshop crew quarters. At left, crewman removes food from overhead oven. In center, crewman checks personal grooming in mirror. In foreground, unrestrained astronaut places vacuum cleaner bag in trash airlock.

feet and again for a 2.3-mile separation. The LM descent propulsion system burn propelled the LM to within 9.6 miles of the lunar surface. The crew had no difficulty identifying landmarks. Stafford said, "It looks like all you have to do is to put your tail wheel down and we're there . . . . The craters (around No. 2 landing site) look flat and smooth at the bottom. It should be real easy" for the Apollo 11 landing. The LM crew took numerous photos of the lunar surface and provided continuous commentary on their observations after their camera malfunctioned.

The CSM entered a transearth trajectory after 61.5 hours (31 orbits) in lunar orbit. Pictures of the moon as seen from the receding spacecraft were spectacular. On the eighth day the crew prepared for reentry, and the SM separated from the CM on schedule. Parachute deployment and other reentry events occurred as planned. Apollo 10 splashed down in the Pacific at 12:52 p.m. EDT on May 26, 3.4 miles from the recovery ship *USS Princeton*, precisely on time. The crew was picked up and reached the recovery ship at 1:31 p.m. EDT. During their busy schedule the three astronauts had taken time to share their voyage with the world. Nineteen color television transmissions totaled almost 6 hours.

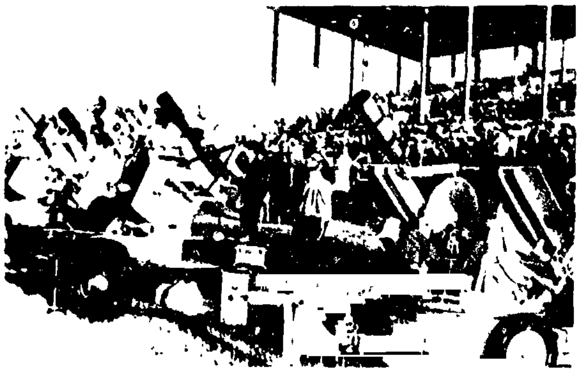
All primary Apollo 10 mission objectives and detailed test objectives had been achieved. Apollo 10 was the seventh Apollo mission to date, the fourth manned Apollo mission, the largest payload ever placed in earth and lunar orbits, and the first demonstration of lunar orbit rendezvous. The mission acquired major quantities of photographic training materials for Apollo 11 and subsequent missions. NASA planned the Apollo 10 mission as a manned lunar mission development flight to demonstrate crew/space vehicle/mission support facilities performance during a manned lunar mission with the Command/Service Module and Lunar Module, and to evaluate LM performance in the cislunar and lunar environment. The Apollo 10 countdown occurred with no unscheduled holds. The major activity in the first period of the launch included space vehicle launch, insertion into earth orbit, and translunar injection. Major activities during the second phase of the mission were a mid-course correction, two lunar orbit insertion burns, and initial LM activation. During this second phase the astronauts conducted a 29-minute scheduled color television transmission of the lunar surface, and the picture quality of lunar scenes was excellent. Major activities in the third period were the LM descent to within 50 000 feet of the lunar surface, and subsequent rendezvous with the orbiting CSM. Fourth period major activity included the LM APS burn to depletion, extensive landmark tracking, photography, TV, and transearth injection (TEI) burn. Although the crew made 18 landmark sightings during this period and took extensive stereo strip and oblique photographs, they deleted two scheduled TV periods because of crew fatigue. Major activities during the fifth period included star-lunar landmark sightings, and a CSM S-band high gain antenna reflectivity test. Major activity during the final phase included live color television, reentry, and recovery [497-501].

Responding to a question on the May 18 NBC TV program "Meet the Press," NASA Administrator Dr. Thomas O. Paine said that use of the MOL and of NASA's Orbital Workshop were "two very different projects." NASA's was a "longer range program aimed at a very substantial facility which would be really a university campus type research station in orbit." MOL was a "program that is well advanced, and is designed to find out the military applications of space" [502].



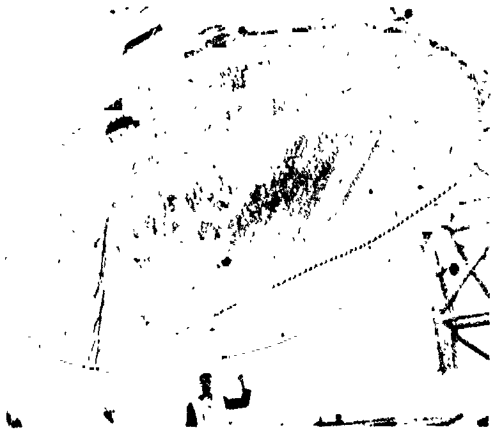
Skylab Workshop wardroom viewed through doorway. Food oven in ceiling; directly below is observation window. At bottom is food preparation table with thigh and foot restraints.

Apollo 12 crew



Cameras and observation stand at KSC during launch of Apollo 12

Apollo 12 lift-off



Heat shield of CM after reentry

In NASA's 1969 *Astronautics and Aeronautics Chronology* entry for May 19 a *Philadelphia Evening Bulletin* reporter was quoted as follows, describing the magnificance of the Apollo 10 lift-off: "TV cameras do not do it justice. It is like 100 claps of thunder, each following the other with machine-gun speed. The flame that leaps from behind the rocket could have come straight from Dante's inferno. It is too bright to be seen with comfort by the naked eye. The earth trembles beneath the feet. two miles away.

"Then the towering rocket, nearly twice as high as Niagara Falls, two-thirds the height of the Washington Monument, creeps with agonizing slowness the first few feet off the ground, enveloped by a white cloud.

"Then it is gone – and man is left to wonder and to pray."

On May 20 the stacked spacecraft and Saturn V launch vehicle for Apollo 11, first lunar landing mission, rolled out to Launch Complex 39, Pad A, at KSC [503].

On June 2 NASA announced its preliminary flight plan for the forthcoming Apollo 11 lunar landing mission. The spacecraft, carrying Astronauts Neil A. Armstrong (commander), Michael Collins (CM pilot), and Edwin E. Aldrin, Jr. (LM pilot), would be launched from the KSC Launch Complex 39, Pad A, by the Saturn V booster on July 16, with touchdown occurring on the moon's Sea of Tranquility on July 20. On July 21 Armstrong would step onto the lunar surface, followed an hour later by Aldrin. The astronauts would collect up to 50 pounds of lunar surface samples for return to earth, take photos, and deploy an experiments package before leaving the moon on July 21 and returning to the CSM being piloted by Collins. They would complete their 8-day mission with splashdown in the Pacific on July 24, 195 hours 20 minutes 42.2 seconds after launch [504].

Charles W. Mathews, Deputy Associate Administrator for Manned Spaceflight, and Astronaut Frank Borman visited MSFC on June 9 for discussions concerning the Space Station and the Space Shuttle. Dr. W.R. Lucas of MSFC hosted the one-day meeting. Mathews recently had been named to head a Manned Space Station Task Group in addition to his duties as Associate Administrator. Astronaut Borman, Commander of the Apollo 8 flight, had been named Field Director for the Space Station effort [505].

On June 9 Dr. von Braun requested of Dr. Mueller "an early program approval for a follow-on procurement of six Saturn V vehicles" in order that procurement activities might continue "in support of" schedules structured to support a delivery of AS-516 to KSC in January 1973 [506].

As a followup to a September 1968 letter in which MSFC had stated a position at the initiation of the cryogenic proof test program that the testing was not considered essential in man-rating the S-II structure, Col. Lee James on June 16 reiterated the MSFC position to Lt. Gen. Samuel C. Phillips in another letter. Col. James wrote, "The cryogenic test results and subsequently inspections of the structural test articles and flight stages S-II-3, S-II-4, S-II-5, S-II-6, and S-II-7 have not disclosed any evidence that decreased our confidence in the S-II stage as manufactured and processed through hydrostatic component tests and pneumostatic tests. Based on this experience, we are recommending that the cryoproof testing be discontinued effective with S-II-10. A cost savings of approximately $1 000 000 could be realized in the current program."

MSFC announced on June 24 the issuance of RFP's relative to an 8-month study of integration of Centaur and Saturn S-IVB stages for possible use in future unmanned high-velocity missions. Proposals for the study, which would include six launch vehicle configurations, would be due on July 10 [507].

The first stage of the Saturn V (SA-508) launch vehicle to be used on the Apollo 13 mission reached KSC on June 16. The second stage, scheduled to leave MTF on June 25, would reach KSC on June 30. The third stage had arrived at KSC on June 13. The Instrument Unit would be flown to KSC on July 7 [508].

MSFC announced the return of Maj. Gen. Edmund O'Connor to the U.S. Air Force following the Apollo 11 launch. General O'Connor joined MSFC 4½ years earlier, as Director of Industrial Operations (currently Program Management), and had been a key figure in MSFC management and in the Apollo Program management team. Lee B. James, Saturn V Program Manager, succeeded General O'Connor as Director of Program Management [509].

On June 26 the Saturn V first stage (S-IC-11) caught fire in the test stand at the Mississippi Test Facility during an acceptance test that was scheduled to last 125 seconds. The test was terminated automatically after 96 seconds when the temperature on the No. 3 engine turboprop exceeded the limit. The fire was extinguished by a fire-control system built into the test stand after burning for less than an hour [510].

On June 30 three aerospace industries received space agency contracts totaling $2 238 734. Under terms of the contracts the three industries would study design concepts and development requirements for a nuclear rocket stage which could replace the current third stage of the Saturn V launch vehicle for advanced missions in the late 1970's and 1980 period and which would serve as a workhorse for earth orbital and planetary applications. The three 10-month contracts went to McDonnell Douglas Corporation, $913 000; North American Rockwell Corporation, $756 734; and Lockheed Aircraft Corporation, $569 000. Payload concepts and their development requirements for potential flight tests and early operational applications of this nuclear stage would also be considered. The proposed nuclear stage would use the NERVA (Nuclear Engine for Rocket Vehicle Application) being developed jointly by NASA and the Atomic Energy Commission [511].

While many throughout the world doubted the possibility of safely landing men on the moon, there were nonroutine indications within MSFC that the Center had strong faith in the technical competence and expertise that would assure a successful mission. Six weeks before the scheduled Apollo 11 launch, a memorandum went to all MSFC employees stating, "We have all worked very hard for a long time to realize a national goal of getting men to the moon and back. For this reason Dr. von Braun wants as many MSFC employees as possible to attend the launching of Apollo 11, scheduled for 10:27 a.m. EDT on July 16, 1969. MARS has been asked to make travel arrangements for those employees who would not otherwise have an opportunity to see this launching." A few days later MSFC gave further indication of its optimism by announcing that Huntsville personnel headed by Messrs. David Newby, General Chairman; John Chase, Manager; Jim Johnson, Co-Manager; and Everette Brouillette, President of the AFGE Lodge, were planning a giant celebration in Huntsville On July 26 following the lunar flight. Dr. von Braun, Dr. Rees, and Mr. Gorman decided a few days before the announcement that it would be appropriate for MSFC to sponsor such a celebration [512].

The Director, MSFC, assigned responsibilities for development and procurement of manned LRV's for use on Apollo missions in 1971. Consistent with the "phased project management" philosophy under the Center's new organizational structure, the Director transferred the overall responsibility for the project from Program Development to Program Management excluding the responsibility of the Dual Mode Lunar Roving Vehicle effort. Within Program Management, the LRV Project Office would become an element of the Saturn Program Office. Pending final plans for the organization, an LRV Task Force consisting of personnel from Program Management, Program Development, and Science and Engineering would be used, managed by Saverio F. Morea, as manager of the LRV Project. Assisting Morea as chief project engineer and acting deputy manager of the project would be James A. Belew, formerly task team manager of the LRV effort in Program Development [513].

The Apollo 11 booster, spacecraft, and Astronauts Neil A. Armstrong, Michael Collins, and Edwin E. Aldrin, Jr., completed a final countdown rehearsal test, July 3. The astronauts achieved a simulated lift-off at 9:32 a.m. EDT at the exact time of the scheduled July 16 launch. Final countdown for the first manned lunar landing mission would begin July 10 [514].

On July 4 NASA officials ordered technicians to repaint the Saturn V third stage (S-IVB) after it was discovered that the old coating had begun to peel. Thermal paint would help protect the super-cold hydrogen fuels from the sun's heat. Repainting of the stage, scheduled to boost the manned Apollo 11 spacecraft toward the moon July 16, would not affect the launch date [515].

The Apollo 11 countdown began at KSC at 7:00 p.m. EDT on July 10 in preparation for launch at 9:32 a.m. EDT on July 16 [516].

On July 11 MSFC issued RFP's for the design, development, test, and delivery for four flight models of a manned lunar roving vehicle. This four-wheeled, 400-pound vehicle would be carried to the moon on board the LM in 1971 to transport astronauts, tools, lunar samples, and other equipment and experiments [517].

That the Saturn Program was nearing the center of the world's stage was apparent as the flight of Apollo 11 approached. First notables to arrive at Cape Kennedy on the eve of the Apollo 11 launch included former President and Mrs. Lyndon B. Johnson and Southern Christian Leadership Conference president, the Reverend Ralph D. Abernathy. The Johnsons arrived in military aircraft assigned by President Nixon. to attend a luncheon honoring James E. Webb, former NASA Administrator. Abernathy led 25 poor Southern families to protest Federal funding priorities. NASA Administrator, Dr. Thomas

O. Paine, met a group of 150 poor people outside a KSC gate where Abernathy requested 40 VIP passes to the launch, asked Dr. Paine to join the fight against poverty, and urged that NASA technology be converted to finding a new way to feed the poor. Dr. Paine agreed to admit members of the group to the launch and pledged to do what he could to adapt space-developed food concentrates to aid undernourished. "It will be a lot harder to solve the problems of hunger and poverty than it is to send men to the moon," Dr. Paine said. But, "If it were possible for us not to push that button tomorrow and solve the problems you are talking about, we would not push the button." He said that the space program and science could be used to help solve the poverty problems. "I want you to hitch your wagons to our rocket and tell the people the NASA program is an example of what this country can do." The poor people said they would pray for the Apollo 11 astronauts. By evening 500 000 tourists had arrived in Brevard County, site of KSC, with 1 million expected by early morning. The air traffic had quadrupled, with 10 local airfields handling over 1200 small aircraft and 200 private jets. Aircraft were to bring Vice-President Spiro T Agnew, over 200 congressmen, 60 ambassadors, 19 governors, 40 mayors, and other public figures for the July 16 launch. More than 1000 police struggled to control road traffic, and hordes settled to sleep on beaches from which they could see the illuminated spacecraft on the launch pad [518].

From July 16 through June 24 the Apollo 11 (AS-506) manned lunar landing mission flown by NASA achieved an 8-year goal set by President Kennedy on May 25, 1961. On July 20 the spacecraft's LM (Eagle) landed on the lunar surface, and the first man stepped out onto the moon. Two astronauts performed their assigned tasks on the lunar surface before reentering the LM to lift off from the moon, redock with the CSM, and return safely to earth. The historic Apollo mission – one of man's boldest adventures – began at 7:32 a.m. EDT, July 16, at the Kennedy Space Center. Millions around the world and thousands at the Florida launch site observed the lift-off of the giant Saturn V vehicle. Crewmen were Commander Neil Armstrong, Michael Collins, and Edwin E. Aldrin, Jr.

A backward glance at the mission shows that the Saturn V booster lifted the spacecraft from the KSC Launch Complex 39, Pad A, as planned, and the spacecraft carried the astronauts into circular earth parking orbit. After the post-insertion checkout, the CSM separated from the Saturn third stage (S-IVB). The successful propellant dump provided the impulse to the S-IVB for a slingshot maneuver to earth-escape velocity. The spacecraft entered lunar orbit at 1:28 p.m. EDT on July 19. Both lunar orbit insertion (LOI) burns were made when Apollo 11 was behind the moon and out of "sight" of the manned space flight network stations.

Armstrong and Aldrin entered the lunar module on July 20, and the LM landed on the moon at 4:18 p.m. EDT, July 20, in the Sea of Tranquility. Armstrong reported: "Houston, Tranquility Base Here – The Eagle has landed." Mission Control replied: "Roger, Tranquility. We copy you on the ground. You got a bunch of guys about to turn blue. We are breathing again. Thanks a lot." The lunar crew readied the lunar module for immediate ascent and then took a brief rest before depressurizing the cabin. Then the astronauts requested and were granted permission to descend to the moon's surface – about 4½ hours earlier than originally scheduled. Aldrin remained inside the LM and recorded Armstrong's descent with a camera. Armstrong took man's first step on the moon at 9:56 p.m. CDT, July 20. An estimated 600 million viewers on earth – one-fifth of the world's population – watched live TV transmission and heard him describe the feat as "one small step for a man – one giant leap for mankind." Collins, orbiting the moon alone in the CSM, was unable to see the landing and subsequent walks on the moon because the CSM was not equipped to receive TV transmission. Aldrin, about 40 minutes behind Armstrong, followed Armstrong onto the moon's surface, and the astronauts collected bulk samples of assorted surface material and selected rock chunks, two core samples, and 20 pounds of discretely selected material. Then the astronauts transferred the material to the LM and reentered the LM themselves.

At 12:45 p.m. CDT, July 21, the LM successfully lifted off the moon after 21 hours 36 minutes on the lunar surface. All lunar ascent and rendezvous maneuvers were normal. The LM docked once more with the CSM, the crew with samples transferred to the CSM, and the LM ascent stage was jettisoned into lunar orbit. The CSM entered transearth trajectory after 59 hours 28 minutes (30 revolutions) in lunar orbit. The CM, code-named Columbia, separated from the SM on schedule. Parachute deployment and other reentry events occurred as planned, and Apollo 11 splashed down in the mid-Pacific at 11:51 a.m. CDT, July 24, 15 miles from the recovery ship *USS Hornet*, 195 hours 19 minutes after launch. The astronauts climbed out of the Apollo 11, and a helicopter carried them to the recovery ship – then the CM was retrieved. The primary Apollo 11 mission objective of a lunar landing and all detailed test objectives had been achieved. Apollo 11 had been the eighth Apollo mission, the fifth manned Apollo mission, and the first manned lunar landing mission [519-522].

On July 18 NASA Administrator Dr. Thomas O. Paine approved the change from the "wet workshop" concept to the "dry workshop" concept for the Orbital Workshop by signing a Project Approval Document change request. Dr. Paine's approval of the "dry workshop" concept followed a May 27, 1969, Apollo Applications Program review presentation to the administrator concerning the "dry workshop" alternative. In general, the change was made necessary when the "wet workshop" concept became obsolete as more and more operational requirements added weight to the project, necessitating the lifting of the Workshop by a Saturn V rather than a Saturn IB.

MSFC employees along with those of all Executive departments, independent establishments, and other Governmental agencies observed a "National Day of Participation" proclaimed by President Nixon because of the historic occasion of man's first step on a celestial body other then the earth [523].

On July 22 NASA announced plans to launch the Workshop and Apollo Telescope Mount together in 1972, using the first two stages of the Saturn V in place of the Saturn I Wet Workshop. The Workshop would be outfitted on the ground and would arrive in a 235-mile circular orbit equipped for immediate occupancy by astronauts and with the ATM attached. Program objectives would remain the same as when NASA intended to use the Saturn IB second stage as the 1971 Workshop to provide an environment in which man could live and work for extended periods in space and to study man's physiological and psychological responses and capabilities in space. As a result of the Apollo Program success, the Saturn V hardware from that program would be available for this revised plan [524].

On July 23 the contract with Grumman Aircraft Corporation for the modification of an LM ascent stage for use with the ATM was terminated. The LM ascent stage was no longer needed when the decision was made to put the Workshop with the ATM attached in orbit with the Saturn V vehicle [525].

NASA announced on July 23 the selection of two aerospace industry teams to conduct design and planning studies of a future manned Space Station which could reach flight status in the mid-1970's. One of the teams would be headed by McDonnell Douglas Corporation, Huntington Beach, California, and the other would be headed by North American Rockwell Corporation, Space Division, Seal Beach, California. The two teams would conduct parallel, 11-month program (phase B) studies. Each would be valued at approximately 2.9 million dollars. MSFC would direct the study contract with McDonnell Douglas, while MSC would direct the study contract with North American Rockwell. Major effort of the studies would be preliminary design and planning of the 12-man, earth-orbital Space Station which could be developed by 1975. It would be designed to have an operational life of 10 years, subject to resupply of expendables and rotation of crews with logistics vehicles. The Space Station was envisioned as the initial element of a large space base and as a means for investigating the problems associated with manned habitation of space for extended periods, such as would be encountered in future manned planetary missions. The work would also include a conceptual design of a 50-man space base made up of specialized modules assembled in low earth orbit in the late 1970's and early 1980's [526].

On July 24 the city of Huntsville, Alabama, held a community-wide celebration at its courthouse square following splashdown of Apollo 11 at the end of the first moon-landing mission. Four local councilmen hoisted MSFC's Director, Dr. Wernher von Braun, on their shoulders as thousands cheered and waved banners saying, "Huntsville is Rocket City USA" [527].

MSFC employees joined in a Lunar landing Celebration at the newly established MARS picnic area at the Center. Foods, rides, a midway, and space exhibits were featured. Dr. von Braun spoke to the employees shortly after noon expressing his thanks for a "job well done." Also at a lunar landing celebration dinner and dance in Huntsville, Dr. Wernher von Braun said: "We worked together and together we accomplished our part of the mission. The moon is now accessible" [528].

MSFC announced on July 28 the transfer of Maj. Gen. Edmund F. O'Connor (USAF), Director of Industrial Operations, effective July 31. General O'Connor, on loan to NASA from USAF for the past 5 years, would become Vice Commander of the Air Force Aeronautical Systems Division. He would be succeeded by Lee B. James, Saturn V Manager, MSFC [529].

On August 1 NASA awarded a $1 170 000 contract to the Martin Marietta Corporation, Orlando, Florida, for certain flight hardware to be used in the Apollo Applications Program. The assignment, which was expected to take 18 months for completion, called for fabrication, testing, and delivery of 15 Saturn V Workshop rate gyro processors, a module test set, and the retrofit of 22 Apollo Telescope Mount gyro processors. The rate gyro packages would fly on a large scale earth-orbiting Workshop in 1972. The gyros would provide precise attitude control of the Workshop cluster including the Apollo Telescope Mount. Work under the contract would be performed at the contractor's facility in Orlando [530].

On August 2 NASA named Rocco A. Petrone as successor to Lt. Gen. Samuel C. Phillips (USAF) as Director of the Apollo Program, effective September 1. Dr. Petrone had been Director of Launch Operations at KSC since 1966. He would be succeeded by Deputy Director of Launch Operations Walter J. Kapryan. Petrone had been Saturn Project Office and Apollo Program Manager [531].

Astronauts O. K. Garriott, R. W. Cunningham, and R. L. Schweickart visited MSFC's Neutral Buoyancy Simulator and evaluated ATM film retrieval systems on August 5. They suggested a number of hardware and procedural changes which should be incorporated [532].

On August 6 NASA named the flight crews for Apollo 13 and 14 lunar landing missions. Prime crewmen for Apollo 13 would be Astronauts James A. Lovell, Jr. (commander), Thomas K. Mattingly II (CM pilot), and Fred W. Haise, Jr. (LM pilot). The backup crew would be composed of Astronauts John W. Young, John L. Swigert, Jr., and Charles M. Duke, Jr. Apollo 14 prime crewmen would be Alan B. Shepard, Jr. (commander), Stuart A. Roosa (CM pilot), and Edgar D. Mitchell (LM pilot). The backup crew would be Astronauts Eugene A. Cernan, Ronald E. Evans, and Joe E. Engle. Both missions would include lunar exploration and deployment of Apollo lunar surface experiment packages (ALSEP). The total lunar surface stay time would include two EVA periods of 3 hours each and would not exceed 35 hours. The flights would be the first for Astronauts Mattingly, Haise, Roosa, and Mitchell [533].

NASA announced on August 7 that General Dynamics Corporation, San Diego, California, had received a contract from the NASA Marshall Space Flight Center to study experiment modules to be used with a proposed manned Space Station. The final amount of the contract was $950 000. This 8-month study would complement the Space Station investigations to be carried out by McDonnell Douglas Corporation and North American Rockwell Corporation. General Dynamics would study the variety of experiments suitable for a manned Space Station. Some of those under consideration included astronomy, space physics, engineering and operations, earth applications and meteorology, biomedicine and biotechnology, space biology, advanced technology, and materials processing [534].

On August 7 NASA modified a contract with the Boeing Company that called for continued Saturn V systems engineering and integration through June 1970. Amount of the award was $15 455 800. The work would be performed in Huntsville and would cover work from June 1967 through June 1970. Boeing, builders of the Apollo/Saturn V's 7.5-million-pound-thrust first stage, performed systems engineering on all six Saturn V vehicles launched so far in the program. This contract modification continued the effort through 10 Saturn V launch vehicles [535].

AUGUST 1969

On August 8 a letter contract between MSFC and the McDonnell Douglas Astronautics Company defined the provision for two Saturn V Workshops. The first one was scheduled for launch into low earth orbit in 1972; the second Workshop would initially serve as a backup. The Workshop would be a converted S-IVB stage in which astronauts could live and work for periods up to 8 weeks. The 10 000 cubic foot hydrogen tank, which the crew would occupy, would be many times larger than any spacecraft flown before. The estimated cost of this cost-plus-fixed fee/award-fee contract was $97 340 000. The contract would run through July 1972, and work would be performed at the McDonnell Douglas Western Division at Huntington Beach, California [536].

On August 8 MSFC modified a contract with the McDonnell Douglas Astronautics Company for continued work on two airlock modules, test, and checkout of the modules, systems and documentation, and logistics support. Cost was estimated at $87 450 000, and the work would be performed primarily at the McDonnell Douglas Eastern Division in St. Louis but also would involve some effort at the three manned space flight centers – MSFC, KSC, and MSC. The airlock would be a part of an Apollo Applications Program cluster to be flown in 1972. The cluster would be made up of certain elements including the Saturn V Workshop, multiple docking adapter, Apollo command and Service module, and the Apollo Telescope Mount. One airlock was already undergoing tests at MSFC [537].

On August 13 NASA released its AAP "Launch Readiness and Delivery Schedule ML-17." According to this new schedule there would be seven Saturn IB and two Saturn V launches with two dry Workshops flown on Saturn V vehicles, and two ATM's planned. The first Workshop launch would be in July of 1972.

Hurricane Camille hit the Mississippi Gulf Coast late Sunday, August 17, and moved inland east of the Mississippi Test Facility. Although there was widespread damage to the small communities in the storm's path, Hurricane Camille caused relatively little damage at the MSFC's Mississippi Test Facility and the Michoud Assembly Facility. No injuries were reported at either facility. Area reports indicated that the Saturn V first (S-IC-12) and second (S-II-10) stages in the test stands were not damaged.

Many Huntsville space workers sped rescue and recovery equipment and supplies to the assistance of their coworkers at the Gulf Coast. By midnight Monday, August 18, a convoy from Huntsville began a long journey to the coast. A mobile 200-bed emergency hospital was part of the convoy. Other equipment and vehicles included large generators, three ambulances, vans of cots, civil defense food supplies, hand tools and chain saws, water trucks, four buses, two gasoline trucks and two diesel trailers, and several utility trucks. Almost two dozen MSFC employees went with the convoy or arrived by plane in the area.

Early Tuesday morning, two doctors, two nurses and two medical technicians flew to MTF for briefings, then to Pass Christian, where they set up an emergency hospital. Working through the night Tuesday, the medical team was not relieved until late Wednesday morning when a 400-man Navy Seabee force began moving into the area.

Meanwhile, the convoy of supplies and equipment reached Pass Christian by late Tuesday afternoon and went into operation, clearing streets, caring for refugees, and cleaning the school building where the hospital and communications center were located. NASA equipment provided the only communications with the outside world for more than 24 hours [538].

The Director, MSFC, sent letters to the Center's Huntsville employees urging support of a Disaster Fund Drive under way to aid MAF and MTF employees who had suffered extensive losses due to Hurricane Camille. The Director established a Disaster Assistance Committee to accept donations [539].

On August 26 MSFC issued a $56 727 contract for development during the next 6 months of a lunar roving vehicle hazard locator. The locator would use a laser beam to spot rocks, holes, and other obstacles on the surface of the moon as the vehicle moved forward. Due to the angles of light on the moon, astronauts could not always see well into certain areas, particularly shadows. The use of the locator would provide information displayed on a screen that would warn them of obstacles hidden from their view. The unit would be mounted high on the lunar roving vehicle and would be aimed at the ground ahead of the vehicle's path. The work would be done by Bionic Instruments, Incorporated, of Pennsylvania. During the first phase of the work, the firm would investigate a number of concepts and then, later in the period, would produce a prototype of the selected concept [540].

As of August 28 approximately 20 claims for damages resulting from static firings at MTF were outstanding. The Legal Affairs Office announced that denial had been recommended in each instance, with the exception of three claims. Portions of the three claims involved broken glass and china for which payment had been recommended. There had been 10 complaints of damage as a result of the static firing of the S-IC-10 stage on April 16, 1969, out of which had arisen one formal claim. This claim had been filed by a resident of Pearl River, Louisiana. Rather extensive noise and disturbance had been reported as far away as Hammond, Louisiana, although no allocations of damage had been received from that area [541-543].

In mid-1969 NASA made studies concerning the conversion of the Skylab from a wet Workshop flown on the Saturn IB vehicle to a dry Workshop flown on a Saturn V vehicle. Following a July decision by NASA that the Apollo program objectives had been achieved, NASA decided that a Saturn V vehicle could be given to the AAP for the first Skylab Workshop. After making this decision on July 18, NASA released its AAP Skylab Launch Readiness and Delivery Schedule ML-17 on August 13. According to this new schedule there would be seven Saturn IB and two Saturn V launches with two dry Workshops flown on Saturn V vehicles and two ATM's planned. The first Workshop launch would be in March of 1972 [544].

On September 4 a contract was awarded to the McDonnell Douglas Corporation for studies relating to a future manned Space Station which might be flown in mid-1970. Under the $2 899 986 effort, which would last 11 months, the firm would propose preliminary design and planning on the earth orbital Space Station which might have a

12-man crew and operate for as many as 10 years, subject to resupply of expendables and rotation of crews with logistics vehicles. The work would be performed at Huntington Beach, California. Meanwhile, a parallel effort was being conducted by MSC in Houston and North American Rockwell's Space Division in Seal Beach, California. The space station was being envisioned as the initial element of a large space base and as a means for investigating the problems associated with man's habitation in space for extended periods, such as would be encountered in future manned planetary missions [545].

MSFC announced on September 10, 1969, that employees had contributed $35 744.22 to help fellow workers at the Mississippi Test Facility and Michoud Assembly Facility whose homes and personal belongings had been damaged and destroyed by Hurricane Camille [546].

Five of six suits against the Government for damages allegedly resulting from static test activities at MTF were heard before Federal District Judge Walter L. Nixon. The plaintiffs and their neighbors (15 in all) testified that the noise was severe, that their buildings vibrated considerably, and that their concrete block homes and buildings cracked severely during the tests. The Government's acoustic and construction experts testified that the sound level in the area of plaintiffs' homes was well below that which would cause damage to a concrete block structure (142 dB), that the structures were old and substandard, and that they had cracked prior to the tests. The Judge apparently felt that the plaintiffs' testimony outweighed that of the Government experts; he ruled in their favor and awarded $27 000 to them for damages [547].

On September 19 MSFC modified a contract with the International Business Machines Corporation in Gaithersburg, Maryland, in connection with 27 instrument units ordered for the Saturn program. This $19 073 032 modification revised the delivery schedule, extended the period of performance by nearly 15 months, and provided for assessment of certain MSFC engineering change requests. At the time of this contract modification IBM had a contract with MSFC which called for fabrication, checkout, and delivery of 27 units for both the Saturn IB and Saturn V launch vehicles. The work would be performed in Huntsville, Alabama [548].

Over 400 management and supervisory personnel attended presentations in MSFC's Morris Auditorium on September 25, 1969. These were given by Director von Braun and other key management officials. The subject was space goals proposed by President Nixon for the next decade. The presentations covered goals for Apollo, the AAP, the Integrated Programs, and Apollo 11 science achievements. Other MSFC employees viewed the presentations via closed circuit television [549].

Dr. Thomas O. Paine, NASA Administrator, awarded a total of 117 awards at an honors ceremony in the Morris Auditorium at MSFC on October 2. Most were in recognition of exceptional service to the Apollo program to send men to the moon [550].

Effective October 7 MSFC signed a new contract with the General Electric Company's Apollo Systems Division in Huntsville, Alabama, for work in connection with the Apollo Applications Program. Under the $10 751 000 contract, GE would provide electrical support equipment for the Apollo Telescope Mount and launch systems for the Saturn V Workshop multiple docking adapter and airlock. The Workshop would be an early manned Space Station to be flown in 1972. The contract called for the work to be performed at Huntsville, Alabama; at the Manned Spacecraft Center in Houston; at Daytona Beach, Florida; and at the Kennedy Space Center in Florida. Work on the project was to be completed by June 30, 1972 [551].

A huge Saturn V first stage was erected for display at the MSFC Orientation Center. The big booster had arrived from the Michoud Assembly Facility aboard the NASA barge *Poseidon* [552].

NASA authorized MSFC in October 20 to issue RFP's to the contractors and enter into preliminary negotiations for the procurement of six Saturn V vehicles, SA-516 through SA-521 [553].

On October 20 representatives from Chrysler Corporation Space Division were at MTF to familiarize themselves with the S-II test stand relative to a planned proposal to perform Space Shuttle Booster vehicle testing at MTF [554].

On October 30 MSFC selected the Boeing Company, Aerospace Group, Huntsville, Alabama, to design, develop, test, and deliver four flight-qualified lunar roving vehicles and related test and training equipment. The four flight vehicles would be used in manned exploration of the moon's surface. Boeing was one of four contractors that had submitted proposals for this work. MSFC estimated the value of the cost-plus-incentive-fee contract at $39 591 000 [555].

On October 31 NASA decided to add television cameras for interior coverage of the Saturn Workshop [556].

On November 1 MSFC became a separate customer (apart from MICOM) of the South Central Bell Telephone Company for administrative telephone service. Center personnel received a telephone prefix of 453 designating the Center's service [557].

At the Mississippi Test Facility there was a successful test of a Saturn V booster on November 3 – the first test of the vehicle since a failure the previous June had caused fire on the test stand; the vehicle tested was the S-IC-12. It was fired for 125 seconds, the standard duration for ground tests, by the Boeing Company, maker of the stage. The test apparently met all objectives [558].

MSFC employees contributed $160 570 to the Combined Federal Campaign, $11 440 more than in 1968. Employee participation was 91.6 percent compared to 92 percent the previous year. Approximately 90 percent of the contribution would go to the United Givers Fund of Huntsville-Madison County and several other counties in Alabama and Tennessee where the employees lived. The rest would be divided between participating organizations of the National Health Agencies and the International Service Agencies [559].

NOVEMBER 1969

On November 9, 1969, Federal District Judge Harold Cox ruled in favor of the Government in the case of Pigott versus U. S., a suit for damages allegedly caused by static firing at MTF. Damages claimed in this suit were the same type as those claimed in prior suits wherein Federal Judge Nixon ruled against the Government [560].

On November 10, 1969, NASA announced the resignation of Dr. George E. Mueller, NASA Associate Administrator for MSF [561].

The Apollo 12 (AS-507) spacecraft carrying Astronauts Charles (Pete) Conrad, Jr. (commander), Richard F. Gordon, Jr. (CM pilot), and Alan L. Bean (LM pilot) rose from KSC Launch Complex 39, Pad A, at 11:22 a.m. EST, November 14 atop a Saturn V. The countdown before the launch went smoothly except for an unscheduled 6-hour hold at T-17 hours (spacecraft cryogenic loading) for replacement of the Service Module's liquid hydrogen tank number 2, which had been leaking. Three thousand invited guests, including President and Mrs. Nixon, watched the launch. During rocket ascent, observers on the ground saw two parallel streaks of lightning flash between clouds and the launch pad. NASA reported that electrical transients, later attributed to electrical potential discharges from clouds through spacecraft to ground, had suddenly shut off the spacecraft's electrical power and turned on numerous alarms in the CM. The spacecraft automatically switched to backup battery power while the crew restored the primary power system. Commander Conrad radioed, "We had everything in the world drop out." Control Center commented, "We've had a couple of cardiac arrests down here, too." "There wasn't time up here," Conrad said. However, the power system remained normal throughout the rest of the mission.

Conrad and Bean began the transfer to the LM during the translunar coast 1-half hour earlier than planned in order to obtain full TV coverage through the Goldstone tracking station. The 56-minute transmission showed excellent color pictures of the CSM, intravehicular transfer, LM interior, earth, and moon. A TV broadcast scheduled before lunar orbit insertion was canceled because of the sun angle and glare on the spacecraft windows. The spacecraft entered lunar orbit at 10:47 p.m. EST on November 17. During the first lunar orbit, good quality TV coverage of the lunar surface was transmitted for 33 minutes. The crew provided an excellent description of the lunar features. Conrad and Bean transferred to the LM for 1½ hours of housekeeping, voice and telemetry tests, and an oxygen-purge-system check; they then returned to the CM. Conrad and Bean reentered the LM, and entry into the approach phase trajectory was close to normal. The crew took over manual control at 370 feet, passed over the right side of the target crater, and landed on the moon's Ocean of Storms about 600 feet from the Surveyor III spacecraft at 1:55 a.m. EST on November 19. Conrad reported extensive dust obscuring the view during the final descent. Gordon, orbiting the moon in the CM, "Yankee Clipper," reported sighting the Surveyor III and "Intrepid" on the moon. Conrad, inches shorter than Neil A. Armstrong, who had stepped on the moon on July 21, had difficulty taking the last step from the ladder, and when he touched the lunar surface at 6:44 a.m. EST on November 19, he said, "Whoopee! Man, that may have been a small step for Neil, but that's a long one for me." The LM had landed so gently that its shock-absorbing legs were barely telescoped. Bean descended at 7:14 a.m. EST on November 19. Shortly after the color TV camera was removed from its bracket, transmission was lost and was not regained for the remainder of the EVA. However, the crew collected 40 to 50 pounds of contingency samples and reported mounds resembling volcanoes. Conrad and Bean dusted each other off and entered the "Intrepid" after 3 hours and 56 minutes walking on the lunar surface.

After resting inside the LM and checking plans for their second EVA period, the astronauts left the LM at 10:55 p.m. EST on November 19, 1 hour and 40 minutes ahead of schedule. After walking, Conrad reported that he had fallen once, but Bean had picked him up without difficulty. The crew obtained the desired photographic panoramas, core samples, trench sample, lunar environment sample, and assorted rock, dirt, bedrock, and molten samples. The crew reported that the Surveyor footpad marks were still visible and that the entire spacecraft looked brown, as if something had rained on it. The crew retrieved parts of Surveyor III, including the TV camera and soil scoop. They reentered the LM closing the hatch by 2:44 a.m. EST on November 20, after 3 hours and 49 minutes of walking on the lunar surface in the second EVA period.

While the LM was on the moon, Gordon, orbiting the moon in the CSM, completed the various photograph assignments.

At 9:26 a.m. EST on November 10, the LM successfully lifted off the moon after 31 hours and 31 minutes on the lunar surface, leaving behind the LM descent stage. The rendezvous maneuvers occurred as planned, and the LM docked with the CSM at 12:58 p.m. EST on November 20. At 3:49 p.m. EST on November 21 the crew fired the engine that injected the CSM into transearth trajectory after 89 hours and 2 minutes (44 revolutions) in lunar orbit. Good quality transmission of a question-and-answer period with scientists and press was conducted for 37 minutes. The CSM was separated from the SM, parachute deployment and other reentry events occurred as planned, and the "Yankee Clipper" splashed down in the mid-Pacific at 3:59 p.m. EST on November 24, 4.03 miles from the recovery ship *USS Hornet*. During the mission the largest U.S. payload had been placed in lunar orbit (72 335 pounds after lunar orbit insertion). Apollo 12 had been the ninth Apollo mission to date, the sixth manned Apollo mission, and the second manned lunar landing mission [562-566].

MSFC transferred technical management of the modified lunar module ascent stage (LM-A) to MSFC on November 15 and the airlock module in December. Contractors for these two modules were Grumman Aircraft Corporation and McDonnell Douglas Corporation, respectively [567].

MSFC announced on November 20 that the top stage of the Saturn rocket which had successfully boosted the Apollo 12 spacecraft to the moon was currently in a large elliptic orbit around the earth. On three previous missions the S-IVB stage had passed behind the moon in a corridor 970 to 2750 nautical miles wide and had entered an orbit around the sun on a path slightly closer and a little faster than that of earth. Passing the trailing edge of the moon at those distances, the announcement reported, "the stage receives a slight velocity increase due to lunar gravity, which slips the stage into sun orbit. This means of discarding the stage is called a slingshot maneuver. During the present mission, the stage passed outside the corridor – about 4000 nautical miles behind the moon. It did not gain sufficient gravitational pull to make the sun orbit" [568].

NOVEMBER – DECEMBER 1969

On November 24 MSFC shipped an F-1 engine and a J-2 engine from MSFC to New Orleans en route to France as part of the NASA exhibit at the Paris Air Show [569].

On December 8 Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight, made his annual staff visit to MSFC. It was his final official visit to the Center, occurring only 2 days prior to the effective date of his resignation [570].

On December 11 NASA announced the appointment of Charles W. Mathews, Deputy Associate Administrator for Manned Space Flight, as Acting Associate Administrator for Manned Space Flight, replacing Dr. George E. Mueller, who resigned the previous day [571].

On December 18 Dr. von Braun requested authorization of Dr. Mueller to proceed with formal negotiations and an award of a contract with the Boeing Company for the procurement of long lead items and associated services for additional S-IC stages. MSFC considered this action necessary "as an interim step pending the approval of the Saturn V Procurement Plan. The estimated cost of this contract is $2.4 M and local approval is intended" [572].

Near the end of 1969 there was much Saturn activity associated with NASA's Mississippi Test Facility. A Saturn V second stage (S-II-12) had arrived at MTF on December 20 for several months of acceptance testing, including a static firing, after shipment from the North American Rockwell Corporation plant at Seal Beach, California. Following extensive checks and inspections, the S-II-12 would be test-fired in February 1970. It would then be stored at MTF until needed at KSC.

Meanwhile, three other S-II stages and one S-I stage were at MTF; S-II-9 was undergoing final inspection before its scheduled shipment to KSC on January 8. There it would become part of the Saturn V that would launch Apollo 14 to the moon. Stages S-II-10 and S-II-11 were having modification checks before their shipment to the Kennedy Center. S-II-10 would be shipped in May 1970, and S-II-11 would be shipped in October 1970. S-IC-13, booster stage for the Apollo 18 mission, was scheduled for static firing at MTF January 14. Its shipment date to KSC had not yet been scheduled [573, 574].

1970

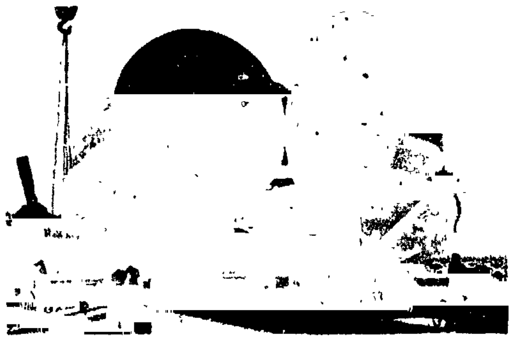
On January 2 MSFC shipped the test version of the Saturn V vehicle's third stage to the McDonnell Douglas plant at Huntington Beach, California, for modification. The S-IVB stage went from MSFC to the West Coast aboard the Super Guppy aircraft. The stage, formerly identified as the S-IVB 500 F, or facilities stage, would be converted into a Saturn V Workshop "dynamics test article." Once the modification was complete, the stage would be used in the Apollo Applications Program's dynamics and acoustics testing activity. The stage was formerly a part of the Saturn V facilities vehicle used to check out manufacturing, testing, and launching facilities early in the Apollo/Saturn V program. The stage had been returned to MSFC from KSC early in 1969 [575].

The Apollo 12 crewmen who visited the moon less than 2 months earlier spent 3 hours in Huntsville on January 8. Astronauts Charles Conrad, Jr., Richard Gordon, Jr., and Alan Bean thanked the many MSFC employees who had helped to make their lunar trip possible. The astronauts made speeches to several thousand employees, and thousands of others saw them as their motorcade passed through the Arsenal to the downtown Huntsville area [576].

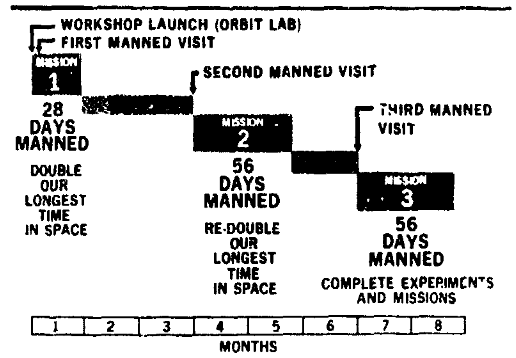
On January 8 NASA announced the appointment of Dale D. Myers, Vice-President and General Manager of North American Rockwell Corporation's Space Shuttle Program, as NASA Associate Administrator for Manned Space Flight, effective January 12. Myers would succeed Dr. George E. Mueller, who left NASA on December 10, 1969 [577].

On January 14 MSFC modified its contract with the Boeing Company to include changes incorporated in the first stage of the Saturn V rocket. The changes had been made on subsequent flight stages after the second Saturn V experienced excessive oscillations on an unmanned research and development flight, April 4, 1968. Under the $4 360 260 modification, Boeing installed "accumulators," or small gas reservoirs, in the liquid oxygen prevalves of the first stage to change the frequency pattern in the propulsion system. Additional ground testing and studies of flight data led to the decision to install the accumulators [578].

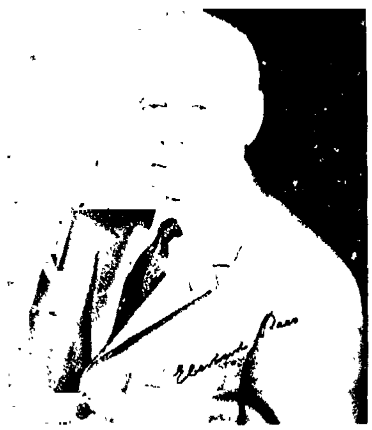
On January 23 NASA awarded separate contracts to three firms to study the possible modification of existing rocket engine test stands for use in developing a new Space Shuttle engine. Not yet under development, the new engine would be used in clusters to power a reusable space vehicle, or Shuttle, which would be flown as many as 100 times. A total of 12 test positions in three locations would be examined, and recommendations would be made as to the possible conversion of the stands for captive firing the new propulsion system. All of the test facilities would be government property. No decision had been made as to how many test positions would be needed in the Shuttle program. Four of the test positions were at MSFC; Aerojet General Corporation, Sacramento, would study the MSFC-Huntsville facilities. Four positions were at the NASA Rocket Engine Test Site, Edwards, California, where the study would be done by the Rocketdyne Division of North American Rockwell Corporation, Canoga Park, California. And four positions were located at the NASA-Mississippi Test Facility, where the study firm would be the Pratt and Whitney Division of United Aircraft, West Palm Beach,



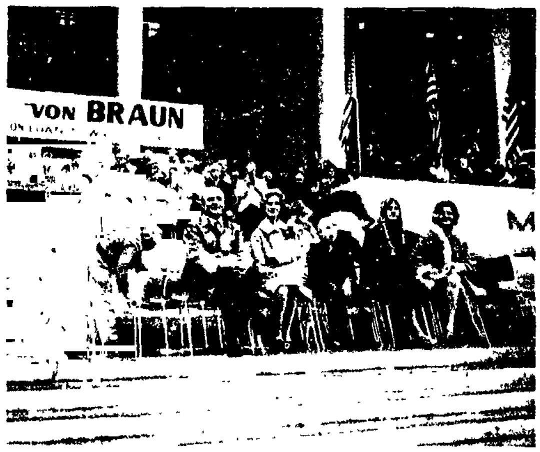
Super Guppy aircraft at MDAC-E



Skylab's three-mission program



Dr. Eberhard Rees succeeded Dr. von Braun as MSFC's Director



Dr. von Braun and family on the speakers platform at MSFC

Dr. von Braun and family, Senator Sparkman, and Governor Brewer standing beside plaque placed in memory of Dr. von Braun by citizens of Huntsville and Madison County, Alabama, at MSFC.

Dr. George Low (center), NASA deputy administrator, answered questions from newsmen at a February 1970 press conference, following his talk to Marshall Center employees. With Low were Dr. von Braun; Dale Myers, newly appointed associate administrator for Manned Space Flight; and Dr. Eberhard Rees, who would become MSFC director March 1.

Florida. The objectives of the studies were identical: to assess each test position and prepare a preliminary engineering report which would state the stands' potential for conversion to the shuttle engine program. Factors to be covered included methods of modification, cost, and timing. All study work would be conducted simultaneously, requiring 3 months. The Aerojet contract was for $167 643; the other two contracts were for $150 000 each [579-581].

On January 23 NASA released its AAP "Launch Readiness and Delivery Schedule ML-18," which moved the scheduled AAP-1 launch date to November 15, 1972, but with a target launch date of July 15, 1972.

NASA announced on January 27 that Dr. Wernher von Braun, head of MSFC for almost a decade, would leave Huntsville for Washington, D.C., where he would head NASA's planning effort for future U.S. space missions. His title would be Deputy Associate Administrator for Planning, National Aeronautics and Space Administration. Succeeding him as Director at MSFC in Huntsville would be his long-time deputy, Dr. Eberhard Rees [582].

Astronaut Walter Cunningham, who flew the first manned Apollo mission in 1968, visited MSFC on January 28 and presented 45 "Snoopy" awards to MSFC employees who had done an outstanding job promoting flight safety [583].

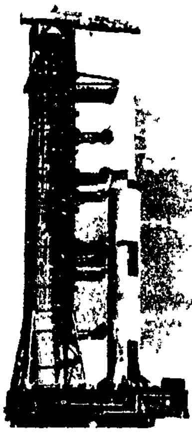
On January 28 and 29 there was a review meeting at MSFC concerning the design of the manned lunar roving vehicle (LRV). Approximately 100 design planners and program managers attended the 2-day session. A result of the meeting was confirmation of the rover's preliminary design, thus allowing the contractors to begin work [584].

AS-509, launched February 2, was the first vehicle to incorporate a center engine accumulator in an S-II stage to inhibit pogo oscillations. NASA announced that the preliminary assessment indicated excellent center engine accumulator performance [585, 586].

In February a number of local and visiting dignitaries were headlined in the MSFC area. On February 10 Alabama Governor Albert Brewer spent an hour visiting MSFC installations. On February 20 Dr. Christian N. Barnard, the surgeon known internationally for his successful human heart transplants, visited MSFC for a lecture and discussion in the Morris Auditorium. Near the end of February Dr. and Mrs. von Braun were honored with several farewell parties and a giant downtown Huntsville parade and courthouse ceremony before their move to Washington, D.C. [587, 588].

After soliciting proposals in September of 1969 from firms interested in defining control systems for two different types of Space Shuttle vehicles, MSFC's Aero-Astrodynamics Laboratory evaluated proposals from 13 participants. As a result of the evaluation, MSFC awarded a $49 982 contract to Honeywell, Inc., on February 11 [589].

On February 12 the House Committee on Science and Astronautics' Subcommittee on NASA Oversight released its report *Manned Space Flight: Present and Future*. One of the conclusions drawn by this staff study was that after 1974 the U.S. would have no



Saturn and mobile launcher aboard crawler at KSC

View of the audience as they listened to Dr. Christian Barnard at Morris Auditorium.

Dr. Christian Barnard (center) of the Groote Shurr Hospital staff, Johannesburg, South Africa, visited the Marshall Center to present a lecture. He also met with Marshall Center leaders for a tour of the installation. Shown here from left to right are: Dr. Wernher von Braun; Dr. Ernst Stuhlinger, MSFC's associate director for science, who invited Dr. Barnard; Otto Kilma, vice president and general manager of General Electric in Philadelphia; and Dr. Eberhard Rees, MSFC deputy director, technical.

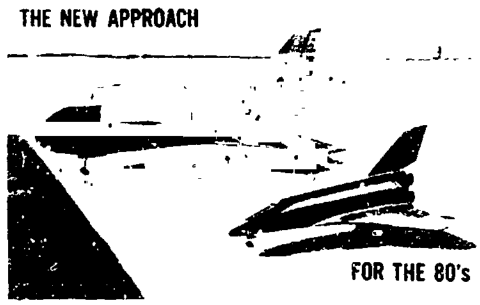
capability for lifting manned payloads over 60 000 pounds into space and would have only three vehicles that could lift a 60 000-pound payload unless Saturn V production was resumed or a substitute was developed. Also, the U.S. would have no long-duration, manned, earth-orbital capability after 1973 without extension of the Orbital Workshop program or initiation of development of a Space Station.

On February 18 NASA requested proposals from the aerospace industry for preliminary definition and planning studies of a Space Shuttle main propulsion system. High performance liquid hydrogen, liquid oxygen fueled engines would make up the Space Shuttle's main propulsion system for launch, orbital insertion and flight operations, and reentry from earth orbit. Preliminary concepts called for a cluster of engines in the booster stage and a lesser number (two or three engines) in the orbiter stage. The engines would be throttleable with a nominal sea level thrust of approximately 400 000 pounds from each engine. The vertical take-off, horizontal landing Shuttle could be operational in 1977 or 1978. From the proposals to be submitted, up to three firms would be selected for parallel 11-month Phase B studies under fixed price contracts to be managed by MSFC. Industrial firms receiving the requests for proposals were North American Rockwell Corporation, Rocketdyne Division, Canoga Park, California; United Aircraft Corporation, Pratt and Whitney Aircraft Division, West Palm Beach, Florida; Aerojet General Corporation, Sacramento, California; TRW Incorporated, Redondo Beach, California; Bell Aerospace Systems, Buffalo, New York; and Marquardt Corporation, Van Nuys, California [590].

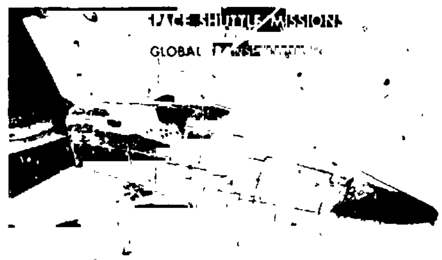
NASA requested proposals on February 20 from the aerospace industry for preliminary definition and planning studies of a Space Shuttle system for transporting crew, passengers, and cargo to and from low earth orbit. The two-stage, fully reuseable Space Shuttle would be a logistic vehicle for manned earth orbital operations including placement, maintenance, and retrieval of experimental modules and satellites; delivery of propulsive stage and payloads; delivery of propellants to a Space Station or orbiting vehicle; and short duration special purpose orbital missions. Proposals were to be submitted to NASA's Office of Manned Space Flight by March 23, 1970. From the proposals, as many as three firms would be selected for parallel 11-month Phase B studies under fixed price contracts. The Phase B contracts would be managed by MSFC and MSC. Industrial firms receiving the requests for proposals were Lockheed Aircraft Corporation, Los Angeles, California; Chrysler Corporation, Detroit, Michigan; Grumman Aircraft Engineering Corporation, Bethpage, Long Island, New York; the Boeing Company, Seattle, Washington; General Dynamics Corporation, San Diego, California; North American Rockwell Corporation, Downey, California; Martin-Marietta Corporation, Denver, Colorado; and the McDonnell Douglas Astronautics Company, St. Louis, Missouri [591].

NASA Headquarters announced on February 24 a change of the program name from Apollo Applications Program to Skylab Program. The Skylab Program would be designed to make maximum use of the existing space hardware developed for the Apollo lunar landing series. Included in the cluster of components making up the Skylab would be the Workshop, airlock, a multiple docking adapter, and an ATM. These components would be launched by a Saturn V rocket with the first two stages providing propulsion Astronauts in an Apollo command/service module would be launched by a Saturn IB rocket to

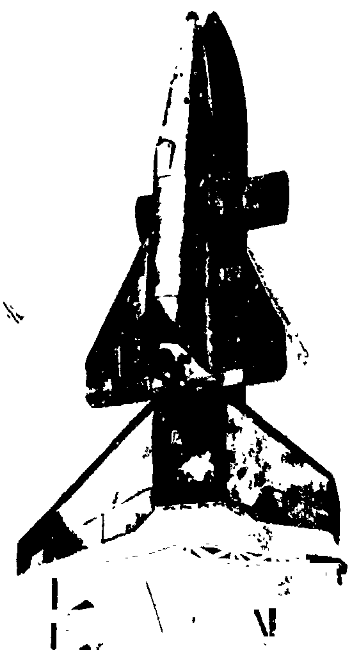
Alabama Governor Albert Brewer, who was in Huntsville early in 1970 to address the Press Club, spent an hour in the afternoon looking over hardware at the Marshall Center James R. Thompson, Jr., (right) of Manned Systems Integration, Astronautics Lab, conducted this portion of the briefing along with Karl Heimburg (left), director of Astronautics Lab.



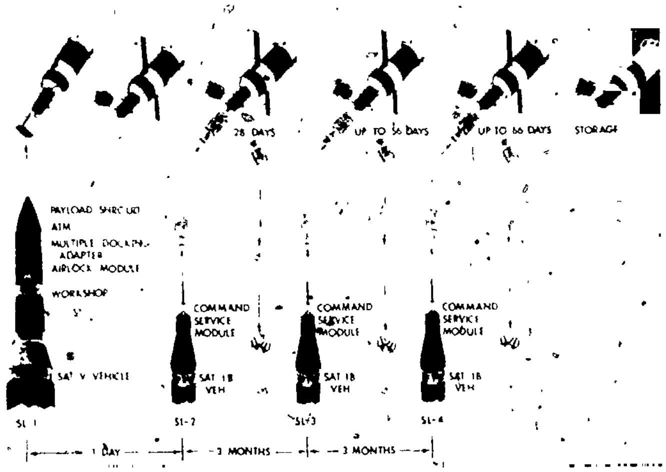
Space Shuttle concept



Artist's concept of Shuttle depicting its use for global transportation



Launch configuration of Space Shuttle



Skylab activation and operation

rendezvous and dock with the Skylab. The ATM would be a solar observatory to be used by the astronauts in studies of the sun from the earth's atmosphere. MSFC would be responsible for development of the Workshop, airlock, multiple docking adapter, and ATM [592].

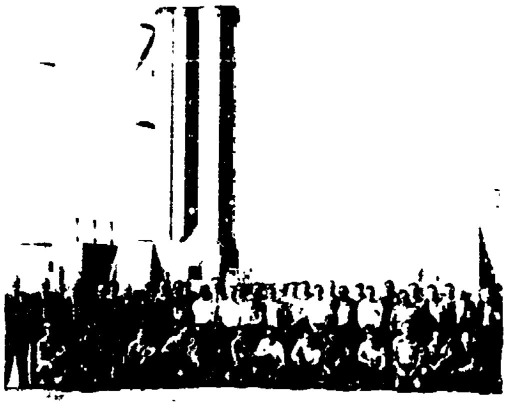
Dr. Eberhard F.M. Rees became the director of MSFC, succeeding Dr. Wernher von Braun, on March 1 [593].

In their Space Station Program Phase B Definition report, dated March 13, 1970, North American Rockwell concluded that the Space Station could be designed to accommodate a broad spectrum of research and applications activities in the following areas: astronomy, earth applications, advanced technology, space physics, aerospace medicine, manned space flight engineering and operations, bioscience and materials science, and processing [594].

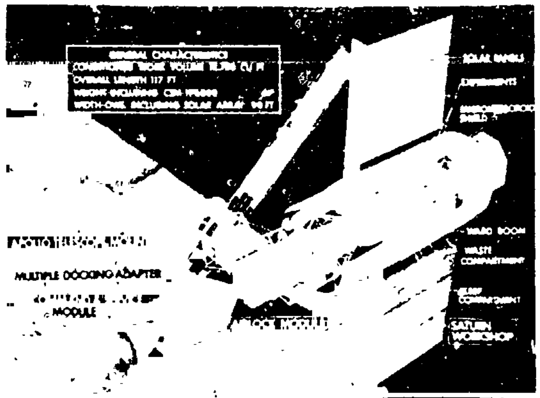
On March 13 NASA Headquarters conducted a briefing on Space Station and Shuttle programs for representatives of 17 nations NASA Administrator, Dr. Paine, said that foreign participation was a step in NASA's continuing efforts to inform other nations of post-Apollo program planning so that they might determine the extent to which they wished to participate [595].

Representatives of three NASA Centers gathered in Huntsville on March 31 to start a 4-day tour of Skylab government and contractor facilities. Those on the tour included Dr. Robert R. Gilruth, Dr. Christopher C. Kraft, Kenneth S. Kleinknecht, Clifford F. Charlesworth, Dr. Maxine E. Faget, Sigurd A. Sjobert, Dr. Donald K. Slayton, George Abbey, Robert F. Thompson, Dr. C.A. Berry, Eugene F. Kranz, and Cadwell Johnson, all of MSC. From KSC there was General Thomas W. Morgan, and from MSFC there were Dr. Eberhard Rees, Ed Mohlere, Lee B. James, Ludie Richard, Dr. F.A. Speer, Dr. Walter Haeussermann, Karl L. Heimburg, Brooks Moore, Leland F. Belew, and Jack Lee. At the Marshall Center on this date the group viewed Skylab work in several laboratories. In the afternoon they departed for a 3-day tour of contractor facilities. Companies visited were McDonnell Douglas Astronautics Company, St Louis, Missouri; Martin-Marietta Corporation, Denver, Colorado; and North American Rockwell Corporation and McDonnell Douglas in the Los Angeles area. The group also visited the NASA-Flight Research Center at Edwards, California [596].

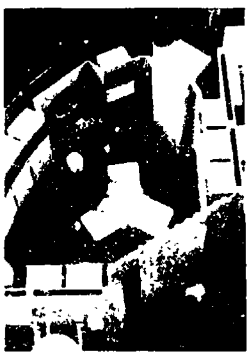
The first U.S. satellite, the 30.8-pound Explorer I, launched from Cape Canaveral, Florida, by a Jupiter C booster on January 31, 1958, reentered the atmosphere over the South Pacific on March 31, 1970. This pioneering satellite had discovered the Van Allen radiation belts and had completed more than 58 000 revolutions of the earth. Dr. Wernher von Braun, NASA Deputy Associate Administrator for Planning, who was Director of the Army Ballistic Missile Agency at the time of launch, said: "By today's standards Explorer I was a feeble, first step in space. But in its day it was an outstanding accomplishment, done on short notice to place the free world in the space race. . . . We have come a long way from that tiny Explorer, demonstrated by the fact that the Saturn V we are now flying can place in Earth orbit about 10 000 times as much payload as the little Jupiter-C that launched Explorer I" [597].



In early 1970, 67 awards were given to Management Services, Inc., motor pool drivers at an annual Safe Driver Awards ceremony. The awards were presented for safe driving records ranging from 1 to 8 years. Here the winners pose in fror of the MSFC Space Orientation Center.



Skylab cluster



View inside Workshop mockup

Dr. Rees, Dr. von Braun, and Astronaut W. Anders with National Aeronautics and Space Council Group in Building 4619, looking over space hardware at MSFC.

Forward skirt being joined to OWS no. 1

Apollo 13 astronauts. Left to right: Lovell, Swigert, Haise

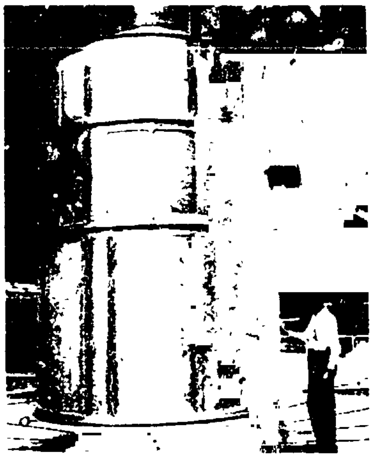
Space Shuttle mission capabilities were described by LeRoy E. Day, Manager, Space Shuttle Task Group, NASA OMSF, in a paper presented on April 1 at the AIAA Conference on Test Effectiveness in the '70's at Palo Alto, California. "It is envisioned that the Shuttle will eventually replace essentially all of the present day launch vehicles or their derivatives except for very small vehicles of the Scout class and the very large Saturn V. This will be possible because low operational costs of the reusable Shuttle will make it competitive even if it carries only a fraction of its full payload capability on particular missions" [598].

MSFC announced on April 2 that eight aerospace firms had submitted proposals to MSFC relative to a study contract aimed at defining the auxiliary propulsion system for a Space Shuttle vehicle. The proposals were being evaluated as of that day. Also under evaluation in a separate action were bids from three aerospace firms for definition of the main engine propulsion system for the Shuttle craft. The firms submitting proposals on the auxiliary propulsion system were Bell Aerospace Systems, Grumman Aerospace, Lockheed Aircraft Company, Martin-Marietta Corporation, McDonnell Douglas Astronautics Company, Rocketdyne Division and Space Division of North American Rockwell Corporation, and TRW, Incorporated. Aerospace firms that submitted bids for the main propulsion system included Pratt and Whitney Division of United Aircraft, Aerojet General, and Rocketdyne Division of North American Rockwell [599].

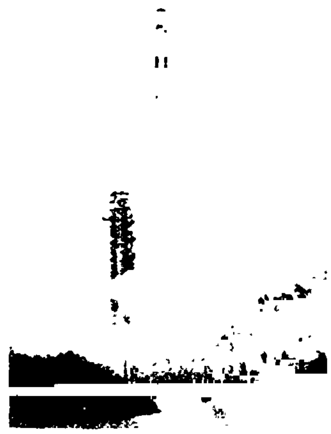
Between April 6 and April 22 MSFC awarded contracts to three aerospace contractors for continuation of nuclear Shuttle definition studies. Contracts were awarded to McDonnell Douglas Astronautics Company, \$343 000; Lockheed Missiles and Space Company, \$282 000; and North American Rockwell Corporation's Space Division, \$245 000. A variety of nuclear Shuttle concepts would be studied under the contract extensions. These contracts assumed use of the NERVA engine, which at the time of these contracts was under development by NASA and the Atomic Engery Commission. North American Rockwell would study a large, 33-foot-diameter nuclear stage which would be placed in orbit by the Saturn V and refueled by an earth-to-orbit Shuttle which NASA was considering for development Lockheed would study a completely modular concept in which the earth-to-orbit Shuttle would be used to transport modules to orbit for assembly into the nuclear shuttle system. McDonnell Douglas would study both the 33-foot-diameter system and the modular concept. The contract extensions were for 1 year [600-602].

In its April 7 Apollo 12 Failure/Anomaly Status Report, NASA announced that it had revised launch mission rules and incorporated procedural and software changes to minimize recurrence of the atmospheric electrical discharge that occurred with the flight of Apollo 12.

MSC on April 10 awarded a \$1.9 million contract to the Itek Corporation for design, development, and delivery of multispectral photographic equipment for Project Skylab. Itek would provide one 6-lens camera flight unit, one backup, and associated lenses and magazines [603].

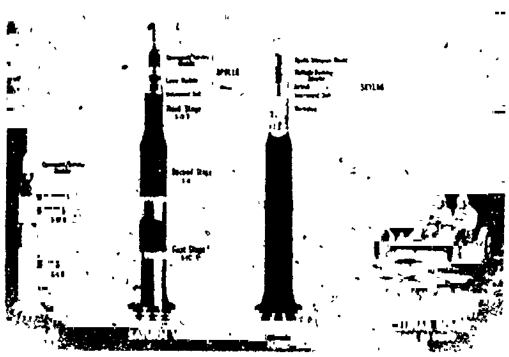


MDA test article in fabrication at MSFC

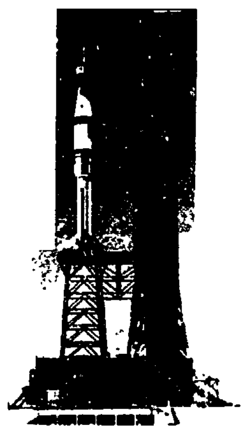


Launch of Apollo 13

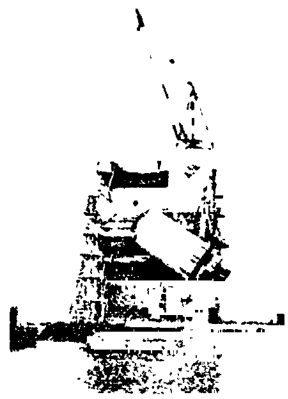
Splashdown of Apollo 13, after flight was aborted because an oxygen tank in the spacecraft's service module ruptured.



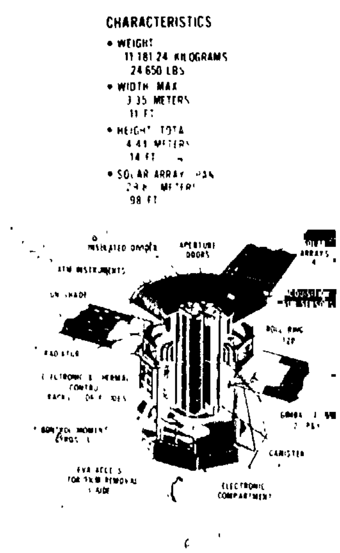
Saturn Program hardware



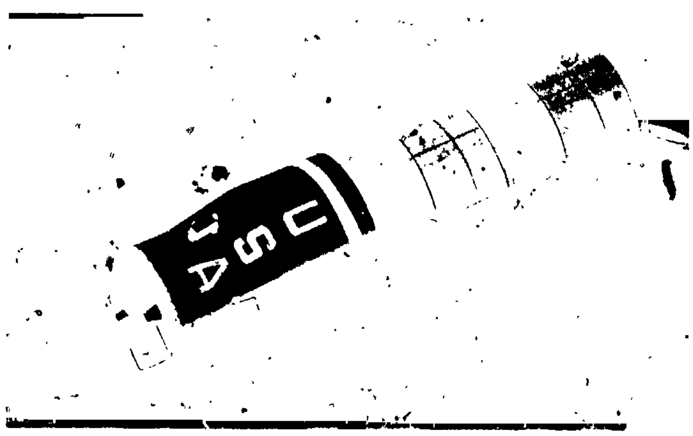
Skylab Saturn IB launch configuration



S-II-9 installation in A-1 Test Stand at MTF



Apollo Telescope Mount



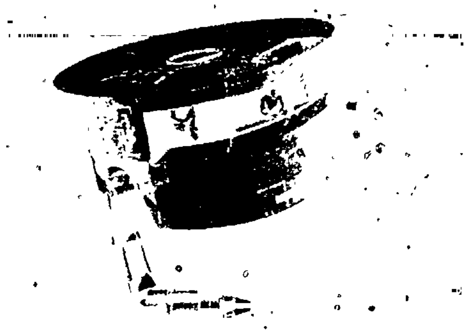
Space Tug concept

NASA's ill-fated Apollo 13 (AS-508) flight began with a successful lift-off as scheduled from KSC Launch Complex 39, Pad A, at 2:13 p.m. EST on April 11, carrying Astronauts James A. Lovell, Jr. (commander), John L. Swigert, Jr. (CM pilot), and Fred W. Haise, Jr. (LM pilot). Perhaps a bad omen for the flight occurred when Swigert was substituted from the backup crew for Thomas K. Mattingly II, who had failed to develop immunity after exposure to German measles. Approximately 4500 VIP's were on hand for the launch, including Vice-President Spiro T. Agnew, West German Chancellor Willy Brandt, and NASA Administrator Dr. Thomas O. Paine. It was during the second-stage boost that excessive vibration of the S-II stages' center engine caused an early shutdown of that engine. The second stage's four outer engines burned about 34 seconds longer than scheduled and the third stage (S-IVB) single engine burned 12 seconds longer to compensate for the early engine cutoff. Preliminary analysis of flight data indicated that an automatic early cutoff occurred due to action of "thrust OK switches" on the center engine. Large pressure oscillations in the liquid oxygen system, coupled with vibrations in the center engine support structure, started a chain of events that led to center engine cutoff 132 seconds earlier than planned. However, sufficient propellants remained for translunar insertion.

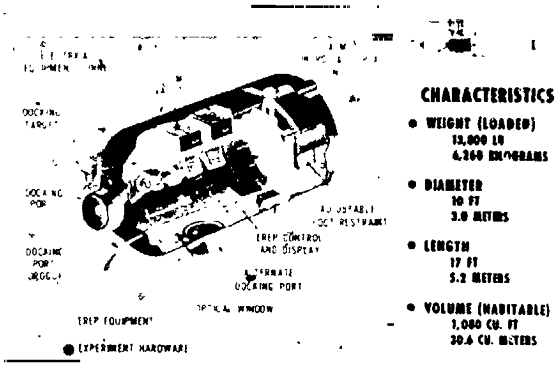
On April 13 Lovell and Haise entered the LM for housekeeping and system checks, but minutes later, at 10:08 p.m. EST, the crew reported rapid loss of pressure in an oxygen tank. Haise reported "a pretty large bang associated with the caution and warning." A few minutes later the crew reported that the spacecraft was venting something – later determined to be oxygen – out into space. Despite desperate efforts nothing seemed to halt the drop in oxygen pressure. The spacecraft dipped repeatedly, apparently because of venting gas. The decision was made to abort the mission. With only minutes of power remaining, the crew fed oxygen into the reserve tank. The public's apparent boredom at the beginning of the mission was transformed into deep concern for the astronauts' safety. Messages and offers of aid were sent to the U.S. from world leaders, and prayers were offered by religious leaders on every continent.

The Apollo 13 was placed on a free-return trajectory around the moon. During the remainder of the transearth coast the crew continued emergency procedures to deal with shortage of water to cool the LM electronic systems, decreasing temperatures in both cabins, and buildup of carbon dioxide in the LM. The crew kept the spacecraft in rotation to let the sun uniformly heat all sides. The astronauts met the cool water shortage by filling every plastic bag they could with water from the CM and carrying it to the LM. The crew tried various ways to keep warm: wearing boots carried for walking on the moon, sleeping in the three-foot-wide tunnel between the LM and CSM that seemed warmer, and wearing extra clothing.

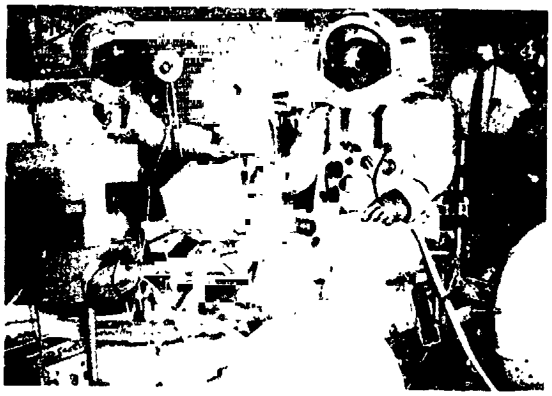
Officials on the ground developed new reentry procedures and verified them in ground-based simulations. Almost every move that the Apollo 13 crew made was first proved on the ground. The crew viewed and photographed the SM when it was jettisoned, reporting that one entire panel was missing and that a great deal of debris was hanging out. Parachute deployment and other reentry events occurred as planned, and the Odyssey splashed down in the mid-Pacific southeast of American Samoa at 1:07 EST on April 17, 4.02 miles from the recovery ship *US Iwo Jima*. The astronauts, exhausted but in good health, were picked up by a recovery helicopter and were safely aboard the



Space Tug Crew Module concept



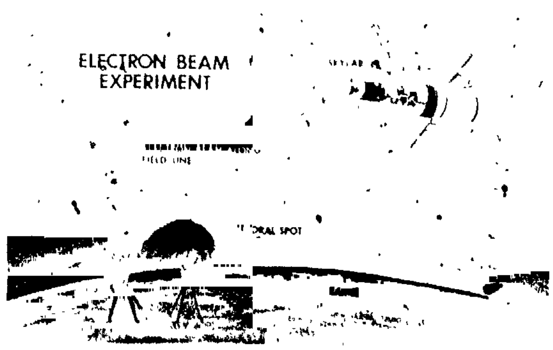
Multiple Docking Adapter



NASA Astronauts Charles Duke (left) and John Young ran through practice exercises with a full scale model of the Lunar Roving Vehicle in June 1970 at the Marshall Center. The two astronauts, wearing pressurized space suits and portable life support systems, spent hours checking crew equipment and systems. They were observed by engineers and technicians from the Marshall Center, the Manned Spacecraft Center, and LRV contractors.

Final assembly of the ATM thermal systems unit at MSFC

S-IV-B Orbital Workshop electron beam experiment



Artist's concept of electron beam experiment in operation recovery ship less than 1 hour after splashdown. The primary Apollo 13 mission objectives were not achieved, but the Apollo 13 flight crew performance was outstanding throughout the mission. NASA Administrator Dr. Thomas O. Paine announced on April 17 that an Apollo 13 Review Board, headed by Langley Research Center Director Edgar M. Cortright, would be established to determine the cause of the accident. The Apollo 13 flight had been the 10th Apollo mission and the 3rd manned lunar landing attempt. The accident was the first inflight failure in 22 manned flights in the U.S. space program [604-608].

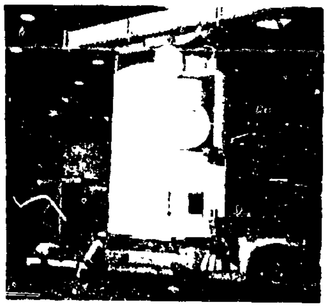
MSFC Director Rees announced on April 16 that effective April 22 Mr. Roy Godfrey, Manager, Saturn Program, Program Management, would be reassigned to Program Development to serve as Manager, Space Shuttle Task Team [609].

On April 23 NASA awarded a $3 million contract to the Garrett Corporation for a portable astronaut life support assembly (ALSA) to support extravehicular and intravehicular activity in the Skylab program [610].

On April 30 Roy Godfrey, Manager of MSFC's new Space Shuttle Task Team, informed Dr. Rees: "... the Apollo/Saturn has without a doubt been one of the most stringently managed programs of its kind. The application of technical and managerial resources within the government and industry has perhaps been unprecedented in bringing to bear disciplines of design control, analysis, and scrutiny of the system. Qualification of design and continued quality control of manufacturing through multiple tests and inspections have been successful in forcing the exposure of potentially critical flight failures. Correction of failures to the most minute detail has been the rule. Regular and in-depth technical audits have detected problems and corrective action has been applied to both technical and managerial problems. Successive cross matric [*sic*] reviews of all disciplines from different perspectives in design, quality, safety, management, as well as different organizational levels; [*sic*] i.e., contractors, suppliers, government resident offices, S&E, PM, and Headquarters have been intense and in-depth" [611].

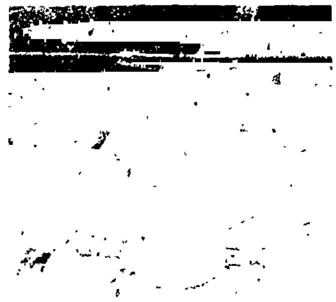
NASA selected two aerospace industrial firms on May 12 for final negotiations of parallel, 11-month contracts for definition and preliminary design studies of a reusable Space Shuttle vehicle for possible future space flight missions. Fixed priced contracts would be negotiated with McDonnell Douglas Corporation, St. Louis, Missouri, and North American Rockwell Corporation, Space Division, Downey, California, valued at approximately $8 million each. MSFC would manage the McDonnell Douglas work and MSC would manage the North American Rockwell contract. Four firms submitted proposals for the studies [612].

MSFC announced on May 15 that NASA had decided to launch Saturn IB and Saturn V vehicles scheduled for the 1972-1973 Skylab Program from Launch Complex 39 at Cape Kennedy. The decision to conduct Saturn IB launches at LC 39, rather than Complexes 34 and 37, was reached after a comprehensive study of the capabilities and costs of both locations, Skylab Program officials said. The original plan was to launch only Saturn V's from LC 39 [613].

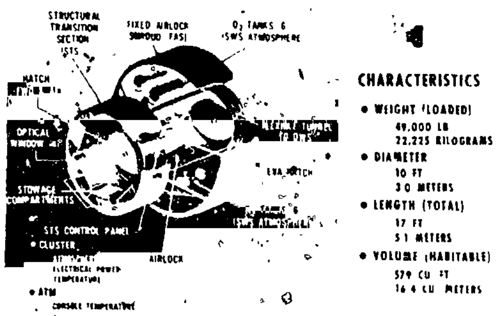


MDA dynamic test article being lowered onto factory trailer.

Deployment of HEAO from Shuttle – artist's concept

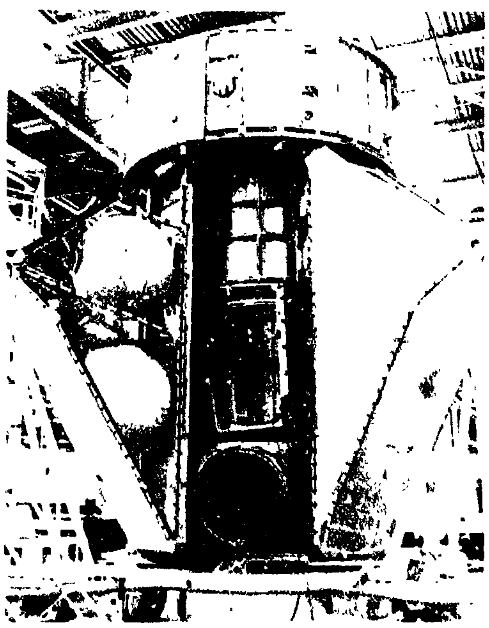


Airlock flight article no. 1 in clean room at MDAC-E being rotated into vertical position



Airlock Module

Three Saturn IB boosters were delivered to the Marshall Center in the summer of 1970 after a barge trip from the Michoud Assembly Facility in New Orleans. The stages were to be placed in storage at MSFC because of a stretch in launch dates. The boosters were for Saturn IB vehicles 212, 213, 214



Airlock flight unit in fabrication and assembly

Airlock Module interior during crew station review

On May 21 MSFC negotiated a supplemental agreement with International Business Machines Corporation for Saturn launch vehicle flight programming computer requirements and development of computer programs. The supplement was valued at more than $1.8 million dollars and extended the effort described above through December 1972. The supplement was part of IBM's original contract with NASA, awarded in August 1964, to build and support 27 instrument units for Saturn launch vehicles [614].

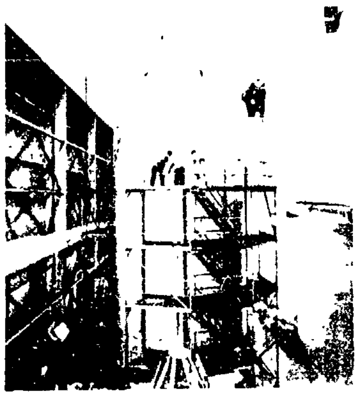
On May 26 MSFC announced that its Advanced Systems Analysis Office was investigating possible uses of a Space Tug multipurpose vehicle to be developed simultaneously with a larger Space Shuttle. This Tug, the only space vehicle that would work with and connect all existing and future vehicles and systems, would first be used as a link between the Space Shuttle and the Space Station to taxi cargo and passengers in earth orbit. Both MSFC and MSC were working to develop space tug plans [615].

MSFC revealed on June 1 the relocation of several Saturn IB and Saturn V stages and instrument units to avoid possible damage or destruction by hurricanes in the area of the Michoud Assembly Facility in New Orleans, Louisiana. Three Saturn IB boosters would be moved from Michoud to MSFC in mid-July [616].

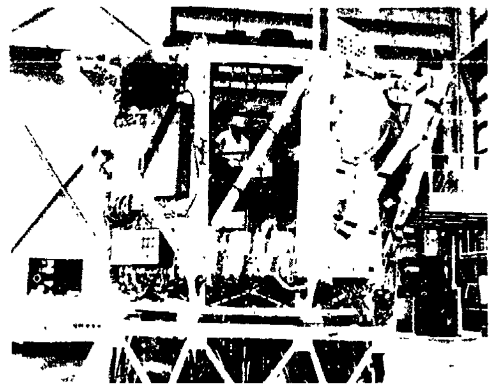
On June 4 MSC awarded the following contracts: North American Rockwell Space Division would receive a $305 700 000 cost-plus-fixed-fee/award-fee supplemental agreement to the Apollo spacecraft contract for four CSM modules for the Skylab program. This agreement defined the March 1969 letter contract and brought the estimated cost of the the contract for both Apollo and Skylab to $3 618 006 813. North American Rockwell Space Division also would receive $250 000 for a preliminary planning study of a reusable Space Tug with multipurpose applications [617, 618].

On June 9 the Martin Marietta Corporation of Denver, Colorado, received a modification to its Skylab program payload integration contract from MSFC. The modification, valued at $2 168 070, was for work on systems integration for the multiple docking adapter, a major segment of Skylab's Saturn Workshop. Schedules called for the work modification to be completed by early 1972. The work would include design development, buying of materials, manufacturing and quality control, testing several test models, and buying ground support equipment and long-lead time materials. Martin Marietta's contract with MSFC gave the company responsibility for integration of all elements of the Skylab Program, including the Saturn Workshop, Apollo Telescope Mount, airlock, MDA, and other equipment [619].

The June 10, 1970, minutes of the Apollo Design Certification Review Board concurred with an earlier MSFC position taken in May 1969 in support of termination of static testing of Saturn V stages; however, this board ruled that a decision to continue static firing for any new buy of vehicles would be reevaluated at a later date based on circumstances at that time. These DCR Board minutes represented "the first time that a Manned Space Flight Headquarters position concerning termination of static firing was put in writing" [520].

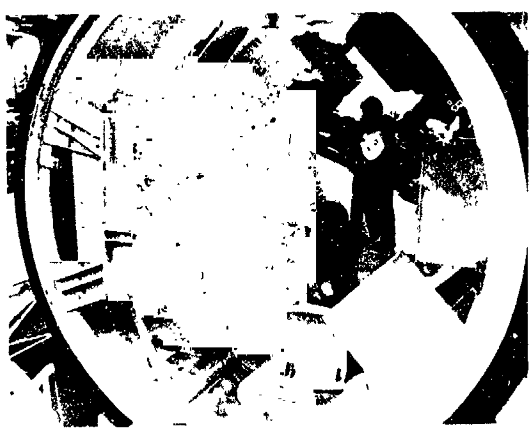


Airlock payload shroud, flight unit no. 1 at MDAC. Installation of nose cone on cylinder section for final installation of electrical, ordnance, and air conditioning components

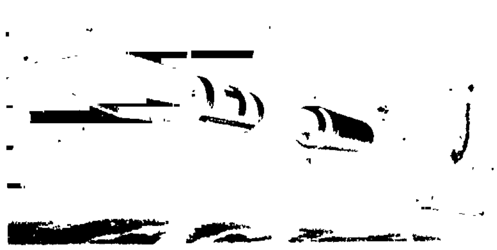


ATM flight rack and canisters

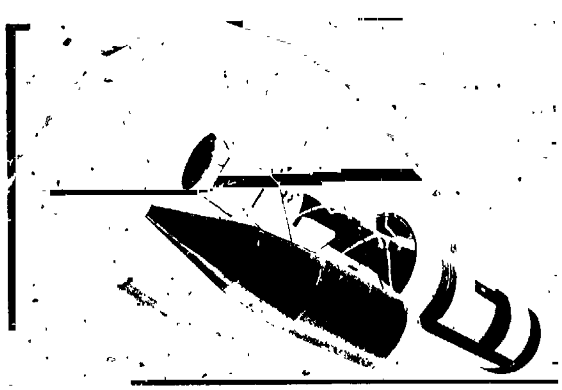
IBM 1410 computer in Computation Lab at MSFC



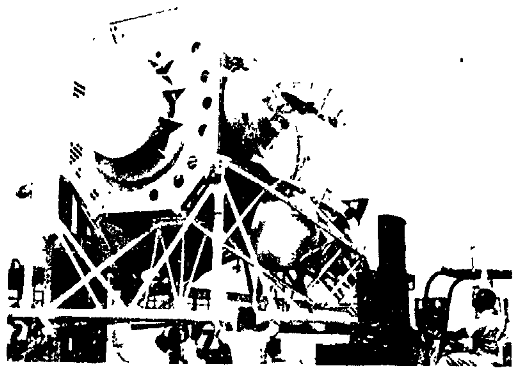
Skylab/MDA NASA trainer – interior view



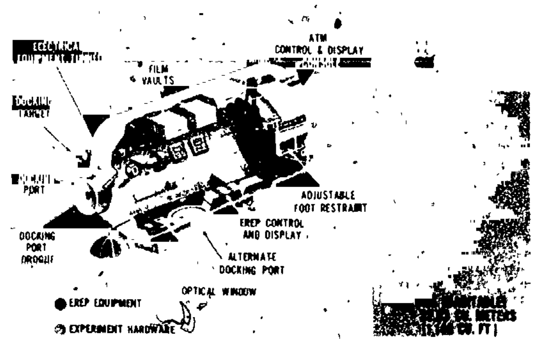
S-II separation from Skylab payload



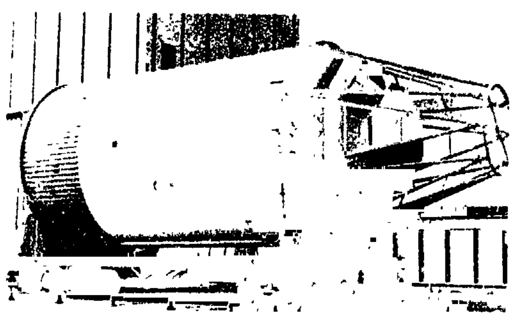
Skylab shroud separation



Airlock trainer tunnel section being loaded on truck for shipment from MSFC to MSC. View looking forward showing EVA hatch

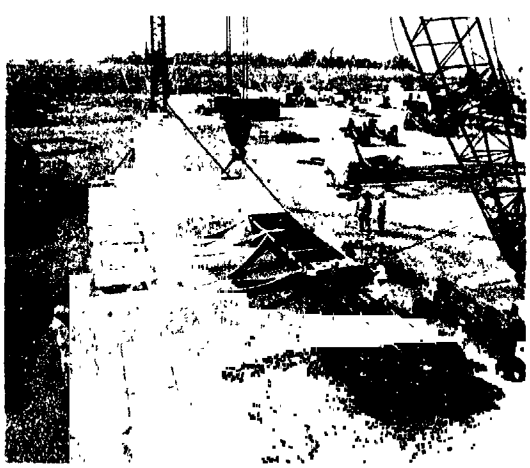


Multiple Docking Adapter

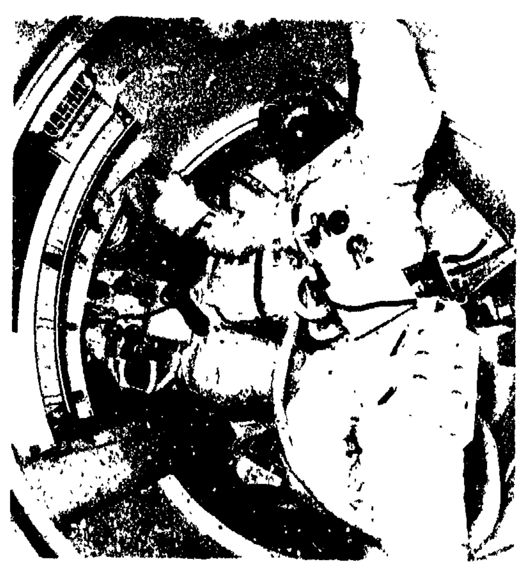


Orbital Workshop dynamic test article at MSC

Workshop dynamic test article exterior view of forward dome



OWS type bogie assemblies being transported by road



Airlock zero-g simulation in KC-135 aircraft

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scanner for the Skylab Workshop experiment to develop techniques and interpretive methods for earth survey from orbital vehicles. This scanner would detect and measure radiated and reflected solar energy from materials on earth [624].

On June 18 MSFC awarded a contract modification to Martin-Marietta Corporation for work on the Skylab Program. The $13 460 726 contract was for continuing work on the Skylab's multiple docking adapter; the work was being done at Martin-Marietta's Denver facility. This modification covered design, development, fabrication, assembly, integration, and testing of the MDA equipment. MSFC made the basic docking adapter structure. At the time of this contract modification Martin was the prime contractor to MSFC for the Skylab Program payload integration [625].

On June 23 NASA awarded a contract to the Rocketdyne Division of North American Rockwell Corporation for Saturn rocket engine support work. Rocketdyne would provide operational and flight support and launch site support for the H-1, F-1, and J-2 rocket engine programs. The $22 641 941 contract covered the period July 1, 1970, to June 30, 1971. At the time of this contract award, Rocketdyne was supporting H-1, F-1, and J-2 rocket engines for Saturn launch vehicles. As of this date all of the rocket engines required for the Saturn program had been fabricated and delivered to the space agency. The rocket engines were purchased from Rocketdyne under separate contracts. MSFC directed the development of the Saturn launch vehicles and would administer this contract [626].

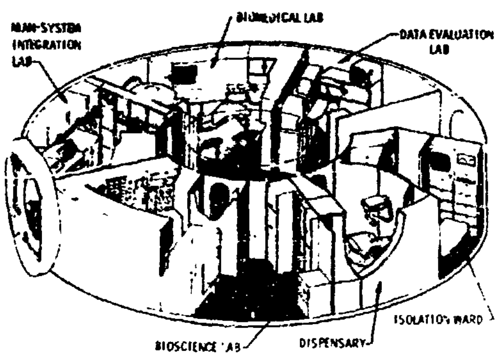
About 4000 employees and their families attended MSFC's big Tenth Anniversary Celebration on Saturday, June 27, in the Redstone Arsenal picnic area. The crowd heard presentations by Dr. Rees, and about 2800 had picnic-style lunch. There were rides and prizes for the children [627].

NASA held a "Skylab and Beyond" press briefing and tour of production facilities at MSFC, on June 29 and 30. William C. Schneider, Skylab Program Director, said that the project was "in the very critical phase of firming up our designs" and predicted that the 1972 launch date would be met. Three missions were planned for the 8-month lifetime of the 48-foot-long Workshop. Primary task of the first mission would be to study physiological and psychological aspects of space flight for 28 days. During the second mission, for 56 days, telescopes would be operated. During the third mission, for 56 days, earth resources would be surveyed with highly sensitive cameras [628].

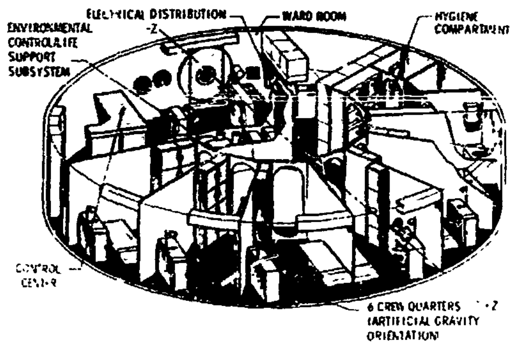
After issuing requests for quotations to 45 firms for a proposed 12-month "Space Base Nuclear System Safety Study," MSFC awarded the contract to General Electric on June 30. The aim of this $369 478 study would be to identify potential and inherent radiological hazards of the space-base program and to recommend approaches for eliminating the hazards or reducing them to an acceptable risk level. The 50-man space base as envisioned would begin with a Space Station in earth orbit in the mid-1970's with station modules being added periodically to eventually form the large base with modular units designed for various functions. A space base would be exposed to radiation from radioactive materials and systems on board plus natural radiation from outer space [629].

Artist's concept of Skylab EVA

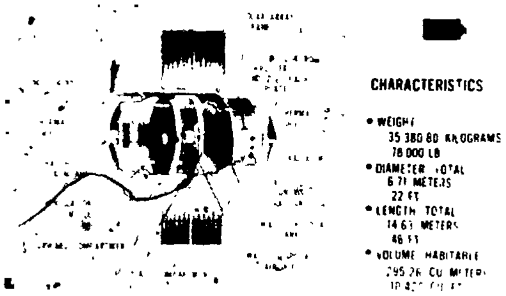
Concept of ATM deployment



Experiments section of Workshop, Deck 2



Workshop crew facilities and operations, Decks 1, 3 and 6



Orbital Workshop

Astronauts in Skylab Workshop mockup

Two weeks after the Apollo 13 Review Board presented its findings on June 15, NASA Administrator Dr. Thomas O. Paine informed the U.S. Senate Committee on Astronautical and Space Sciences that the recommendations of the Apollo 13 Review Board would be implemented before the Apollo 14 mission would be approved for launch. This would require postponing the launch date to no earlier than January 31, 1971. The Review Board had reported that a short circuit ignited electrical insulation in spacecraft oxygen tank number 2, causing failure of the tank, subsequent loss of electrical power, and abortion of the lunar landing mission 200 000 miles from Earth on April 13. Command and Service Module systems would be modified to eliminate potential combustion hazards in high-pressure oxygen of the type revealed by the Apollo 13 accident [630].

In a July 2 letter NASA Associate Administrator for Manned Space Flight, Dale D. Myers, wrote Dr. Rees requesting particip tion in a review of the Apollo and Skylab programs. Myers stated that the review would be a followup to the report of the Apollo 13 Review Board which included recommendation No. 9 that in essence called for reassessment of all Apollo spacecraft subsystems and the engineering organizations responsible for them at MSFC and its prime contractors. Myers added that the scope of the coverage under the recommendation had been expanded to include all elements of Apollo (spacecraft, launch vehicle, and GSE) as well as Skylab. It would be a major review, followedsby others, with more than 100 MSFC personnel participating directly in various stages of the reviews.

On July 7 Dr. Wernher von Braun and eight other NASA Headquarters officials began attending a series of meetings at MSFC to discuss the Skylab, the High Energy Astronomy Observatory (HEAO), and future scientific space projects. Although a new and relatively small project as of this date, the HEAO signified a type of payload that could become one of the major scientific experiments in early phases of the Shuttle flight program [631].

On July 8 MSFC modified an existing contract with Martin Marietta Corporation, Denver, Colorado, for additional work on the Skylab Program. The $1 863 000 contract modification covered development, implementation, and operation of a change integration and configuration control system for the Skylab Program. At the time of this announcement Martin was the Skylab payload integration contractor for MSFC. This action brought the contract total to $104 946 600 [632].

MSFC announced on July 13 that Richard G. Smith, formerly Deputy Manager, Technical, Saturn Program, had assumed the duties of Manager, Saturn Program [633].

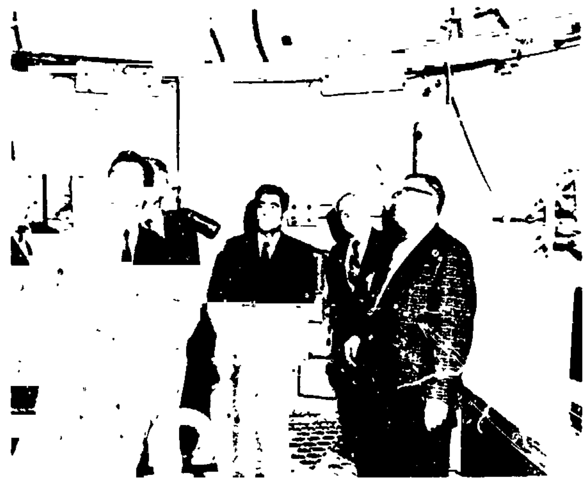
Fourteen employees of MSFC presented papers during the Space Shuttle conference at the Lewis Research Center, Cleveland, Ohio, July 15-17. Two other employees chaired sessions at the conference, and 30 additional employees attended the sessions. The 3-day conference for United States and foreign contractors reviewed the status, progress, and plans of technology programs required to support Space Shuttle development. Technical topics included aerothermodynamics, configurations, structures, materials, electronics, propulsion, biotechnology, and safety. Chairing these sessions were H.G. Paul and C.C. Wood, both of MSFC's Astronautics Laboratory. Presenting papers were J.A. Forney,

Astronaut Overmyer at ergometer station in Skylab mockup

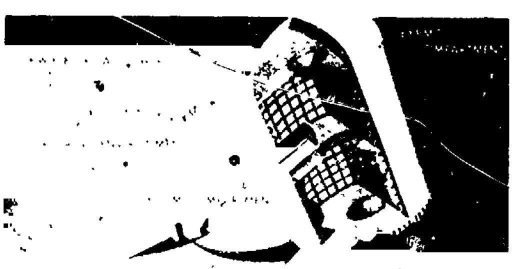
S-IC stage erection at MTF

Cosmonaut Sevastyanov at Airlock EVA work station in Neutral Buoyancy Facility at MSFC

Space Shuttle booster/orbiter concept



Cosmonauts Sevastyanov and Nikolayev with interpreter Barsky being briefed by Dr. Rees, Mr. Belew, and Mr. Hardy in Workshop mockup



Space Shuttle sortie mission basic experiment module

Research Applications Module

H.G. Struck, J.H. Jones, R.S. Ryan and M.H. Rheinfurth, all of the Aero-Astrodynamics Laboratory; W.O. Frost of Astrionics Laboratory; and E.E. Engler, K.D. Coates, R.W Schock, C.E. Cataldo, J.E. Curry, E.C. McKannon, A.L. Worlund, and T.W. Winstead, all of Astronautics Laboratory [634].

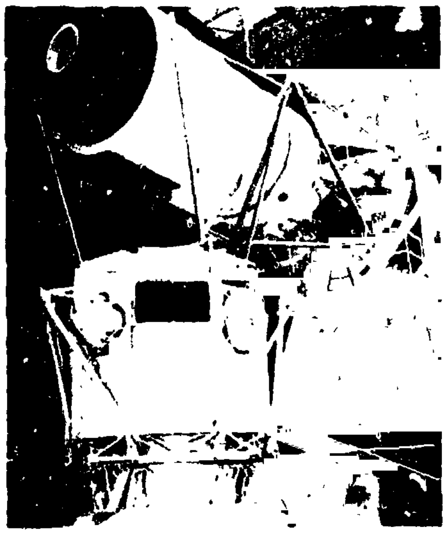
On July 23 MSFC modified an existing contract with McDonnell Douglas Astronautics Company for additional work on the Skylab airlock. Under the contract, McDonnell Douglas' Eastern Division at St. Louis, Missouri, was building two Skylab airlock modules, one for flight and one for spare. The contract modification totaled $38 979 000. The airlock module would provide the major work area and support equipment required to activate and operate the Workshop and would also form a passageway for the astronauts to move from the Apollo command module and multiple docking adapter into the Workshop. The airlock could also be depressurized and sealed off for exit into space outside the vehicle [635].

In line with Recommendation No. 9 of the Apollo 13 Review Board, MSFC hosted a massive review at MSFC on August 12-14. The review, directed by Dr. Rees, dealt exclusively with the Saturn Program. Official NASA visitors included Charles W. Mathews, heading the delegation from Headquarters, and C.C. Kraft of MSC.

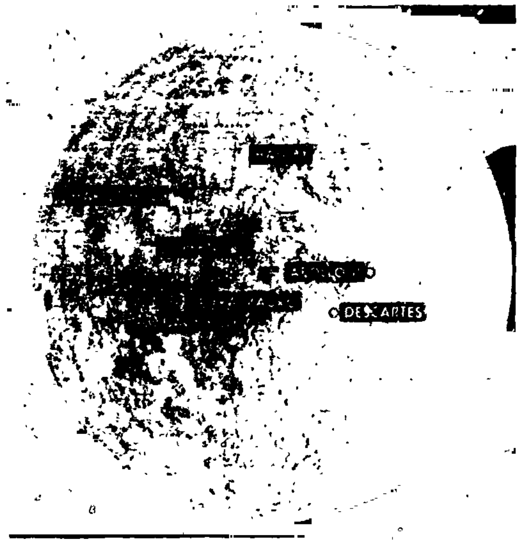
Lee B. James, charged with responsibility for the Apollo 13 review at MSFC, felt that the review had benefits beyond the recommendations of the Apollo 13 Review Board. "I think a bigger purpose of the overall review was we found out in the Apollo program that occasionally the entire program needs to be shaken down by the very top management in an overall review . . . that had seldom happened in Skylab, and this Apollo 13 Review gave an occasion to really spend some time from this one point of view to go through the entire Skylab program, and to really check it in the end from the top management point of view. We get a lot of good out of these things; they turn up different things if there isn't any other way to do this. . . I would watch for occasions such as this to give the program an end-to-end review, and have a good orderly review just for the good of the program" [636-638].

Within a year after Apollo astronauts first landed on the moon MSFC and other NASA centers were faced with a major reduction in force. On August 14, 1970, MSFC Director Rees wrote to MSFC employees as follows: "Over the past months since first we knew that a reduction-in-force in all of NASA was probable, we have tried to keep you informed on the developing situation. On July 15, it was a painful duty to tell you that the MSFC portion of the reduction was 190 positions. In the interim, 69 eligible employees have accepted their retirement. I can assure you that all but a very few of these took retirement at this time rather than later because they knew it would ease the impact of the RIF on their fellow employees. We are deeply indebted to all of them for this unselfish gesture. This brings our net loss of positions down to 121. While this is an improvement in our overall position, I am acutely conscious that this is small consolation to 121 of our co-workers. Letters to our people who will leave the rolls of MSFC will be delivered Monday, August 17, as well as letters to other employees affected by resulting personnel actions -- change of grade or positions. . . . It is our aim to reduce to the absolute minimum the impact of the reduction-in-force on our employees and their

Senator John J. Sparkman (second from left) visited the Marshall Center in November 1970 for talks with Dr. Eberhard Rees, director, and other MSFC officials and for a tour of some of the facilities. His visit was sponsored by the MARS Women's Club. From left above are Mrs. Peggy Shanahan, President of the club; Senator Sparkman; Mrs. Martha Farish, MARS Club member; and Dr. Rees. They are inspecting the lunar rock on display in the lobby of Building 4200 at MSFC. Senator Sparkman inspected the Skylab mockup during his visit.

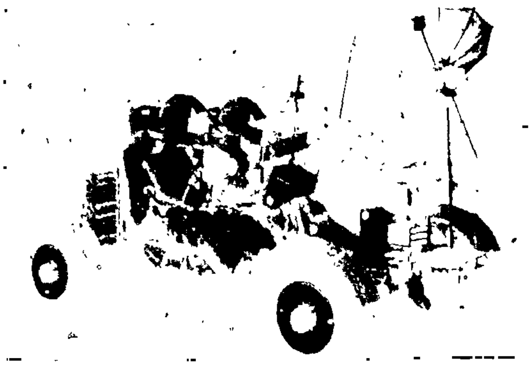


Airlock, MDA, and ATM mockups used during EVA CDR



Lunar exploration sites

Neutral Buoyancy "clothesline testing" at MSFC



Lunar Roving Vehicle 1-g trainer

families. We couldn't make it pleasant, but we will do everything possible to minimize hardship for you who have been our valued and respected fellow workers."

MSFC announced on August 17 that manufacture of the 15th and final Saturn V booster stage (S-IC-15) had been completed by its builder, the Boeing Company, at the Michoud Assembly facility in New Orleans. The stage was being shipped on August 17 by barge to the Mississippi Test Facility where it would be prepared for a static test firing in late September. S-IC-15 was scheduled to boost the Apollo 19 moon landing mission in 1974 [639].

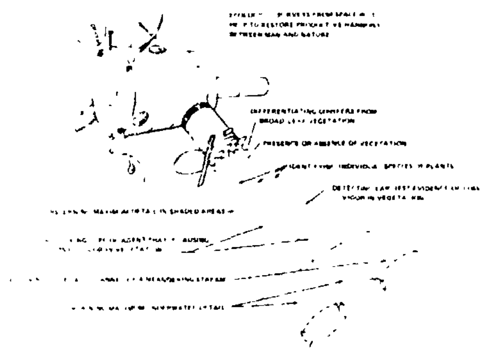
On August 21 MSFC issued a modification to a contract held by IBM for changes to digital computers. The modification, in the amount of $7 932 440, would cover changes required when the basic concept for the Workshop was altered in 1969. The computers involved would be aboard the Apollo Telescope Mount, a major component of the Skylab [640].

On August 21 MSFC awarded the North American Rockwell Corporation two modifications to its basic contract for the second (S-II) stage of the Saturn V launch vehicle. The first modifications, valued at $1 768 228, covered changes to the basic contract, originally awarded in 1962, for the manufacture and test of 15 S-II flight stages for the Saturn V. The amendment was due to stage design changes. The second modification called for North American at Seal Beach to identify the S-II's capabilities in launching possible Space Station missions and to determine what production impacts would result from Space Station mission studies being conducted by MSFC. This modification was valued at $2 429 005, and the work was to be completed by March 31, 1971 [641].

More than 150 representatives of NASA and industry conducted a week-long critical design review of the Skylab multiple docking adapter during the week of August 24 at the Martin Marietta facility in Denver, Colorado. This was scheduled as the final technical review before approval would be given for manufacturing flight hardware. Skylab officials from MSFC, MSC, KSC, and NASA Headquarters attended. The MSFC delegation was headed by F.M. Drummond, manager of the Airlock/MDA Project. Martin Marietta was the Skylab payload integration contractor for the Marshall Center. While MSFC was building the multiple docking adapter external structure, Martin was integrating the experiments. Other contractors included the Bendix Corporation and McDonnell Douglas Corporation [642].

On August 27 MSFC issued a modification to an existing contract with the McDonnell Douglas Astronautics Company for Skylab program work. The modification would pay for the conversion of the original Orbital Workshop to be launched by a Saturn IB rocket to a completely outfitted Workshop to be launched by a Saturn V. The original contract with the firm was for $97 340 000 and called for one Orbital Workshop and one backup; this modification added $60 918 000. Originally the plan was to launch the second stage (S-IVB) of a Saturn IB into earth orbit. The S-IVB would be filled with fuel so that it could propel itself into orbit. Astronauts launched by a second Saturn IB would then rendezvous with the empty stage and convert it into living and working quarters. In 1969

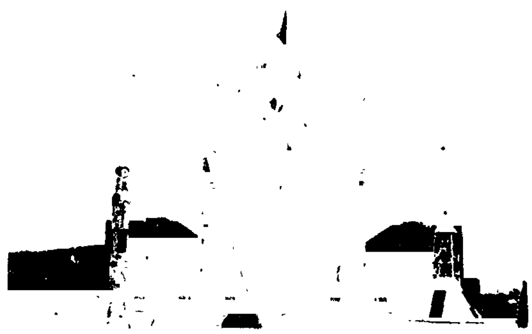
ATM sun end work station mockup used during EVA CDR



Concept depicting earth resources surveying from space

Workshop dynamic test article on transporter being loaded on USNS Point Barrow

Workshop dynamic test article in vibration test at MSC



A Christmas tree and lots of holly were not the only decorations sprucing up the MSFC Headquarters complex during the 1970 Christmas holiday season. On display on the front lawn of Building 4200 were models of the Saturn V and the Apollo command module.

Former astronaut James A. McDivitt addressed about 1100 government and contractor employees at a Manned Flight Awareness gathering at the Michoud Assembly Facility in December 1970.

a decision was made to outfit an S-IVB on the ground and launch it ready for use. The launch vehicle for this new version would be the Saturn V [643].

On August 28 a group of MSFC engineers successfully completed a week-long series of tests of Skylab program hardware in simulated weightlessness aboard a USAF KC-135, four-engine-jet, research aircraft. Tests included operation of flight-configuration doors for film cassette compartments, retrieval and replacement of film cassettes, and evaluation of handrails and foot restraints. A lunar soil penetration experiment was conducted aboard the aircraft to study load-bearing characteristics of lunar soil and performance of the LRV wheels on the moon. The KC-135 was flown in parabolas, with 30 seconds of weightlessness achieved on each parabola in a technique that most nearly duplicated zero g [644].

On August 31 NASA published its "Skylab Launch Readiness and Delivery Schedule ML-19," which moved the scheduled Skylab launch date to November 1, 1972, and dropped the July 15, 1972, target date scheduled under the earlier ML-18 schedule.

On September 3 MSFC awarded the Ball Brothers Research Corporation, Boulder, Colorado, a $195 000 space agency contract to study a solar telescope for possible inclusion in a manned solar observatory on a future flight opportunity. At the time of this contract award, NASA's first manned solar observatory (Apollo Telescope Mount) was scheduled for launch in 1972 as an element of the Skylab cluster. This ATM containing solar experiments designed by five principal investigators was being built at MSFC. The space agency had asked Ball Brothers to define requirements for a 26-inch, solar telescope as a major new experiment to be included in a follow-on observatory [645].

On September 8 NASA issued a supplemental agreement to the McDonnell Douglas Astronautics Company in the amount of $97 057 455 for S-IVB program realignment. The basic contract, with a value of $1 026 393 830, covered the furnishing of the S-IVB stages for Saturn IB and Saturn V. The supplemental agreement adjusted the contract as a result of schedule stretchouts. Costs would cover storage of completed stages; maintenance of ground support equipment, tooling, and facilities over an extended period; and maintaining engineering capability. Period of performance under the agreement would be extended from May 15, 1970, through July 31, 1972. The contract was being administered by MSFC which had responsibility for Saturn vehicle development [646].

MSFC announced on September 8 that the flight design of the Saturn Workshop, a part of the Skylab program, would be accepted in a series of important reviews scheduled for the next few weeks at MSFC in Huntsville and at Huntington Beach, California. Government engineers, astronauts, and industry representatives would determine if changes were necessary before the final approval would be given for completing the flight Workshop currently scheduled for launch into earth orbit in 1972. First in the review series would be an astronaut procedures review on September 9 and 10 at MSFC. Astronauts would study many proposed Workshop procedures in a mockup. A critical design review would be conducted September 14-18 at the McDonnell Douglas Astronautics Company facility at Huntington Beach, California. McDonnell Douglas was manufacturing the Workshop for the space agency. More than 200 government and industry representatives were expected to participate in the critical design review. A Workshop crew station review would be held September 21-24 at MSFC. Astronaut crewmen would "walk through" many of the Skylab tasks in this review.

Results of the reviews would be considered in a Workshop Critical Review Board meeting October 2 at Huntington Beach, with Leland Belew, manager of the Skylab Program Office at MSFC, presiding. Many of the same participants would have taken part in a preliminary review of the results September 28 and 29 at Huntington Beach, with William K. Simmons, Jr., manager of the Workshop project under Belew, acting as chairman [647].

On September 8 MSC and North American Rockwell Space Division selected Messerschmitt-Boelkow-Blohm of Munich, West Germany, and BAC of Bristol, England, to conduct subsystems studies for NASA's Space Shuttle. In a major step for international cooperation in space, Messerschmitt would study the attitude control system and BAC would study structures, aerodynamics and flight-test instrumentation, and data handling under contracts financed by their respective governments. Work would be performed in Downey, California [648].

Dr. Ernst Stuhlinger headed a four-member MSFC team that attended a Space Station meeting at Ames Research Center on September 9 and 10. At the meeting were approximately 500 NASA members, company executives, representatives from universities and colleges, engineers, scientists, and members of government from both inside the U.S. and abroad. In reporting to Dr. Rees concerning the meeting, Dr. Stuhlinger indicated that there seemed to be general concensus that the three major projects in the space program for immediate consideration should occur in the following priority: (1) broad activities in applications and exploration; (2) Shuttle; (3) and the Station. The concensus seemed to be that the U.S. at this time could not afford all three. Therefore, the first should have highest priority. The Shuttle would be useful without the Station, but the Station could not be operated and utilized properly without the Shuttle. Therefore, the Shuttle should have Priority No. 2, and the Station should be postponed until the financial situation proved to be better in terms of the nation's space commitments [649].

MSFC announced on September 10 that a test model of the Apollo Telescope Mount solar observatory was being returned to MSFC from MSC where it recently underwent extensive thermal vacuum chamber tests. The ATM thermal systems unit was being barged to Huntsville from Houston. Upon arrival here in late September, the model would be disassembled and used in other test programs. The unit's rack, without the experiment canister, would be converted by MSFC into an astronaut trainer. This trainer would be sent back to MSC for use by Skylab crewmen there. The experiment canister would be used in further environmental control system evaluations at MSFC.

Thermal vacuum chamber tests of the ATM test model were completed on August 17, well ahead of schedule, in the MSC Apollo vacuum test chamber. The ATM prototype and flight units, both of which were being fabricated at MSFC, would be flown to Houston for a series of tests in the same vacuum chamber. The ATM would have a cluster of telescopes and other scientific instruments which would be used to study the sun from earth orbit – above the distorting effect of the atmosphere. The ATM was scheduled for launching in 1972 as a part of the Skylab program [650].

One of the extensive recommendations of the report of the Apollo 13 Review Board was that "NASA should conduct a thorough reexamination of all of its spacecraft, launch vehicle, and ground systems which contain high-density oxygen, or other strong oxidizers, to identify and evaluate potential combustion hazards in the light of information developed in this investigation." Further indication of NASA's extensive reappraisal following the Apollo 13 accident was included in a September 15, 1970, letter from Dale Myers to Dr. Rees in which Myers requested that "a similar investigation . . .be undertaken to include the MSFC in-house facilities, laboratories, and test equipment which may handle high-density oxygen or other oxidizers and are not directly related to the Apollo program. I think that we would be in a vulnerable position if we were to have an accident in one of our facilities not directly related to Apollo and had not examined these with the same rigor that we exercised in examining the Apollo flight and ground support systems."

Dr. Thomas O. Paine, who joined NASA in 1968 as deputy administrator and became administrator later that year, departed NASA on June 15 to return to the General Electric Company. No successor was named immediately. During an earlier press conference Dr. Paine said that Dr. George Low would automatically become acting administrator pending action by the President [651].

MSC announced on September 15 the selection of Singer-General Precision, Incorporated, Link Division, to receive a $4-million, cost-plus-award-fee contract to design, develop, install, and support a Skylab simulator for astronaut and ground crew training at MSC [652].

On September 21 a Saturn Workshop crew station review began at MSFC as a part of the Skylab Program. A group of nine astronauts headed by Richard Truly participated in the week-long review conducted in a mockup at MSFC. Government and industry engineers monitored the astronaut crewmen's progress and commented as they "walked through" many of the Workshop tasks. Medical experiments scheduled for the Skylab flight were reviewed during the week. This crew station review followed a critical design review conducted September 14-18 at the McDonnell Douglas Astronautics Company facility at Huntington Beach, California. At the time of this review, McDonnell Douglas was manufacturing the Workshop for the space agency [653].

Meetings to select requirements for the main engine design of the proposed Space Shuttle began on September 22 at MSFC and continued through the following day. About 100 people from three NASA centers, the U.S. Air Force, and several NASA contractors attended the series of meetings. The work of three study contractors for the Space Shuttle's main engine was reviewed. The companies were Aerojet General Corporation, Rocketdyne Division of North American Rockwell Corporation, and Pratt and Whitney Division of United Aircraft Corporation. At the time of this 2-day meeting the three companies had 11-month study contracts with NASA for main engine design work. They each had spent about 3 months on their preliminary study. Decisions were currently being made on what would be required for the Shuttle's main engine system. The contractors would then incorporate these requirements into their studies. Attending the meetings were representatives from NASA Headquarters, MSC, MSFC, and the Air Force; Space Shuttle study contractors from McDonnell Douglas Corporation and North American Rockwell Corporation; and the three main engine study contractors. Preliminary design reviews for the three contractors were scheduled to be held at MSFC in about 2 months, giving the companies a final 6 months to complete their design work before their study contracts ended [654].

As a followup to Dale Myers' July 2 letter to the Center Directors concerning the Apollo 13 Review Board Recommendation No. 9, Charles Mathews on September 25 wrote Dr. Eberhard Rees confirming arrangements for a Skylab subsystems review, with a review team headed by himself which would meet at MSFC on November 17-19, 1970, and MSC and KSC early in 1971.

The last in a series of 15 Saturn V first stages (S-IC-15) was successfully captive-fired for 2 minutes 15 seconds at MTF on September 30, thus ending a 5-year static firing program at MTF. Captive testing of the S-IC stages had begun at MTF on May 16, 1967, to check out and flight-certify stages for manned lunar missions. Meanwhile, as a result of NASA direction in February and March 1970 to delete the requirement for storage of stages at Seal Beach, five stages (S-II-11 through S-II-15) would be shipped from MTF to KSC during the 6-month period between July and December 1970. The S-II final assembly line at Seal Beach came to a halt with the completion of systems installation of the S-II-15 in July 1970. This final stage was checked out and shipped to MTF in September [655, 656].

NASA's Flight Research Center announced on October 12 that tests had demonstrated that unpowered approaches and landing maneuvers of the Space Shuttle could be made safely and readily by qualified pilots and did not require highly trained test pilots. Pilots had flown landing approaches in a four-engine jet transport configured to simulate the Space Shuttle during a NASA study of energy-management techniques for the proposed Shuttle Orbiter [657].

After issuing requests for quotations to 13 aerospace firms for a study to define space biology payloads for possible use in a manned earth orbital research facility, NASA awarded the $230 528 contract to General Dynamics/Convair on October 13. The Ames Research Center would assist MSFC in directing this 12-month study and would be responsible for experiment selection and definition. At the time of this announcement Ames was actively engaged in development of biological flight experiments for the Skylab program and unmanned missions. The overall purpose of the study would be to learn the problems involved in integrating space biology experiments with manned space flights, particularly space biology applicable to manned earth orbiting space stations. Payloads described in this study would feature research activities defined by NASA as suitable for incorporation in the manned earth orbital space program in the period 1974 to 1980 [658].

Cosmonauts Adrian Nikolayev and Vitali Sevastynov, crewmen for the Soviet Soyuz 9, arrived at MSFC on October 20 for a 2-day visit. Astronaut Edwin Aldrin, a member of the Apollo 11 lunar landing crew, accompanied the two Soviet cosmonauts as host for the American tour [659].

On October 21 Russian Cosmonauts Sevastyanov and Nikolayev were briefed on the Skylab mission during a tour of MSFC [660].

On October 26 and 27, U.S.-U.S.S.R. talks on the possibilities for compatible rendezvous and docking arrangements in space were held in Moscow between the NASA delegation headed by MSC Director, Dr. Robert R. Gilruth, and a Soviet Academy of Sciences team headed by Academician Georgy I. Petrov. During the exchange of basic information on docking systems, NASA officials described Gemini and Apollo techniques, procedures, and docking adapters and the Skylab project. The Soviet team described plans for a future system similar to Apollo's, with a tunnel between the spacecraft to accommodate docking apparatus. Agreement was reached that 12 scientific technical elements required further joint study, including guidance systems for rendezvous, docking hardware, coordinate systems, and reference markings [661].

On October 28 MSFC modified an existing contract with the Boeing Company for work on Saturn V launch vehicle's first stages. The contract modification totaled $21 029 756. This change extended the contract performance period through March 31, 1973. Space agency officials said that the extension was caused by a redirection of the Apollo program calling for longer periods between missions. At the time of this modification, the Boeing Company was building the Saturn V first stages (S-IV) at the Michoud Assembly Facility. Work under this contract modification would be performed at the Michoud plant [662].

MSFC announced on October 29 that NASA had issued a request for quotations for a study entitled, "Shuttle Orbital Applications and Requirements." As envisioned at the time of this request for quotation, the vehicle would consist of a large booster stage that would carry the orbiter to an altitude of about 200 000 feet before separating and flying back to earth. The smaller stage, carrying the payload, would proceed to orbit, complete the mission, and return to earth. Under direction of MSFC, the contractor selected would analyze the use of the Space Shuttle and flight systems delivered by it to earth orbit, fc accomplishing and supporting various prospective missions. The contract would do the preliminary definition of a selected manned-support module and any other new hardware necessary to supplement the orbiter's mission support capability. A manned support module – like a small "house trailer in space" – would be carried to earth orbit by a Shuttle vehicle to serve as temporary living quarters for a crew of four. It would be small enough to fit into the Shuttle cargo bay, probably about 20 feet long and less than 15 feet in diameter. It would have no propulsion system. The support module could be joined with experiment modules, satellites, planetary probes, and other objects.

Also, the contractor would define the operational and design interfaces between the ground support systems, Shuttle, manned support module, special purpose flight hardware, and prospective payloads or classes of payloads. Another objective of the study was tc provide total mission descriptions, including definition of the new flight hardware required, systems interfaces, support requirements, new hardware costs and schedules, and pertinent integration and prelaunch schedules for selected Shuttle-payload combinations. Due date for the quotations was set as November 23, 1970 [663].

NOVEMBER 1970

On November 8 NASA invited industry to submit proposals on the preliminary design of a Research and Applications Module (RAM) which could be used with the Space Station and Space Shuttle currently being studied. Proposals for the 12-month design studies would be due January 8, 1971. Conceptual (Phase A) studies of the RAM had recently been completed. The firm selected for this new contract would carry the work through preliminary design. At the time of this invitation to submit proposals, NASA was studying the use of a Space Shuttle for low cost transportation to orbit, and it was studying the Space Station as a semipermanent facility which would have general and special purpose laboratories. The RAM concept offered an economical way to extend the capabilities of both the Shuttle and Space Station. These modules would provide versatile and economical laboratory facilities for doing earth orbital research and applications work. Two modes of operating RAM units were being considered by the space agency. Plans were to operate RAM's either attached to the Shuttle or Space Station or as free-flying units. Free-flying modules could be returned to the earth by the Shuttle or to the Space Station for servicing and maintenance. Such free-flying modules might be required for experiments which could be extremely sensitive to vibrations, contamination, or unique pointing accuracy [664].

An awards ceremony to observe the successful completion of more than four years of Saturn V launch vehicle test firings occurred at MTF on November 9. Among guests invited to the ceremony were Mississippi Governor John B. Williams and U.S. Senator John Stennis. They headed the list of federal, state, and local government officials who paid tribute to the work of several thousand workers at the NASA test site during the Saturn V test program. MTF workers represented NASA, private contractors, and several other government agencies. In addition to NASA officials attending, mayors and other government officials from MTF's surrounding communities and counties in southern Mississippi and southeast Louisiana also attended the ceremony [665].

On November 9 NASA's Apollo 14 spacecraft was moved from the assembly building to the launch pad at KSC in preparation for the launch toward the moon on January 31 [666].

A proposal for a Space Station to be assembled in orbit one module at a time was being studied at MSFC and MSC, NASA announced on November 12. This Station, to provide a centralized facility for research, applications, and operations for 6 to 12 men over 10 years, would be composed of cylindrical modules 14 feet in diameter and 58 feet long, joined to form a variety of shapes. Individual modules would be carried into orbit on a reusable Shuttle vehicle. This Station would be assembled within months in a circular orbit 200-300 miles high with a 55 degree inclination [66.].

Two Skylab Program reviews were under way as of November 17 at MSFC. An extravehicular activity critical design review was being held at the Skylab mockup area and the Neutral Buoyancy Simulator. The EVA review, which started on November 16, included astronaut performances under normal earth gravity in the Saturn Workshop mockup and simulated weightlessness in the Neutral Buoyancy Simulator. Ten astronauts from the Manned Spacecraft Center, headed by Russell Schweickart, took part in the review activities on November 16. The review lasted a week.

Charles W. Mathews, Deputy Associate Administrator, Office of Manned Space Flight, NASA Headquarters, was chairman of a Skylab Subsystem Review Team meeting which began the same day The team members inspected the Skylab mockup area, toured simulation facilities in Astrionics and Manufacturing Engineering Laboratories, and viewed Apollo Telescope Mount hardware being assembled in the Manufacturing Engineering Laboratory. The review team ended its activities on November 19 [668].

A major milestone in the manned lunar roving vehicle (LRV) program was reached on November 17 when a special training vehicle arrived at MSFC from the Boeing Company, LRV prime contractor. The vehicle, called a "1-G trainer" because it would operate in earth's gravity, was built for Boeing by its major LRV subcontractor, the Delco Electronics Division of General Motors Corporation "This milestone is second in importance only to the final accomplishment of delivery of the first flight LRV," said S.F. Morea, LRV project manager from MSFC, during brief delivery ceremonies at the GM Defense Research Laboratories, Santa Barbara, California, where the trainer was built. Morea, Astronaut Charles Duke, and officials of both Boeing and Delco Electronics were present at the informal ceremony. The 1-G trainer would be shipped to MSC to arrive there in about 1 week. The vehicle would be used in a training program to teach astronauts how to operate the vehicle under many simulated situations [669].

On November 18 the flight model of the Skylab multiple docking adapter was flown from MSFC to Martin Marietta Corporation Space Center in Denver, Colorado aboard the Super Guppy aircraft. It would be outfitted with controls and display panels for solar astronomy and earth resource experiments, storage vaults for experiment film and a thrust-attitude control system. When completely equipped, the adapter would be mated with the Skylab airlock flight version at McDonnell Douglas Astronautics Company in St. Louis, Missouri, and the unit would perform a simulated mission in the altitude chamber [670].

On December 2 MSFC announced that a Saturn Workshop would be shipped on December 4 from the McDonnell Douglas Astronautics Company facility at Huntington Beach, California, to MSC in Houston, Texas, for extensive ground tests. This Workshop was a ground test version of one which would be used in the Skylab Program to accommodate teams of three astronauts for stays of up to 56 days in earth orbit [671].

A 2-week preliminary design review of main engines for the proposed Space Shuttle ended at MSFC on December 11. More than 170 representatives of government and private industry attended the meetings. About 60 representatives were from the three prime study contractors for the Shuttle's main propulsion system: Aerojet General Corporation, Pratt and Whitney Division of United Aircraft Corporation, and Rocketdyne Division of North American Rockwell Corporation. Government participants represented NASA Headquarters, the U.S. Air Force, and several NASA field centers. The three aerospace companies had 11-month study contracts with NASA to define Shuttle engine requirements, provide prototype designs, and determine design feasibility to meet technical requirements. The purpose of these meetings was to review the design approaches taken by the contractors, to discuss potential problems in the designs, and to assure that all three efforts were proceeding satisfactorily under the same basic design requirements. Jerry Thomson, chief engineer of the Shuttle Engine Office, Space Shuttle Task Team, was coordinator for the meetings [672].

A meeting to review two parallel studies of a proposed chemical inter-orbital Space Shuttle was held at MSFC on December 16. Two aerospace firms, North American Rockwell Corporation and McDonnell Douglas Astronautics Company, were making detailed analyses of what modifications would be required to adapt either the second (S-II) stage or the third (S-IVB) stage of the Saturn V launch vehicle into an inter-orbital Shuttle for operation to and from earth orbit and lunar orbit. MSFC managers were assuming that further lunar exploration, if approved and funded, would require a Shuttle much larger than the Apollo spacecraft in order to transport larger payloads and crews between earth orbit and the moon. Primary objectives of the two analyses were to make preliminary designs of how the stages must be modified, determine orbital launch operations and procedures, and gather information on preliminary costs, logistics, and facilities. Whichever stage would be chosen would be carried into earth orbit attached to a newly developed Space Shuttle booster. North American was building the S-II stage and McDonnell Douglas was building the S-IVB stage. About 45 people, most of them from MSFC, attended the all-day meeting, called a "mid-term review" because the two 7-month studies were now half completed. Both efforts began September 1 and were due to end April 1, 1971 [673, 674].

The three companies conducting nuclear Shuttle studies for MSFC gave progress reports to Center authorities in a series of meetings on December 16 and 17. The firms carrying out this work were Lockheed Missiles and Space Company, North American Rockwell Corporation, and McDonnell Douglas Astronautics Company. In addition, several companies conducting technology studies related to the reusable nuclear stage were scheduled to prepare summary reports. They included General Dynamics/Fort Worth, Whittaker Corporation, Hughes Aircraft Company, Aerojet Nuclear Systems Company, and North American Rockwell. These technology studies were being done under the direction of the MSFC Astronautics Laboratory [675].

As NASA neared the end of 1970, there was much activity relative to the movement of Saturn stages. A few days before Christmas two Saturn V flight stages (S-II-15 and S-IVB-512) were en route to KSC, and a Saturn Workshop test model would soon complete its journey to MSC in Houston; MSFC had shipped both the vehicles. Meanwhile on December 18 the ship *Point Barrow* had reached the Michoud Assembly Facility in New Orleans from California carrying the Saturn Workshop and the S-IVB-512. The Workshop was unloaded for later shipment to MSC while the S-II-15, which had been brought from MTF the previous day, was loaded aboard the *Point Barrow* for the remainder of the trip to KSC. The ship would reach KSC on December 20, where the two stages would be stored until needed for flight missions.

The Workshop vehicle destined for MSC, known as the "dynamic test article," would leave Michoud December 31 aboard the MSFC barge *Orion*. It would be unloaded at a NASA dock at Clear Lake, near MSC, the first such hardware to move to the Houston center in this manner. It was to arrive on January 5, 1971. The Workshop model would undergo a series of tests at MSC to verify its bending and vibration characteristics. Another Saturn V stage, the S-II-13, was taken from a test stand on December 18 at

MTF. The stage would be prepared during the following two weeks for shipment to KSC. It was scheduled to be loaded aboard the barge *Poseidon* December 30 at MTF. The barge would leave Michoud on December 31 for the trip to KSC [676].

MSFC announced on December 22 that highlights of 1970 at MSFC included: launch of an Apollo/Saturn V vehicle, (AS-508); renaming the space agency's embryonic Space Station project Skylab; continuing work on the Space Shuttle and Space Station; doing early planning on the unmanned astronomy satellite HEAO; Dr. Eberhard Rees' being named MSFC director. These and other highlights combined to make the first year of the decade an eventful one at NASA's largest field center [677].

MSFC old-timers were reminded in the winter of 1970 that the Center's work policy during severe weather had changed considerably over a 10-year span. In early MSFC days there had been a liberal policy relative to granting administrative leave to employees who desired to go home if the impending weather seemed threatening. But in a December 23, 1970, announcement MSFC Deputy Director, Management, R.W. Cook, wrote a memorandum to employees stating that, "As you know, we are approaching the time of year when the Huntsville area is apt to suffer its most severe weather conditions. Marshall Space Flight Center employees are reminded of their responsibility to prepare themselves and their vehicles for possible hazardous travel conditions. I urge each of you to be prepared by acquiring tire chains, snow tires, shovels, etc. As in recent years, work activity at the Marshall Center will continue during severe weather, and the granting of administrative leave and excused absence because of weather conditions is not anticipated. If, however, an individual feels personal danger is involved in traveling to work, annual leave may be granted" [678].

An assessment of the feasibility of providing a crew rescue capability for Skylab was conducted by the three MSF Centers during 1970. This culminated in a Headquarters decision to provide a limited capability based on failure of CSM return capability while docked to the Saturn Workshop. The rescue vehicle for the first two Skylab missions would be the next Skylab vehicle in flow at KSC. Upon receipt of a rescue call, the in-flow CSM would be prepared for launch after some minor modifications to permit a two-man crew launch and a five-man crew return [679].

1971

On January 8 three aerospace teams, including seven European firms as prospective members, submitted proposals on the preliminary design of a Research and Applications Module (RAM) for NASA. NASA was considering the RAM for use with the Space Shuttle and the Space Station currently being studied. Submitting proposals for the RAM were teams headed by General Dynamics, Convair Aerospace Division; General Electric, Space Division; and Martin Marietta, Denver Division. Conceptual (Phase A) studies of the RAM had recently been completed; the team selected for this new contract would carry the work through preliminary design. For the purposes of this preliminary design study, the first module launch would be planned for 1978 and would be a part of the modular Space Station which would have an orbital lifetime of 10 years or more or, alternatively, operate in a Shuttle sortie mode. The maximum size of a module would depend upon the Shuttle's cargo capacity. This could be 14 feet in diameter and up to 58 feet long, with a weight of 20 000 pounds [680].

On January 22 more than 150 representatives of governmentsand industry attending a quarterly review at MSFC inspected a mockup of one Space Station concept under study by NASA. This mockup depicted the proposed 12-man station concept studied by the McDonnell Douglas Astronautics Company for MSFC. A 50-foot tall structure, 33 feet in diameter, the mockup had four decks and a large simulated power section. The McDonnell Douglas space station concept was based on guidelines which included using the two-stage Saturn V as a launch vehicle. The Space Station could be placed in a low earth orbit of about 250 miles; its lifetime would be 10 years. McDonnell Douglas had recently been asked by NASA to extend the Space Station study contract to include the preliminary design and planning for a modular Space Station of a smaller diameter. Several Space Station configurations and module combinations which could be assembled in orbit from modules sent from earth in a Space Shuttle would be examined. The study was making use of the data produced in the preliminary design of a larger diameter station [681].

On January 29 President Nixon delivered to Congress his proposed budget for Fiscal Year 1972. MSFC Director Eberhard Rees wrote a detailed letter to MSFC employees stating in detail the probable impact of this proposed budget on MSFC. "I regret . . . that I must advise you there are reductions within the total budget, namely in the personnel area, which will affect the agency's civil service employment levels. . . . A reduction in civil service employment . . . in each element of the agency will be necessary. Marshall will be required to reduce from our present strength of 5804 to 5507 by the end of June 1972. We expect to achieve this reduction through a combination of normal attrition, retirements, and I am sorry to say, RIF procedures. Due to the difficulty in predicting attrition for the next 18 months, it is not possible at this time to determine exactly how much of the required reduction we will be able to achieve through attrition and retirement. I assure you that I will advise you as soon as we can determine this."

Apollo 14 vehicle (Saturn V 509) proved to be one of the best performing vehicles in the Saturn V series as it lifted off from Cape Kennedy at 3:03 p.m. CST January 31, 1971, after a 40-minute-2-second hold caused by weather. Low clouds in the launch site area delayed the launch for the first time in the nine vehicle Saturn V series. The Saturn V

Food management area in the Orbital Workshop

Food management area in the Skylab mockup at MSFC

Sleep compartment in Skylab mockup

Waste management area in Orbital Workshop

Lift-off of Apollo 14

Modular equipment transporter

Apollo 14 about to splash down

Apollo 14 astronauts aboard recovery ship

Artist's concept of manned Skylab/Saturn IB launch

Apollo 14 recovery operation

509 was also several thousand pounds heavier than any of the earlier vehicles. Lift-off weight for this vehicle was estimated at 6 423 754 pounds. Commander of the Apollo 14 was Alan B. Shepard, Jr., Lunar Module Pilot was Edgar D. Mitchell, and Command Module Pilot was Stuart A. Roosa.

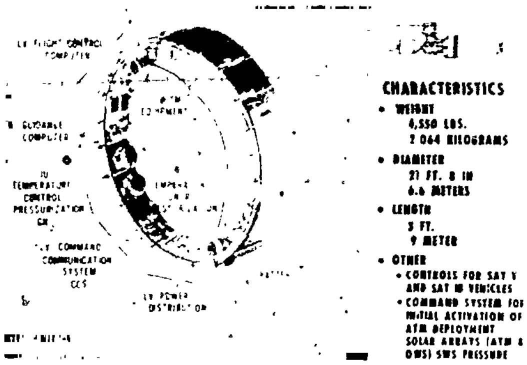
The first (S-IC) stage inboard engine cutoff occurred exactly on time at 2 minutes 14.7 seconds. Outboard engine cutoff came at 2 minutes 43.5 seconds, one-half second early. The second (S-II) stage inboard engine burned for 4 minutes 58 seconds. Nominal burn time for this engine was considered to be 4 minutes 57.6 seconds. The S-II outboard engines operated for 6 minutes 33.4 seconds. The four engines were scheduled to operate for 6 minutes 30.5 seconds. The third (S-IVB) stage first burn was 2 minutes 20.4 seconds; nominal time for the burn was considered to be 2 minutes 25.7 seconds. A second burn of the third stage's single J-2 engine took place about 5:30 p.m. on January 31 The 5 minute 52 second burn speeded the stage and Apollo 14 spacecraft out of earth orbit on its way to the moon. Walter I Kapryan, director of Launch Operations, said immediately after the launch that early data indicated there was no "turbulence or pogo" as experienced on earlier flights.

Onboard TV was initiated to cover the CSM docking with the LM, but difficulty in docking was encountered. The first five docking attempts by CM pilot Roosa were unsuccessful. Mission control at Houston, watching on TV, studied this problem that could prevent the extraction of the LM and make lunar landing impossible. Alternate missions also were under study. The astronauts noted that catches seemed properly cocked but did not release. However, the sixth try was successful, although docking was achieved 1 hour 45 minutes later than planned.

Apollo 14 entered lunar orbit at 1:55 a.m. February 4. Touchdown of the "Antares" occurred at approximately 3:16 a.m. on February 5. Aboard were Shepard and Mitchell who made two "moonwalks." During their stay on the lunar surface the men set up a series of experiments and conducted geological surveys of the area around the Fra Mauro landing site. The two gathered approximately 80 pounds of lunar material for return to earth. Shepard and Mitchell had a two-wheeled pull-cart carrying experiments and geology tools during their lengthy field geology trek. The astronaut's main problem was lunar dust which stuck to their space suits up to their knees. Just before reentering the LM Shepard dropped a golf ball onto the lunar surface and on his third attempt drove the ball about 400 yards, the first golf ball hit on the surface of the moon.

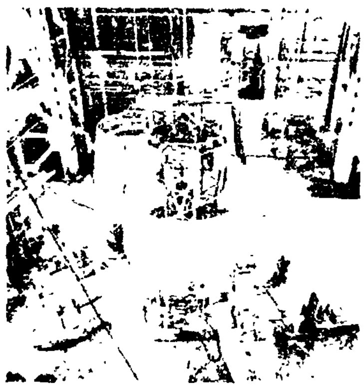
While the LM was on the moon, Roosa, orbiting the moon in the CSM, completed photography of the Descartes landing site and astronomic photography.

The LM carrying Shepard and Mitchell lifted off the lunar surface, 33 hours 31 minutes after landing on the moon. During the braking phase for docking, telemetry indicated that the abort guidance system had failed, but no caution and warning signals were on. Docking was accomplished successfully on February 6, and the crew transferred from the LM to the CSM with samples, equipment, and film. The transearth injection maneuver was on schedule, and the CM Kitty Hawk separated from the SM. Parachute deployment and other reentry events occurred as planned, and the Kitty Hawk splashed down in the mid-Pacific about 4 nautical miles from the recovery ship *USS New Orleans* at 3:05 EST

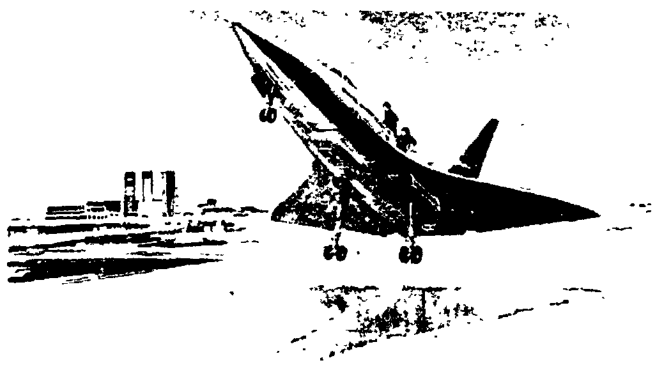


Skylab instrument unit

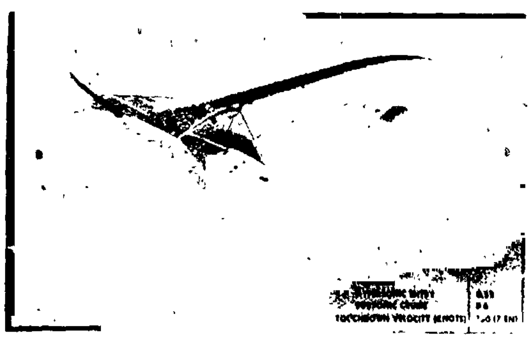
Lunar Roving Vehicle deployment sequence



Setup for ATM simulated flight loads test (ATM vibration unit is in background)



Shuttle flyback (concept)



Composite design single body canard booster

Shuttle model for subsonic Reynolds number on February 9. The astronauts were carried by helicopter from the CM to the recovery ship, where they entered the mobile quarantine facility with the recovery physician and technician. The Apollo 14 had been the 11th Apollo mission to date, the 8th manned Apollo mission, and the 3rd successful lunar landing mission [682, 683].

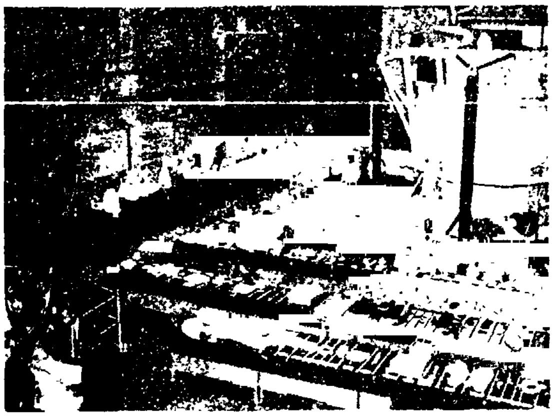
Requirements for seven astronomy experiments for a proposed High Energy Astronomy Observatory (HEAO) were defined under contracts awarded by NASA, effective February 1, 1971. The HEAO spacecraft was envisioned as a 21 000-pound, 30-foot-long craft, designed to carry relatively few but heavy instruments, accounting for more than half its weight. Planning called for the spacecraft to be launched by a Titan IIID rocket into a 230-statute-mile orbit. MSFC was directing the HEAO experiment definition phase (Phase B) studies. Should the HEAO become an approved flight program after the definition phase, the instruments study would be considered for the first HEAO mission currently planned for mid-1975 [684].

A high-level advisory group responsible for guiding NASA in all aspects of mission safety opened a 2-day meeting at MSFC on February 8. The Aerospace Safety Advisory Panel, which was appointed by the NASA administrator, was headed by Dr. Charles D. Harrington, president, Douglas United Nuclear, Incorporated, Richland, Washington. At MSFC the group discussed safety aspects of the lunar roving vehicle, the Skylab cluster of spacecraft, and the proposed reusable space vehicle (Space Shuttle) [685].

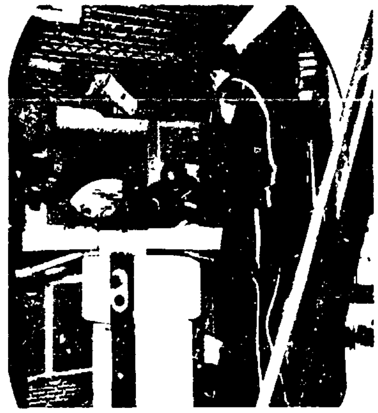
On February 10 the Kennedy Space Center awarded a $917 900 contract to the Holloway Corporation of Titusville, Florida, to construct a launcher-pedestal that would be used during the upcoming Skylab Program. The 127-foot-tall pedestal would be adapted to an existing Launcher-Umbilical Tower so that manned Saturn IB space vehicles could be launched from facilities now supporting the larger Saturn V rockets. The Holloway Corporation contracted to construct the launcher-pedestal in 180 days after receiving its notice to proceed [686].

Accumulators for center engine feedlines were being installed on all second (S-II) stages of the Saturn V launch vehicle under terms of a contract modification granted to the North American Rockwell Corporation by MSFC on February 12. The modification amounted to $2 163 217. The work was being done at the contractor's plant at Seal Beach, California, and at MTF. It was to be completed by June 1972. The accumulator would lower the frequency of the line to prevent unusually high oscillations like those recorded during the launch of Apollo 13 in April 1970. Those oscillations caused an early shutdown on the S-II center engine, although the launch vehicle met all flight objectives. The first accumulator in this modification was installed on the Saturn V vehicle that launched Apollo 14 on January 31, 1971. No unusual oscillations were recorded during the launch [687].

In a February 18 memorandum to all employees MSFC Manpower Director Paul Styles stated, "The Civil Service Commission has incorporated in the Federal Personnel Manual (Supplement 831-1 Subchapter S-11) a policy and procedure statement providing more flexibility in permitting retirements in situations where those retirements will help meet needed reductions in personnel strength." This memorandum was distributed in an era of steady output of retirement bulletins informing employees of various possibilities inherent

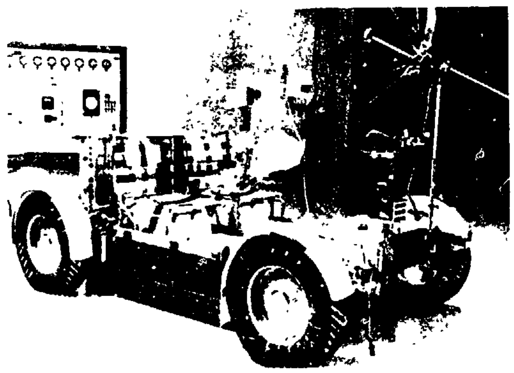


Crew compartment stowage review bench check component layout



Astronauts sampling food in wardroom during workshop crew compartment stowage review

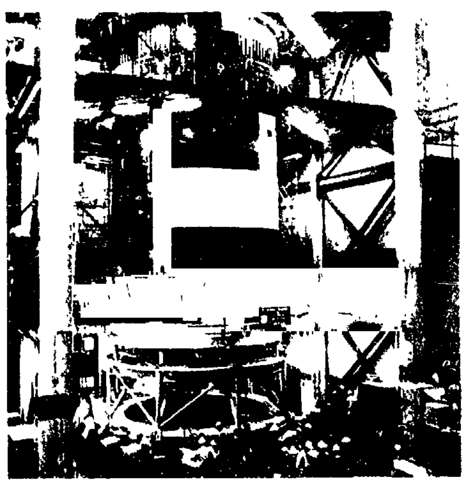
A dozen of MSFC's 15 taxicabs and the drivers lined up for a quick photo in the spring of 1971. Shuttle buses had been removed from the routes for a trial period.



LRV flight unit

Hand controller on LRV no. 2

Dr. James C. Fletcher became NASA's fourth Administrator on May 1, 1971



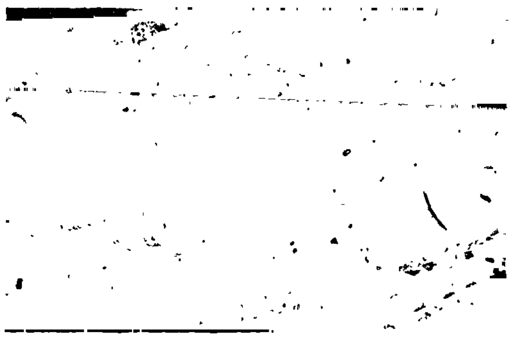
Workshop flight unit in assembly at MDAC-WD in early and regular retirement from the government. Background for this letter was continuing probability of a reduction-in-force at the Center [688].

On February 23 MSFC granted to the International Business Machines Corporation a contract modification for the manufacture of instrument units (IU) for Saturn launch vehicles. Valued at $14 407 743, the modification would extend IBM's delivery schedule for IU's through December 31, 1973, to be compatible with the extended Apollo and Skylab Program launch schedules. IBM was under NASA contract to build 27 IU's for Saturn vehicles: 12 Saturn IB's and 15 Saturn V's. Ten of the Saturn IB units and 12 Saturn V units had been completed. All work was being done at the company's facilities in Huntsville, Alabama. The original IU contract had been granted to IBM in March 1965 for the fabrication, assembly, checkout, and delivery of the 27 units and related support functions [689].

NASA announced on March 1 that it would modify the former Saturn V second (S-II) stage test facilities at MTF for the Space Shuttle engine testing. Plans were to convert two former S-II stands for testing the shuttle's orbiter and booster engines. A contract for the final design of the required modifications to provide two operable engine test stands was awarded to the architect-engineering firm of Sverdrup and Parcel and Associates, Incorporated, St. Louis, Missouri. The total price of the design contract was $447 000. The modifications that would be required to convert the existing S-II stands for Shuttle engine testing included the addition of liquid oxygen and liquid hydrogen run tanks, a thrust measuring system, and modifications to the stands' structural, mechanical, and electrical systems. The Missouri architect-engineering firm would provide the engineering drawings and specifications that would be needed to accomplish the construction effort. Engine testing was planned to start in the second quarter of calendar year 1973.

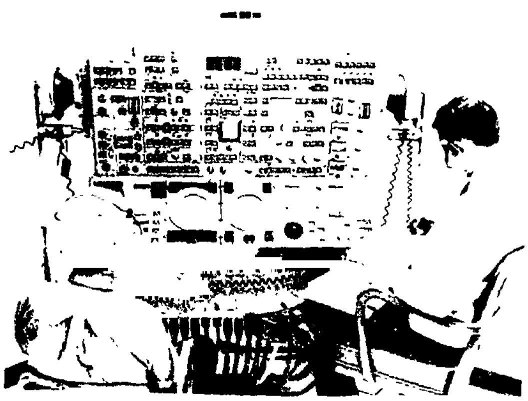
NASA also announced that testing of Space Shuttle engines under simulated altitude conditions would be done at the Air Force Arnold Engineering Development Center, Tullahoma, Tennessee. Some 100 development tests under simulated altitude conditions at AEDC were planned, beginning in 1974 and running through 1976. Selection of the two test sites was made following studies by a Site Evaluation Board which surveyed existing government-owned or controlled sites with proven capability of reasonable potential to accomplish Shuttle engine testing. This selection of the engine test site was the first step in carrying out a master plan for Shuttle facilities. Work was currently under way to identify and define detailed technical and operational requirements for other Space Shuttle facilities. A decision on the location of a vertical launch facility was expected in the fall [690, 691].

NASA on March 1 asked three aerospace firms for proposals concerning the development of the main engines that would power a two-stage reusable launch vehicle (Space Shuttle). The firms were the Aerojet General Liquid Rocket Company, Sacramento, California; the Pratt and Whitney Division of United Aircraft Corporation, West Palm Beach, Florida; and the Rocketdyne Division of North American Rockwell Corporation, Canoga Park, California. Since June 1970 all three companies had been performing preliminary design and definition studies of the Shuttle engine under independent, parallel contracts costing $6 million each. As of this request for proposals one of the companies would be chosen to develop the engine [692].

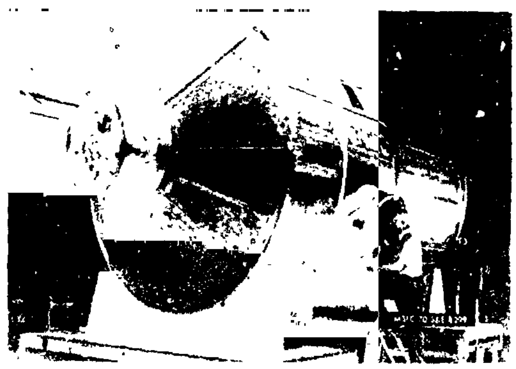


Airlock flight unit in assembly at MDAC-ED

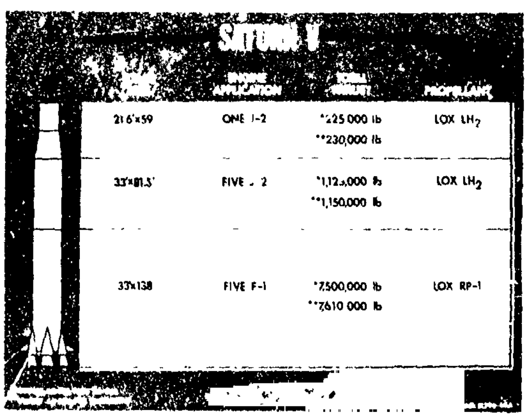
ATM flight experiment NRL-A in checkout at MSFC



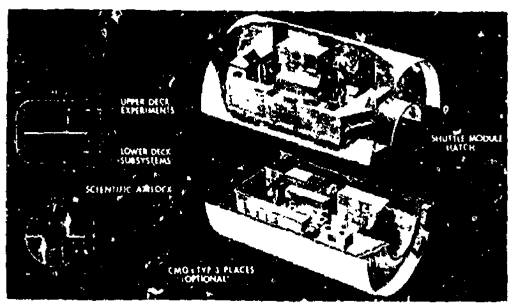
ATM prototype controls and display during checkout at MSFC



MDA structural test hardware at MSFC's PE Lab



Saturn V parameters



Space Shuttle sortie mission pressurized laboratory concept

On March 1 President Nixon submitted to Congress the nomination of Dr. James C. Fletcher to be the new NASA Administrator. The senate confirmed Dr. Fletcher 11 days later on March 11 [693].

Following a "Sonic Boom Meeting" at LRC in which participants from ARS, LRC, FRC, MSC, and MSFC discussed sonic boom relative to the planned shuttle flights, Dr. Eberhard Rees requested, on March 5, policy guidance from Dale Myers concerning "just how much of the sonic boom business is to be discussed internally and with contractors." Dr. Rees pointed out that there would be a Flight Mechanics Working Group meeting at MSFC the following week and that sonic boom was on the agenda. Dr. Rees wanted to know if this should be cancelled, or just how much should be discussed. Myers said that he would get with Donlan "and they would get a policy to Dr. Rees on this, hopefully by Monday or Tuesday" [694].

On March 10 the first flight model LRV that would be lofted into space by a Saturn vehicle was formally delivered to NASA in a ceremony at the Boeing Company's Space Center at Kent, Washington. MSFC Director, Dr. Eberhard Rees, accepted this first of three flight models from Boeing Company Group Vice-President for Aerospace, O.C. Boileau. This model would be shipped to arrive at KSC on March 15 for final checks and installation aboard the Apollo 15 LM. This delivery would be two weeks before the April 1 contract delivery date [695].

On March 10 MSFC modified a contract with Chrysler Corporation to authorize additional work in the Saturn IB program. Chrysler was the prime contractor for the first stage of the Saturn IB, which it assembled at the Michoud Assembly Facility in New Orleans. Under the current $29 136 622 modification, the company would maintain nine Saturn IB boosters in storage. Three of the nine vehicles were for the Skylab program and would be launched in 1973. Those three, plus a fourth that would serve as a backup, would be maintained and modified as necessary under terms of this contract. Prelaunch checkout of the Skylab vehicles would also be accomplished under this modification. The period of performance was from January 1, 1971, to August 15, 1973. Six of the vehicles were located at the Michoud Facility, and the other three were at MSFC in Huntsville [696].

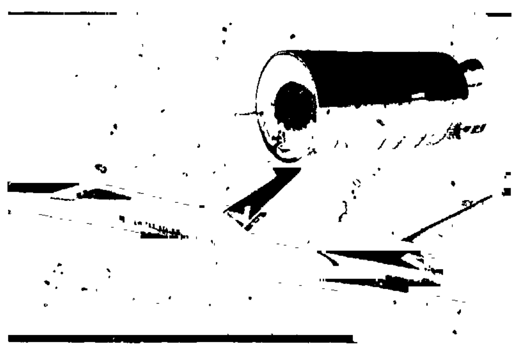
The first lunar roving vehicle arrived at KSC on March 16, 1971. During the delivery ceremonies Boeing personnel presented Dr. Eberhard Rees and MSFC with a license plate for the vehicle [697].

MSFC announced on March 31 that NASA had modified its contract with the Boeing Company, Huntsville, Alabama, for the design, development, manufacture, and delivery of three lunar roving vehicles for the Apollo Lunar Exploration Program. Total estimated cost to contract completion was $37.8 million. The contract included procurement of three lunar roving vehicles and a number of test articles, plus subsystems for a fourth vehicle to be used as spares. The lunar roving vehicle would be sent to the moon on the Apollo 15 mission, scheduled for July 26, and again on Apollos 16 and 17 in 1972. Boeing delivered the first flight vehicle on March 15, two weeks ahead of schedule, and deliveries of the remaining two flight models were anticipated earlier than contract requirement. The four-wheel vehicle would provide transportation for two astronauts and

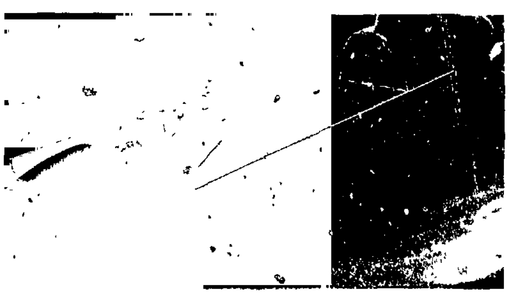
Shuttle with fuel drop-tanks (concept)

Spacecraft communications modes

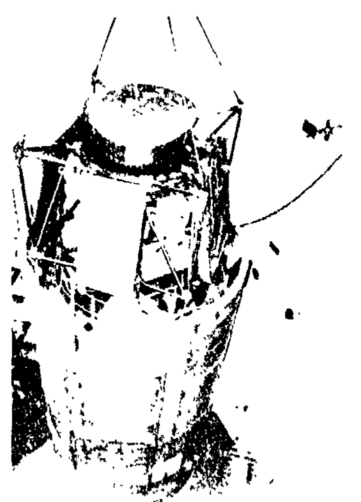
Concept of Skylab crew rescue command module



In addition to its role in the Skylab Program the S-II stage, shown here, is envisioned as servicing the Space Shuttle



Research Applications Module pallet mission



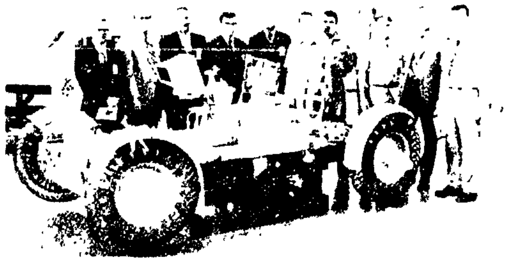
Stacking of Skylab payload assembly at MSC for acoustic testing their tools, scientific equipment, and lunar samples collected during several traverses across the lunar surface. The astronauts and equipment would weigh 1000 pounds – twice the weight of the vehicle itself. Boeing had been selected in October 1969 as the vehicle development contractor for MSFC [698].

On April 1 MSFC awarded to Air Products and Chemicals Corporation, a contract for the supply and delivery of liquid hydrogen for all government aerospace use in the eastern United States. The 1-year contract would end March 31, 1972. It was valued at $2 249 700. NASA's Saturn launch vehicles were the prime users of liquid hydrogen, which was the propellant for the second (S-II) and third (S-IVB) stages of the Saturn V vehicle and for the second (S-IVB) stage of the Saturn IB vehicle. NASA, through MSFC, supplied liquid hydrogen for all Government agencies in the eastern U.S., including the Atomic Energy Commission and the U.S. Air Force. Air Products and Chemicals was headquartered in Allentown, Pennsylvania, but its liquid hydrogen supply and delivery work for NASA would be done from a plant at New Orleans, Louisiana [699].

Dr. Eberhard Rees, Director; Richard Smith, Saturn Program Manager; and several others from the Marshall Center attended a Design Certification Review of the Apollo 15 and other "J" missions in NASA Headquarters on April 5 and 6. Also attending the review were representatives from MSC, NASA Headquarters, and the DCR Board. The purpose of the review was to certify the changes on Apollo 15 that had not been on previous missions to the moon. These included new experiments, use of the lunar roving vehicle, and changes to the spacecraft [700].

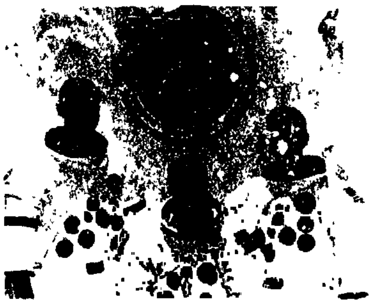
About 400 persons from aerospace companies and Government agencies attended a conference at MSFC on April 6 and 7. Approximately 50 of these were from foreign countries – mostly Europe. The conference participants discussed space vehicle propulsion systems with an operational life requirement of 100 flight missions. This was one in a series of space shuttle technology conferences being conducted by NASA at several locations from March through May 1971. The theme of the conference was that the Shuttle would be a more economical approach to a variety of space missions. All the missions would be manned, but during some flights unmanned satellites could be deposited in or retrieved from earth orbit. Chairman of the conference was Jerry Thomson, chief engineer for the Space Shuttle main engine at MSFC. Thomson pointed out that the Shuttle would demand major advancements in propulsion technology beyond those applied in the Apollo program. The Shuttle was projected as a vehicle about 250 feet long which would take off vertically. The booster would have a swept wing and 12 engines. During launch, the booster would have another airplane-like vehicle – called an orbiter – riding piggyback. At an altitude of about 250 000 feet, the orbiter would separate from the booster and continue to fly into space under the power of two engines in the tail. Once in orbit, it could delivery cargo or could be used as a space laboratory for up to a week. It normally would carry a two-man crew, but it could also carry additional passengers in the cargo or passenger compartment, which would be about 15 feet in diameter and nearly 60 feet long. After separation, the booster would return to earth and land like any large airplane. It, too, would have a two-man crew. Following the space mission, the orbiter would also return to earth and land like an airplane. NASA hoped to have an operational Space Shuttle by 1979 [701].

ATM prototype in the thermal vacuum chamber at MSC



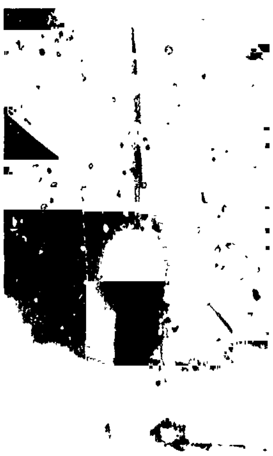
Astronaut Dr. Robert Parker visited the Marshall Center in the summer of 1971 for Apollo 15 Lunar Roving Vehicle work. During his lunch hour he presented 11 "Snoopy" awards to MSFC employees (from left) Harold Johns and Norm Thomas, Quality Lab; James Orr, Jewell Moody and William R. Adams, Program Management; Otha Vaughan, Aero-Astrodynamics Lab; Dr. Parker; Denny Kross, Astronautics Lab; John Farmer, Astrionics Lab; and Hugh M. Campbell and Roy Runkle, Astronautics Lab.

Saturn V on Pad A at KSC



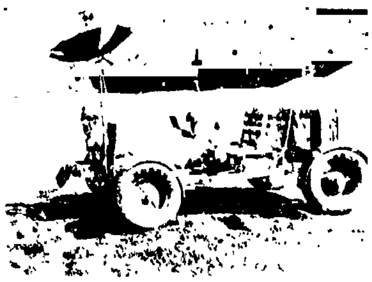
Apollo 15 Astronauts Scott, Worden, and Irwin

Lift-off of Apollo 15



Close-up view of Apollo 15 launch

Deployment of U.S. flag by Apollo 15 astronauts on lunar surface



LRV on lunar surface during Apollo 15 mission

MSFC announced on April 9 that NASA had asked industry to propose methods for determining long-life mechanical components for reusable vehicles, such as the Space Shuttle, satellites, Space Stations, and other space-related equipment. S.B. Wynn of MSFC's Astronautics Laboratory said, "We're looking for components that can operate for many years.' He said that the Saturn rocket development effort called for extremely high reliability of components, but not necessarily long life; Saturns were expended with each launch. Industrial firms were asked to submit proposals concerning short term test methods to prove the long life of mechanical components [702].

On April 12 space engineers and astronauts studied Skylab Workshop stowage facilities during a review at MSFC. Astronauts taking part performed Workshop activation procedures, reviewing each compartment's storage areas and running through deactivation procedures. Astronauts participating included Alan Bean, Charles Conrad, Joseph Kerwin, Paul Weitz, Walter Cunningham, Gerald Carr, Russell Schweickart, William Lenoir, and Richard Truly [703].

On April 13 NASA published "Skylab Launch Readiness and Delivery Schedule ML-20," which moved the scheduled Skylab launch date from November 1, 1972, to April 30, 1973.

By April 15 the proposed Skylab rescue mission profile requirements were: the trajectory planning for a rescue mission would be the same as the nominal Skylab mission; nominal mission duration from launch to recovery would be limited to 5 days; the orbital assembly would maneuver to provide acquisition light support for the rescue Command and Service Module (CSM); the rescue CSM would be capable of rendezvous without VHF ranging; landing and recovery would be planned for the primary landing area; transfer of the crew from the MDA to the CSM would be in shirtsleeves (no extravehicular activity); the KSC rescue launch response times would vary from 10 to 45½ days depending on the transpired time into the normal checkout flow [704].

MSFC announced on April 17 that 15 taxicabs had replaced the Center's shuttle buses for a trial period. This was another example of reducing costs because of budgetary restraints [705].

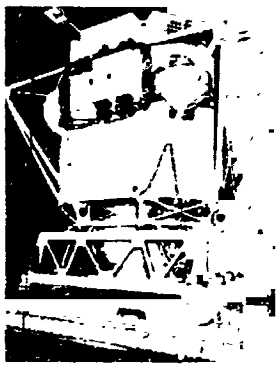
As workmen at KSC installed the first flight model lunar roving vehicle aboard the Apollo 15 lunar module, MSFC scientists and technicians continued preparations for MSFC's closest coordination of activities with any moon landing to date. MSFC prepared to simulate in its Computation Laboratory the three exploration traverses to be made by the Apollo 15 LRV. As a contingency measure, MSFC would use its computer resources to simulate every inch of the progress of the LRV occurring simultaneously on the moon [706].

At KSC on April 25 workmen installed the world's first flight model lunar roving vehicle aboard the Apollo 15 lunar module. The LRV would transport astronauts on three exploration traverses of the moon's Hadley-Apennine area during the Apollo 15 mission, scheduled to begin July 26. Workmen installed the LRV in a triangular storage bay of the lunar module's descent stage [707].

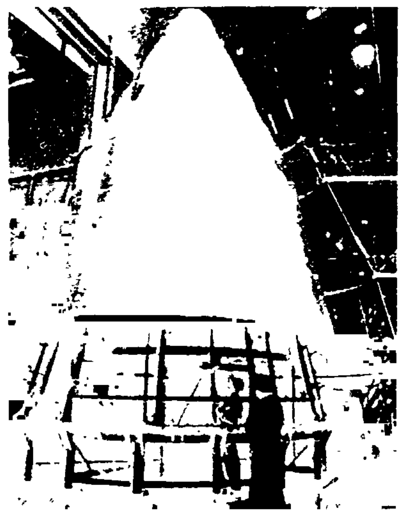
Hadley-Apennine, landing site of Apollo 15

LRV on Hadley rille during Apollo 15 mission

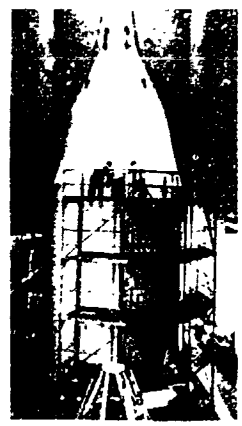
First deep-space EVA was performed during Apollo 15 mission



ATM prototype unit at MSC

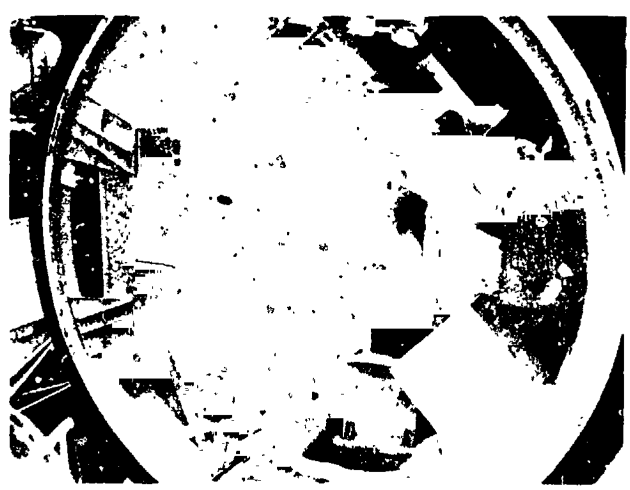


Airlock payload shroud flight unit biconic section being transferred from final subassembly fixture to final assembly reassembly.



Payload shroud flight unit in final assembly at MDAC-WD

Angus L. Bevil threatened to slap her hand if Linda (Mrs. Chester) Foreman of CC tried to abscond with one of the small packages decorating his Christmas tree in the lobby of Building 4200 during Christmas 1971.



Skylab/MDA NASA trainer - interior view

MSFC announced on April 30, 1971, the retirement of Lee B. James, Director of Program Management at MSFC, the retirement to become effective on May 31. Succeeding him as Acting Director of Program Management would be J.T. Shepherd. In 1963 James had become manager of the Saturn I and IB Program, then had joined General Phillips in OMSF for 1 year as Deputy Director of the Apollo Program. Upon his return to MSFC he was appointed Saturn V Launch Vehicle Manager and later became Manager of the Saturn Program. James was appointed the Director of Program Management at MSFC upon the transfer from MSFC of General Edmund F. O'Connor on July 28, 1969. As Director of Program Management James had directed both the Saturn I and Saturn V projects. Program Management under James also had charge of the Skylab Program, Mission Operations, as well as the management of the Michoud Assembly Facility and the Mississippi Test Facility [708].

In a prominent front-page story Huntsville's largest paper, The *Huntsville Times*, sub-headlined on May 9, 1971, "Plan gives Shuttle to Houston." The article went on to state, "Marshall Space Flight Center would have a subsidiary role in the proposed earth-to-earth orbit Space Shuttle under a current plan being studied by the National Aeronautics and Space Administration. Houston's Manned Spacecraft Center appears to be emerging as the lead center with a lion's share of the anticipated effort heading there." The article added that the decision was still under discussion and not final. "Marshall Center and the Manned Spacecraft Center had been in a foot race for months to try to win either single center management or a 50-50 split. While the plans being reviewed lays [sic] heavily in Houston's favor, some experts emphasize that discussions could alter the plan to be more compatible with Marshall Center's capabilities."

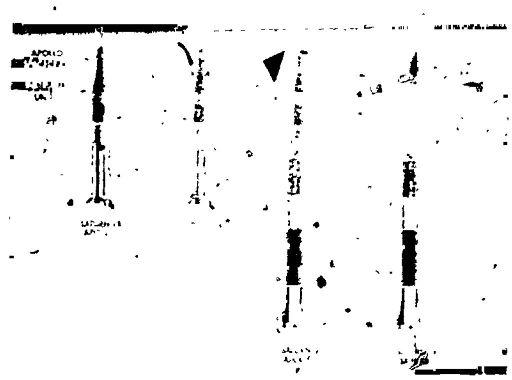
On May 10 the first segment of an LRV qualification test unit was delivered to MSFC, with the last segment arriving on May 26. The first flight LRV would go to the moon on Apollo 15 in July 1971, as reported previously. The qualification unit was a replica of flight LRV's. It would be at the Marshall Center through the Apollo 15 mission, where it would be used for possible troubleshooting while the first flight LRV was making three exploration traverses of the lunar surface. The second flight LRV would remain at Boeing's Kent Space Center near Seattle until after Apollo 15. It would be joined in temporary storage by the third flight model, due for delivery to NASA in June. The qualification unit would undergo several tests at MSFC before it was prepared for use during Apollo 15, when it would be deployed and checked at MSFC as its counterpart transported two astronauts on the moon [709].

In a May 13 news conference at MSFC, NASA Administrator Dr. James C. Fletcher announced that no decision had been made concerning the location of headquarters for the sought-after Space Shuttle system contract. Dr. Fletcher told newsmen that he could not understand the apparently deep local concern about the Shuttle because "no matter how the decision is made, the Marshall Center will get a sizable, if not a major responsibility." He said further, "there is no way to predict at this time" where the management will be headquartered. Until word could be received from Congress about next year's funding, which was expected to be "small, $100 million or so," no details will be forthcoming, Dr. Fletcher said. "I think that's coming too," Dr. Fletcher added, referring to potential Congressional appropriations. Future manpower reductions were not expected to be a part of MSFC's future, he predicted. After the last announced drop of

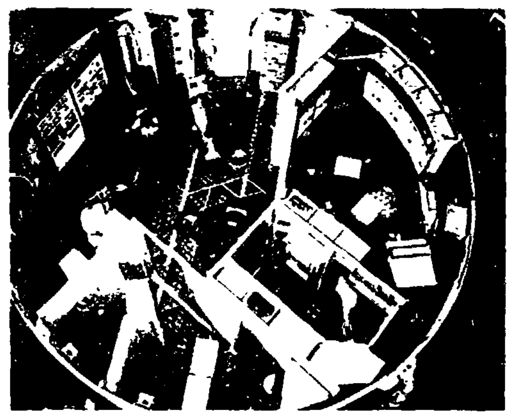
The Apollo 15 crew crammed a lot of activity into the six hours they spent at MSFC in October of 1971. They thanked employees for the Saturn V and Lunar Roving Vehicle they used on their lunar landing mission. Some representative scenes appear here. David Scott (top left) signs autographs outside Building 4619, crew and Dr. Rees (top right) examine LRV model; and Irwin signs autographs as pretty fan watches and others wait in line (bottom photo).

View of Saturn I Workshop mockup

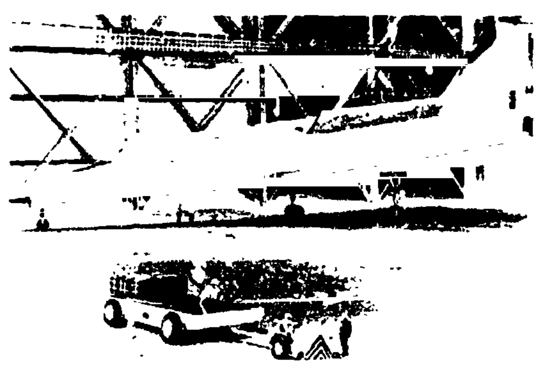
Astronaut Ed Gibson (center) practices EVA in Neutral Buoyancy Simulator at MSFC



Commonality of Saturn hardware



Workshop 1-g trainer delivered to MSC from MSFC (crew quarters view)



Airport concept for Shuttle

297 employees from the payroll, to be completed by July 1971, no more reductions were expected to be announced for MSFC, Dr. Fletcher said. This was considered to be another indication that MSFC would have a major Shuttle role [710].

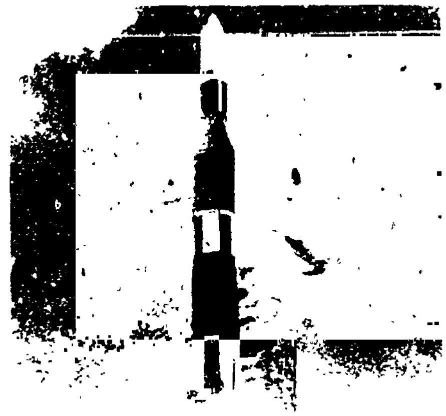
On May 24 Director Rees reminded MSFC employees of his January 29 letter concerning the President's budget to Congress and the probability of personnel reduction at MSFC. Dr. Rees wrote, "I can tell you now that the effective date, NASA-wide, of the reduction-in-force has been set by Headquarters as October 1, 1971. This means that notices to the affected employees will be distributed on or before the 16th of August." NASA's agency-wide reduction rate would be 5 percent for each Center [711].

MSFC announced on June 1 that a recent rocket engine test firing at MSFC had led to extension of the "certified lifetime" of seals, O rings, and gaskets in all types of rocket engines and stages of Saturn IB and Saturn V vehicles. In effect this extended the storage lifetime of the 29 Saturn stages then in existence from 8 years to 10. Nine S-IB (first) stages and seven S-IVB (second) stages of the Saturn IB, plus five S-IC (first) stages, five S-II (second) stages, and three S-IVB (third) stages of the Saturn V, were awaiting use at the time of this test. More than half were scheduled for use before the end of 1973, but some were presently uncommitted and were in indefinite storage. As part of a continuing test series, engineers at MSFC took a single H-1 engine, number H-2033, from storage where it had been "hibernating" for almost 9 years. The engine had been kept in its original configuration. The test consisted of three starts of the engine and a full-duration run of 140 seconds. The engine performed as well as it did when it received its initial qualification test firing. The tests were conducted by the Test Division at MSFC, and examination of engine components was by the Materials Division of MSFC's Astronautics Laboratory. The Quality and Reliability Assurance Laboratory performed complete pre-test and post-test examinations of the engine [712].

On June 2 MSFC awarded a contract modification to the Rocketdyne Division of North American Rockwell Corporation for continued support work on rocket engines for Saturn launch vehicles. The $26 228 158 contract modification covered the period from July 1, 1971, through December 31, 1972. At the time of this modification, Rocketdyne had built and delivered the F-1, J-2, and H-1 engines that powered the Saturn IB and V launch vehicles. This contract modification allowed the continued analysis of engine performance, field engineering, logistics, and retention of a Rocketdyne problem-solving group [713].

On June 3 the United States House of Representatives breathed new life into the blossoming U.S. Space Shuttle Program when members shouted down efforts to cut out two Apollo moon flights and the proposed Space Shuttle program. Instead, the House approved a $3.4 billion authorization for the space program. Attempts to cut $400 million for the final Apollo 16 and 17 flights scheduled for 1972 and $125 million to start development of the Space Shuttle to ferry passengers and equipment to space stations were overwhelmingly defeated by voice votes. NASA's authorization for the fiscal year starting July 1 then passed the House 302 to 64 and went to the Senate [714].

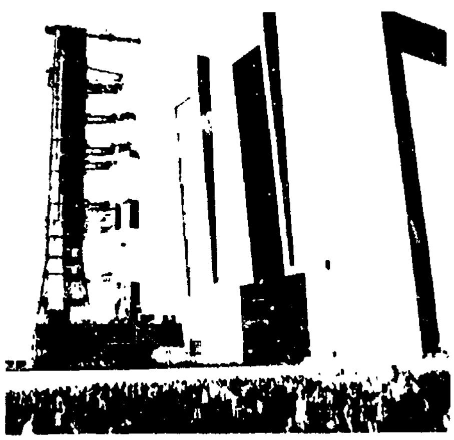
Installation into Workshop flight unit prior to start of checkout



Saturn V/Skylab launch configuration

Artist's concept showing facility for space astronomy

Seven astronauts were at the Marshall Center in November 1971 to inspect the Lunar Roving Vehicle and participate in deployment exercises. Four of the group are shown here. They are (l to r): John Young, commander for Apollo 16; Eugene Cernan, commander for Apollo 17; Fred Haise, Apollo 16 backup commander; and Charles Duke, Apollo 16 lunar module pilot. The LRV shown here was a qualification test model used in the deployment exercises.



Rollout of Apollo 16

On June 3 a Skylab Workshop test unit arrived at MSFC aboard the NASA barge *Orion*. It came from MSC where it had been through vibration and acoustic testing. This test unit was a ground test version of the Workshop [715].

On June 7 in a step toward building orbital Space Station, the Soviet Union's manned Soyuz 11 linked up with the space laboratory Salute launched 7 weeks earlier, and three cosmonauts went aboard. The two craft together formed a vehicle 60 feet long, 12 feet in diameter, and weighing 25 tons. Portending an era of orbiting Space Stations in which MSFC hoped to play a major role, the Russian news agency declared, "A Soviet manned orbital scientific station is functioning." The linkup climaxed a chase through space lasting more than 25 hours. Soyuz 11 streaked into orbit the morning of June 6 and began pursuing Salute, launched April 19. Aboard Soyuz 11 were three cosmonauts: Victor Patsayev, Vladimir Volkov, and Lt. Col. George Dobovolsky [716].

On June 10 NASA outlined its management plans for the Space Shuttle Program. Overall management of the Space Shuttle Program would be in the Headquarters Office of Manned Space Flight which would be responsible for detailed assignment of responsibilities, basic performance requirements, control of major milestones, and funding allocations to the various NASA field centers. Dale D. Myers, Associate Administrator for Manned Space Flight, assigned responsibilities to the three Manned Space Flight centers for the Space Shuttle Program as follows:

1. Manned Spacecraft Center would have program management responsibility for program control, overall systems engineering and system integration, and overall responsibility and authority for definition of those elements of the total system which would interact with other elements, such as total configuration and combined aerodynamic loads. MSC also would be responsible for the orbiter stage of the Space Shuttle.

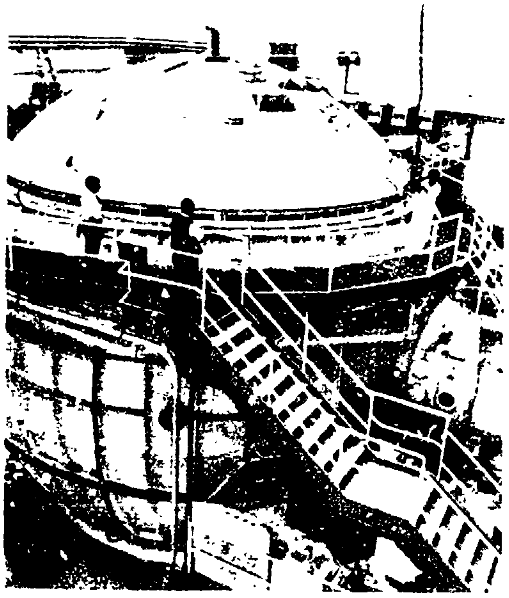
2. MSFC would be responsible for the booster stage and the main engines for the Shuttle.

3. KSC would be responsible for design of launch and recovery facilities.

All three centers would have personnel located at MSC as part of the overall systems engineering and systems integration activity.

Dr. James C. Fletcher, NASA Administrator, had the following additional comment which was of interest to MSFC:

> In reaching the decision on the management of the Space Shuttle program, we have also decided that future programs under the Office of Manned Space Flight will be managed in a similar way, wherein a center will be given a major integration responsibility commensurate with its experience, skills and workload. It is currently planned, for example, that this integrating responsibility will be assigned to the Marshall Space Flight



39-foot diameter vacuum chamber as lid is being secured for test

Preparation of MDA flight unit for shipment to MDAC-ED

MDA flight article in Denver

> Center for the Research and Applications Module studies now underway, and for any other Space Station studies at the end of the current Phase B studies.

In a large headline Huntsville's major morning newspaper, the *Huntsville News*, declared:

> Reactions vary here today in the wake of the announcement that while Huntsville gets the Shuttle booster Houston gets the leading management role, but all seem to agree on this: Huntsville's glad it's been given the chance to develop the booster for the reusable Shuttle craft, but the city had certainly hoped for more. Says county commission chairman James Record: "The space program here got the low end of the totem pole. This will probably maintain the current level of employment here, but what we had really hoped to see was growth. If we had gotten the management position, employment certainly would have increased in Huntsville and Madison County."

The paper quoted one MSFC official as saying:

> The way the responsibilities have been allotted is going to cause MSFC here considerable difficulties. In the past, Houston had handled the spacecraft, Huntsville the actual rockets, and Cape Kennedy the launch details. But Thursday afternoon is an unlooked for shift in policy, NASA decided that the three centers would no longer work autonomously as in the past. During previous operations, Huntsville's MSFC has answered directly to the Apollo office at NASA Headquarters in Washington, D.C. But now Huntsville will answer to Houston.

The paper further quoted the Marshall employee, who preferred to remain unidentified, as stating that Marshall "will find it very hard to develop the booster part of the Shuttle. NASA is now asking one center to make distribution to the other centers and to itself. If it comes to a choice of giving funds to Houston or one of the other centers, Houston is going to get it." The paper added that the Marshall employee is among ranking men in the administration of the space flight center here. He said, "the situation could even cause the center to dwindle if enough [*sic*] funds are cut." Huntsville's job, he said, "will be ten times tougher than it was under the Apollo system." The paper quoted Mayor Joe Davis as saying, "We had hoped that the headquarters would be here in Huntsville, but this will be a boost to the city's economy, and will help to keep the space program here from dying out" [717, 718].

In a June 11 lead editorial entitled "The Shuttle Pie," The *Huntsville Times* wrote:

> The organizational pie for management of the U.S.A. Shuttle Program has now been officially sliced by the powers in Washington, and we cannot say we are pleased with how the pieces of the action were partialed out among the space agency's field centers. According to the NASA announcement yesterday, Marshall Space Flight Center here will be responsible for developing the booster portion of the proposed 2-stage

> Shuttle, but the smaller Manned Spacecraft Center in Houston has won overall management responsibility for the entire program as well as the job development of the Shuttle's orbiter craft. . . One can definitely question the efficacy of the decision to make NASA's Houston installation "the lead center" for the Shuttle program. This step marks an unexplained departure from the highly successful approach following the project Apollo, in which no field center was to serve in another but all answer directly to a central project office at NASA Headquarters and one can question the wisdom of assigning to the Houston Center the responsibility for the so-called integration of so large a space vehicle as the 2-stage Shuttle. This is precisely the kind of challenge that Marshall Center faced . . . and successfully met . . . in overseeing the development of the gargantuan, multistage Saturn V launch vehicle for Apollo, while MSC in Houston handled the spacecraft end. . . . The space center in populous Texas did not win its new, pre-eminent role on the basis of in-house experience and existing resources alone. We can only conclude that factors other than merit figure prominently in this decision.

NASA announced on June 16 that it was examining the advantages and disadvantages of a "phased approach" to the development of a reusable Space Shuttle system in which the orbiter vehicle would be developed first and initially tested with an interim expendable booster. In a "phased approach," full scale hardware development of the reusable booster would be started later, but some design and preliminary development work for it would proceed concurrently with development and test of the orbiter. For the interim booster NASA and its industrial contractors would study the use of a modified Saturn S-IC (first stage of the Saturn V that launched Apollo flights to the Moon), a booster based on the Titan III, and a booster system using solid rockets. The contractor studies nearing completion as of the date of this announcement confirmed the feasibility and desirability of a reusable Space Shuttle as the key element of the space transportation system which would meet the continuing needs and long-term objectives of the United Stated in space.

In making the June 16 announcement, NASA Administrator James C. Fletcher said:

> The preferred configuration which is emerging from these studies is a two-stage delta-wing reusable system in which the orbiter has external propellant tanks that can be jettisoned. Although our studies to date have mostly been based on a "concurrent approach" in which development and testing of both the orbiter and the booster stages would proceed at the same time, we have been studying, in parallel, the idea of sequencing the development, test, and verification of critical new technology features of the system. We now believe that a "phased approach" is feasible and may offer significant advantages. We believe that the additional studies we are now undertaking, together with those previously undertaken and now being completed, will put us in a position to make a decision this fall on the technical and programmatic approach to be followed in the Space Shuttle program [719].

In a leading front page story, the *Huntsville Times* on June 17, 1971, expressed further alarm concerning MSFC's prospects in what it considered the MSFC/MSC competition for the Shuttle program. Under the headline "NASA eyes plans for expendable Shuttle Booster," the story declared, "the possibility of a phased approach to the development of a reusable Space Shuttle system . . . with already available engines being used . . . is being seriously considered by the National Aeronautics and Space Administration. Under the plan, the orbiter vehicle would be developed first and initially tested with an expendable booster, probably a modified first stage of a Saturn V moon rocket, a booster based on the Titan III, or a booster system using solid rockets." The article went on to express the fear that this likely "decision would highly strengthen Houston's job in systems integration for both vehicles, sources here contend, as well as increase Houston's responsibility as the lead center for the Shuttle development." The paper quoted NASA's new administrator, Dr. James Fletcher, as stating, "we now believe the 'phased approach' is feasible and may offer significant advantages." The paper indicated that such a decision did not bode well for MSFC.

After asking 19 companies with experience in communications and navigation to bid on a 10-month study effort that would define experiments and instrumentation necessary for a manned communications and navigation research laboratory, NASA awarded the contract to TRW on June 18. Such a laboratory could be launched late in the decade by a Space Shuttle. The laboratory was envisioned as one of a class of Research Applications Modules that would be flown aboard the Shuttle. Such a laboratory would be used for various demonstrations, measurements, and tests. Generally, it would be oriented toward improving communications and navigation on earth. Some of the experiments discussed included laser communications, satellite navigation techniques, terrestrial noise measurements, transmitter breakdown tests, noise identification, and autonomous navigation systems for space. MSFC would monitor this contract valued at $288 000 [720].

On June 21 four MSFC engineers took part in discussions with Russian counterparts regarding the possibility of developing compatible space docking equipment. The meeting between U.S. space agency officials and about 20 Russian officials occurred at the Manned Spacecraft Center. Attending from MSFC were George Hardy of the Skylab Program Office, Joe Cremin of the Aero-Astrodynamics Laboratory, Melvin Brooks of the Astronautics Laboratory, and Robert G. Eudy of the Astrionics Laboratory. Hardy had been in a group of five Americans who initiated these discussions in Moscow during October 1970 [721].

On June 23 NASA awarded a contract to North American Rockwell Corporation, Space Division, Downey, California, for studying the feasibility of developing a low-cost, reusable chemical propulsion stage that could be launched from earth on the Space Shuttle booster and then subsequently refueled in space for up to 10 space missions. The 10-month "phase A" contract was for $250 000. This vehicle could be used for a high-lift capability to low earth orbit, the placement of large payloads of the order of 100 000 pounds to geosynchronous orbit, and eventually for lunar and unmanned planetary missions. At the time of this contract, engineers at MSFC were requiring that the interorbital stage have a lifetime of three years or 10 uses in space, whichever came first from the cutoff period. It would be designed so that maintenance could be carried out in earth orbit and for a quiescent state in orbit for periods of up to 180 days. The interorbital stage would utilize many of the components and systems of the Space Shuttle; for example, it would burn liquid hydrogen and liquid oxygen and the engines would be the same as those to be used on the Space Shuttle [722].

On June 23 NASA announced receipt of more than 600 proposals from potential domestic and international users of data expected from the Earth Resources Experiment Package to be carried on Skylab. It was the greatest number of proposals for experiments ever received by NASA in response to announcement of opportunity for analysis of space-derived data [723].

In mid-summer 1971 MSFC officials felt it necessary to reassure MSFC employees concerning the extent of the proposed RIF at MSFC. Director Eberhard Rees wrote, "On May 24 my letter discussing the reduction-in-force scheduled to be effective on October 1 of this year was distributed to all employees. . . . In view of the recent news story I want to inform you that what I said in that letter is still valid. Your management has no information from any source that in anyway changes or increases the plan for the NASA-wide reduction-in-force previously announced. The MSFC's share of this reduction is approximately 300 positions. We are not aware of any additional reduction-in-force" [724].

On June 30 MSFC selected Rocketdyne Division of North American Rockwell Corporation to develop turbopump assemblies for a hydrogen and oxygen Space Shuttle auxiliary propulsion system (APS) technology program. Rocketdyne was being asked to develop the technology and supply the Shuttle APS turbopump assembly "breadboard" for the space agency's technology advancement program. The term "breadboard" was applied to a nonflight, working model used for repeated ground tests. There was no flight hardware called for in the contract. Total cost of the 16-month contract was $1 016 636. Rocketdyne was being asked to develop three major turbopump components. These included the turbine, gas generator, pump, and required control valves [725].

On June 30 Russia's worst space tragedy to date brought quick reassurance from NASA that NASA's Skylab and Space Shuttle programs should not be affected. The tragedy occurred when the three Soyuz 11 cosmonauts died as their spaceship brought them back to earth from the world's first manned orbital space laboratory and a record of nearly 24 days in space. An official announcement said the three spacemen (Lt Colonel George Dobrovolsky, Flight Engineer Vladislav Volkov, and Test Engineer Viktor Patsayev) completed their flight program the day before and communicated with ground control on their way down. Soyuz 11 made a smooth landing where it was supposed to, the announcement said, but the rescue crew that opened the hatch found the men dead. The announcement published by Tass the official Soviet new agency, said the cause of the deaths was being investigated. It gave no indication what that might be. In a NASA news conference called on this same date by Dr. George M. Low at 1:30 p.m., Huntsville time, NASA expressed condolences over the death of the three cosmonauts and speculated that it must have been machine failure rather than human failure that caused the accident. Dr. Low indicated that a failure in the environmental control system was one of the prime suspects. He stated that it was very unlikely that this problem in the Soviet's spacecraft would cause a delay in NASA's Shuttle or Skylab programs [726].

The CDDT for Apollo 15 began at 6 p.m. CDT on July 7. The first hold in the CDDT would be for 12 hours and would occur at T-48 hours. The next hold would be for 9 hours 34 minutes at T-9 hours. Schedules called for the wet CDDT to begin on July 13 and the dry CDDT on July 14 [727].

MSFC announced on July 12 that NASA had selected it to take the integration role in managing two proposed earth orbital projects currently in the planning stage: The Space Station and the Research and Applications Modules (RAM). This action followed a similar decision to assign the integration role in the Space Shuttle program to MSC. Under this announcement MSFC would be responsible for the Shuttle booster design and fabrication, and for the main engines for both the orbiter and the booster of the Shuttle. Dale D. Myers, Associate Administrator for Manned Space Flight, made both assignments.

The Space Station had been under study for nearly 2 years. The current concept called for a semipermanent facility in earth orbit which would be carried to orbit by the Space Shuttle. Development of the Space Station would follow the development of the Shuttle. RAM, a newer concept, would be a family of space payload carrier modules to be delivered to earth orbit by the Shuttle. RAM's would be capable of supporting the diverse technological and scientific investigations and practical applications. Certain RAM's would remain attached to the Shuttle during short duration missions; others would be released from the Shuttle in orbit and operate as free-flying, unmanned, automated spacecraft. These free-flying RAM's would be designed for long-term usage; they would be serviced and maintained in orbit during subsequent Space Shuttle missions. When the Space Station would become available, some RAM's would operate directly attached to the Station; others would operate in the free-flying mode and be supported by the Space Station.

In making his announcement, Myers called attention to the present "major effort" MSFC was directing to determine a preliminary design of the RAM. "This study is a very important effort because it will not only define the early sortie payloads for the Shuttle, but also because it will be one of the first detailed looks at Shuttle payload interface problems and operational requirements" [728].

Confirming NASA's speculation that the Soviet's space tragedy resulted from a failure in environmental control, the Soviet government announced on July 12 that a pressure leak killed the Soyuz 11 cosmonauts one-half hour before their landing on June 30 and indicated that human error rather than a fault in the space ship was responsible. There was speculation in the Soviet Press that the men died because they did not seal the landing craft's hatch properly, and that prolonged exposure to weightlessness sometimes causes "a false feeling of complacency." This later warning was of special interest to NASA as NASA itself prepared for longer flights in space [729].

On July 20, the second anniversary of man's first lunar landing, the countdown began for a fourth American expedition to the lunar surface. The Apollo 15 launch team started the countdown clock at 7:30 a.m. EDT, preparatory to their July 20 lift-off. The clock started at 104 hours 30 minutes. It would be halted at several preplanned points to provide crew rest periods and catchup time on any item that might fall behind schedule [730].

As of July 21, 1971, development of the Lunar Roving Vehicle had utilized the work of engineers, technicians, and administrative people at MSFC, a production that would reach its big test in a little more than a week when the first LRV would be used by the Apollo 15 astronauts on the moon. Several MSFC laboratories contributed to the LRV Program Office during the 17-month LRV development program. Two groups in particular merited special recognition for their work: The Astrionics Laboratory engineers who helped design the LRV system, and the Astronautics Laboratory people who designed the vehicle manual deployment system.

The navigation system first designed for the LRV was very sophisticated – and also very complicated, fragile, and expensive. The Astrionics Laboratory Guidance and Controls Division was asked to devise a better system, and the job was given to the Sensors Branch. Engineers developed a simple, rugged, and cheap navigation system based on dead reckoning navigation. In a series of tests that lasted several months, and moved from the Marshall Center to Flagstaff, Arizona, and back again, the Sensors people ran a prototype vehicle to prove that their system would work. It did and was made a part of the LRV.

The deployment system was a development of the Astronautics Laboratory Engineering Division. A manual system that was originally intended as the backup deployment system to be used if the primary automatic system failed was devised by the Division. Problems with the automatic system led LRV program managers to decide that the backup manual system was the most reliable, so the MSFC-developed system became the primary method of deployment [731].

It was reported on July 25 that the KSC launch complex where the Apollo 15 spacecraft and Saturn V booster stood ready for lift-off had been struck by lightning 11 times during the past 6 weeks. The first strike, on June 14, had been almost three times as powerful as the average lightning strike and two-thirds as strong as the biggest lightning strike ever recorded in Florida. On July 20 five separate lightning bolts with total amperage of almost 100 000 amps had been recorded. Neither the spacecraft nor the launch vehicle had been damaged. Apollo 15 was the first spacecraft to have even a near-miss from lightning strikes while being prepared for launch [732].

At 8:34 a.m. CDT on July 26, 1971, Apollo 15 (AS-510) rose into space from KSC Launch Complex 39, Pad A. Aboard were Astronauts David R. Scott (commander), Alfred M. Worden (CM pilot), and James B. Irwin (LM pilot). Approximately 1 million television viewers watched as the Saturn V booster started this fourth lunar landing mission on the way to the moon. Astronaut David Scott commented shortly after reaching earth orbit, "Okay, she was a smooth ride all the way." Scott and crewmates James Irwin and Alfred Worden seemed to be unusually relaxed. There was little unnecessary conversation.

After the spacecraft and S-IVB combination entered parking orbit and translunar injection was achieved, the docking of the CSM with the LM was shown clearly by onboard color television. One and then a second S-IVB ATS burn sent the stage toward the moon. Shortly after the CSM-LM docking, telemetry data revealed an electrical short in circuitry. After troubleshooting isolated the problem, ground technicians felt that the SPS bank could be safely operated manually and modified procedures for bank burns were developed and relayed to the crew. Scott and Irwin entered the LM 50 minutes earlier than planned, to check out LM communications and other systems. TV pictures of the CSM and LM interiors were shown. During checkout the crew discovered that the range/range-rate exterior glass cover had broken, and the crew began LM housekeeping 1½ hours earlier than scheduled and vacuumed the broken glass. During preparations for water chlorination, a water leak developed and the crew stopped the leak, following repair instructions from the ground, and the water was absorbed with towels. Apollo 15 entered lunar orbit on the afternoon of July 29. On the afternoon of the following day, at 5:16 p.m. CDT, the LM Falcon touched down on the moon's Hadley-Apennine region near the Salyut Crater. The first EVA began the following day, July 31, at 8:14 a.m. CDT. Scott climbed down the ladder, deployed a camera which recorded his descent, and stepped onto the lunar surface; Irwin followed. They had difficulty deploying the LRV; during checkout they found that the front steering mechanism was inoperative, and the decision was made to perform EVA-1 without any LRV front wheel steering. Stops at stations where they collected lunar samples and made photographs were broadcast on television with excellent transmission. Scott and Irwin reentered the LM after 6 hours 33 minutes exploring the surface, 28 minutes sooner than planned because Scott used up more oxygen than anticipated.

Beginning their second EVA, they left the LM at 6:49 a.m. CDT on August 1. This time the LRV front steering was found to be completely operational. During this second EVA they obtained numerous samples and photographs, and TV transmission was good. After 7 hours 12 minutes on the surface during the second EVA-2, the astronauts reentered the LM. The third EVA began at 3:52 a.m. CDT on August 2. During this third EVA Scott tripped over a rock and fell, but he experienced no difficulty in getting up. After 4 hours 50 minutes on the lunar surface during this third EVA, the astronauts reentered the LM, making a total EVA time of 18 hours 35 minutes. While the LM was on the moon, Worden orbited the moon in Endeavor. To meet him, Scott and Irwin lifted off the lunar surface with 180 pounds of lunar samples on August 2, 66 hours 55 minutes after landing on the moon. The lift-off, accompanied by the USAF anthem, "Off We Go Into The Wild Blue Yonder," was taped and broadcast by the astronauts from the LM, and was photographed in color by a camera left on the moon and was seen by millions of TV viewers. The spacecraft docked successfully as TV viewers watched, and Scott and Irwin transferred from the LM to the CSM with samples, equipment, and film. The transearth injection maneuver put the CSM on its trajectory for home after 85 hours 18 minutes (74 revolutions) in lunar orbit. The CM, Endeavor, separated from the SM, the drogue and main parachutes deployed, but one of the three main parachutes partially closed during descent, causing a harder landing than expected. The CM splashed down in the mid-Pacific about 5.5 nautical miles from the recovery ship *USS Okinawa* at 3:46 p.m. CDT on August 7 – 12 days 7 hours 12 minutes after lift-off. The astronauts were carried by helicopter to the biomedical area on the recovery ship for post-flight examinations. After being declared in very good shape, the astronauts were flown on the following day to Hickam AFB, Hawaii, and to Ellington AFB, Texas. The CM was retrieved and placed on board the recovery ship. The lunar samples, data, and equipment were flown to Ellington AFB, and the CM was off-loaded at San Diego. Apollo 15 had been the 12th Apollo mission to date, the 9th manned Apollo mission, and the 4th successful lunar landing mission [733-737].

On July 30 NASA selected Rocketdyne Division of North American Rockwell Corporation, Canoga Park, California, for negotiations leading to the award of a cost-plus-award-fee contract for the Space Shuttle main engine. NASA had received proposals for this program from three firms on April 21, 1971. The contractor's proposed cost for the design, development, and delivery of 36 engines by 1978 would be approximately $500 million. MSFC would manage the program and would support Space Shuttle orbital flights beginning in 1978. The selection followed a 12-month Phase B competition during which contractors conducted preliminary design studies and produced program definition documents for this ensuing phase. The Space Shuttle main engine would be a hydrogen-oxygen engine employing a high-pressure staged combustion cycle in which all of the fuel would be used in the main combustion process to produce the highest possible impulse. The engine, producing 550 000 pounds of thrust at sea level, would be used as the primary propulsion for both the booster and orbiter of the reusable Space Shuttle. The engine and the Shuttle vehicle itself would be designed for multiple reuse as in airline operations. Rocketdyne would do this work at its Canoga Park, California, plant. In addition, engine system development testing would be at NASA's Mississippi Test Facility near Bay St. Louis, Mississippi, and at the Air Force's Arnold Engineering Development Center, Tullahoma, Tennessee [738].

GAO investigation of NASA's selection of North American Rockwell Division for the Space Shuttle contract work was requested by President Bruce N. Torell of Pratt and Whitney Division of United Aircraft Corporation in an August 3, 1971, telegram to U.S. Comptroller General Elmer B. Staats. Basis for this protest was that source selection had disregarded the objective of the RFP, that NASA had failed to conduct "written or oral discussions" on proposals, that Pratt and Whitney felt that its proposal was "clearly entitled to a superior technical evaluation to the technical proposal of Rocketdyne," and that NASA had failed to give proper consideration to "Pratt and Whitney's test-proven flight weight design and greater experience." In a letter to Dr. James C. Fletcher, NASA Administrator, nine senators requested that no award of the Space Shuttle engine contract be made until GAO investigation had been completed [739].

On August 13, 1971, Pratt and Whitney filed a formal protest against NASA's award of a $500-million Space Shuttle main engine contract to North American Rocketdyne Division and asked the Federal Government to reverse this award. In a letter to GAO, Pratt and Whitney charged that selection of Rocketdyne was "illegal, arbitrary and capricious, and based on unsound decisions" and reitereated complaints cited August 3 to the GAO [740].

On August 31 MSFC signed a level-of-effort contract with North American Rocketdyne Division for the design of the Space Shuttle main engine. The interim contract, for 4 months at $1 million per month, had been signed pending GAO review of the protest of the contract award by the United Aircraft Corporation, Pratt & Whitney Division [741].

On September 1 the Boeing Company delivered a second flight model of the Lunar Roving Vehicle to KSC for the Apollo 16 mission [742].

Apollo 15 Astronauts David R. Scott, Alfred M. Worden, and James B. Irwin spent 6 hours at MSFC on September 30. They thanked MSFC employees, shook hands, signed autographs, and made short speeches during their stay. They made stops at Morris Auditorium and Building 4707 before going to lunch at the Officer's Club, an affair attended by 500 persons. In the afternoon they stopped at Building 4619 where they were greeted by the Grissom High School Band and at Building 4201 where Snoopy awards were presented [743].

In a September 9 memorandum, MSFC sought to clarify for its employees the role of support contractors in an MSFC reduction-in-force. Deputy Director, Management, R.W. Cook wrote, "I feel that it is an appropriate time to reaffirm NASA/MSFC policy concerning the utilization of support contractors. The work previously performed by any of our Civil Service employees being affected by the reduction-in-force will not be assigned to a support contractor. The Civil Service employee's duties must be eliminated or absorbed by other Civil Service personnel, if necessary" [744].

On September 13 the S-IC-511 first stage for the Saturn V launch vehicle that would launch Apollo 16, next to the last flight in the Apollo flight series, was shipped by barge from the Michoud Assembly Facility, to arrive at KSC on September 17 [745].

Further reductions in MSFC's R&PM budget required drastic measures for reducing MSFC's overall operating cost in order to stay within the revised Center budget. With this in mind, MSFC scheduled a planned reduction in motor pool services to be effective October 1, 1971, "as one step in our efforts to curtail overall R&PM costs." This curtailment would mean that on-Center taxi service would be eliminated, leaving a few cabs available for emergency service only [746].

On September 24 NASA accepted the Skylab payload shroud (nosecone) from the McDonnell Douglas Astronautics Company. This shroud, 60 feet long with a 22-foot diameter, weighed almost 26 000 pounds and was the first major piece of Skylab hardware to be delivered to NASA [747].

As of September 30 conceptual drawings of the structural arrangements for the 156-inch diameter, solid-cluster Space Shuttle booster had been completed [748].

On October 7 NASA announced a 6-month delay in the development of the Space Shuttle to give contractors more time to study concepts. Under this new schedule North American Rockwell Corporation, McDonnell Douglas Company, Lockheed Missiles and Space Company, and Grumman Corporation would study Shuttle designs until April 30, 1972. Preliminary design studies were to have been completed by the end of October [749].

On October 11 training mockups of two Skylab spacecraft components (the Orbital Workshop and Apollo Telescope Mount) arrived at MSC aboard the NASA barge *Orion* from MSFC. The shipment also included the multiple docking adapter exterior shell and portion of the airlock module mockup. Trainers and hardware would be used by MSC for training prospective Skylab crewmen for missions scheduled to begin in early 1973 [750].

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On October 15 NASA announced that Skylab astronauts would begin extravehicular training in pressurized suits in the MSFC Neutral Buoyancy Space Simulator later in 1971. Mockups of the Skylab space laboratory modules had been submerged in a water tank 40 feet deep and 75 feet wide, which simulated the weightlessness of space environment.

On October 19 the Saturn IB first stage for the first manned Skylab launch vehicle was removed from the environmentally controlled enclosure at Michoud Assembly Facility after 3 years in hibernation. This booster, one of nine IB stages stored there in December 1968, would begin a 10-month refurbishment program in preparation for launch in the Spring of 1973 [751].

On November 2 Dr. Fletcher, NASA Administrator, approved the Skylab Student Project, a joint effort between NASA and the National Science Teachers Association to stimulate interest in science and technology by directly involving students in space research. In this project, experiments proposed by students would be conducted by the astronauts on board Skylab in the course of the three planned missions. MSFC was directed by the Skylab Program Director to perform the development and integration efforts and to be the NASA interface with the students. Upon selection, MSFC would design and fabricate the experiments [752].

On November 10 MSFC issued a $64 389 contract to Waldemar S. Nelson and Company, New Orleans, Louisiana, for a feasibility study of a Space Shuttle fly-away airport [753].

Amid rising speculation as to what the Space Shuttle would eventually prove to be, NASA Administrator James C. Fletcher explained the Space Shuttle current situation in a speech before the National Space Club in Washington on November 18, 1971. He explained that the baseline Shuttle (two fully-reusable, hydrogen-fueled stages) remained NASA's preferred approach, but NASA had been studying for the past several months a number of options to the baseline Shuttle. NASA might possibly develop the orbiter and the booster in two phases. The Mark I orbiter could be flown in orbit in 1978, and the Mark II orbiter in the early 1980's. Development of the first booster could be completed in time to fly the Mark I orbiter. Studies had been extended for 4 months beginning July 1 and then extended again for up to 6 months beginning on November 1 in order to review the above options. As the result of studies to date, NASA's thinking was now reasonably firm on the orbiter. It would have an external, expendable tank carrying both hydrogen and oxygen. The main orbiter engine would initially be either an improved version of the J-2 engine used in upper stages of the Saturn V (called the J-2S), or a new high pressure engine. For the booster, four major concepts were still under study: One concept would use the F-1 engines developed and proved in the first stage of the Saturn V. This booster would be manned and would fly back to the launch site. The second and third concepts would be unmanned and the booster would be recovered from the ocean after a parachute landing. The second concept would be a single, pressure-fed booster which would require development of a new engine. The third concept would use twin, pressure-fed boosters firing simultaneously with the orbiter; development of a new engine would be required. The fourth booster concept would be unmanned and the booster would not be recovered from the ocean [754].

On November 19 MSFC awarded a contract to Chrysler Corporation, Space Division, New Orleans, Louisiana, for further study of Space Shuttle booster concepts. The contract was for $765 000. It would continue through February 29, 1972. NASA had asked Chrysler to define recoverable booster concepts for the Space Shuttle program. Results from this study and other definition (Phase B) studies would be used by NASA to select a preferred Space Shuttle design. Earlier studies had called for a two-stage vehicle, each stage powered by high-pressure hydrogen engines. Both stages would return to the launch site and land horizontally, like airplanes. In the alternative that Chrysler was studying, the orbiter stage would operate as described, but the booster stage would land in the ocean and be recovered at sea. Chrysler had also conducted work under a recent 11-month, $750 000 contract for a Shuttle feasibility (Phase A) study. MSFC awarded the contract and was directing the work [755].

The Manned Spacecraft Center on November 22 issued RFP's to 10 firms for a $150 000 firm-fixed-price R&D contract to study space walking requirements in the Space Shuttle program. The proposal called for an investigation of emergency, contingency, and normal extravehicular and intravehicular activities (EVA/IVA) while outside the earth's atmosphere and called also for a study of protective equipment needed to perform EVA/IVA. The proposals were due on December 6, 1971 [756].

On November 24 MSFC selected the Itek Corporation to perform a large space telescope definition study under a $400 000, 12-month contract. This high-resolution optical telescope would be placed in orbit aboard a research and applications module (RAM) by a reusable Shuttle vehicle or Titan III launch vehicle in the late 1970's as a national facility for use by many astronomers [757].

On November 30 Dr. Rees was so impressed by a speech that NASA Administrator Dr. Fletcher made before the National Space Club in Washington on November 18, 1971, that he sent the following memorandum to all key MSFC officials:

> Your attention is invited to the enclosure, an address by Dr. Fletcher to the National Space Club. This address, entitled "The NASA Space Program Today – and Tommorrow," is an excellent work, dealing clearly and concisely with matters pertaining to the Shuttle. In defining the current status and in announcing plans for the future, the document stabilizes the NASA course in clear and unmistakable terms. The address is of great interest and value to everyone at Marshall. Accordingly, I ask that you give it the widest possible distribution within your office or directorate.

One of the points made by Dr. Fletcher was that in the immediate future, NASA's space efforts should center in space around the earth, and that with programs such as Skylab and the Space Shuttle, NASA would have an ideal opportunity to bring space dividends back to earth [758].

On December 13 an estimated 10 000 persons watched the rollout of the Apollo 16 spacecraft and launch vehicle at KSC. Some 40 members of the news media were on hand. This Saturn V launch vehicle (AS-511) left the Vehicle Assembly Building at 7 a.m. EST as planned. The vehicle and its launch tower rode the transporter at a speed of between 0.5 to 0.75 miles per hour. KSC personnel had originally estimated a trip time of 7 hours, but the operation went so smoothly that it required only 6 hours 5 minutes [759].

On December 15 an inter-Center agreement was approved between the Manned Spacecraft Center and Marshall Space Flight Center detailing the responsibilities of the two Centers for Skylab flight crew training in the Neutral Buoyancy Simulator at MSFC. The agreement was approved by Kenneth S. Kleinknecht for the Manned Spacecraft Center and by Leland F. Belew for the Marshall Space Flight Center [760].

Dr. Rocco A. Petrone, Apollo Program Director, visited MSFC on December 16 and 17. He reviewed the status of the Saturn V and Lunar Roving Vehicle programs with program management officials and discussed changes to Saturn vehicle SA-511 and LRV-2, both of which would be integral parts of the Apollo 16 mission [761].

As 1971 neared the end, MSFC announced that among the highlights of 1971 at MSFC were the following: A successful Lunar Roving Vehicle mission, launch of two Apollo/Saturn V vehicles, a Stratoscope II balloon-borne telescope flight, and continued work on the Skylab, Space Shuttle, and High Energy Astronomy Observatory. The Lunar Roving Vehicle made its successful debut on the Apollo 15 mission in July of 1971. Two Saturn V vehicles performed flawlessly on the Apollo 14 and Apollo 15 missions. Stratoscope II was a change-of-pace for MSFC when launched on September 9; the 36-inch astronomical telescope photographed scientific targets from an operating altitude of 82 800 feet. Skylab flight hardware began to take shape at various sites across the country, with Skylab missions scheduled to start in the early 1973. The Space Shuttle or the reusable space transportation system continued to be an important project at MSFC. NASA had made the decision in October to have five contractors or aerospace teams explore in detail various alternatives resulting from previous Space Shuttle studies, and NASA had selected TRW Systems Group, Redondo Beach, California, in November of 1971 as the spacecraft contractor for the High Energy Astronomy Observatory (HEAO) project which MSFC was directing [762].

On December 17 MSFC accepted the flight multiple docking adapter for Skylab at the Martin Marietta Corporation facility in Denver, Colorado. Five days later, the flight MDA went from Denver to the McDonnell Douglas Astronautics Company facility in St. Louis, Missouri, aboard the Super Guppy aircraft [763].

1972

As preparations for the Apollo 16 launch continued at KSC, MSFC officials announced that the following would be among the highlights of NASA's predicted 1972 space flight program: two manned Apollo missions to the moon, the launch of a Pioneer 2-year flight to Jupiter, and the first Earth Resources Technology Satellite [764].

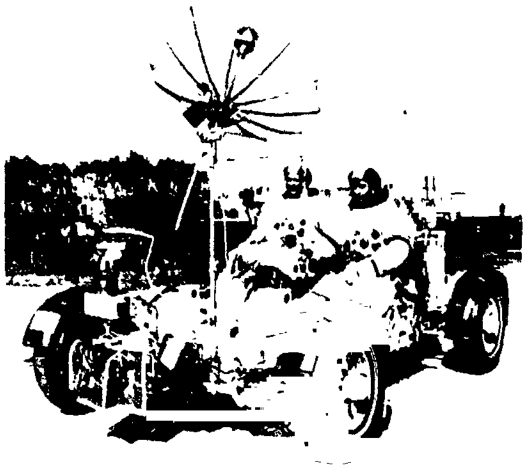
On January 5 President Nixon announced the decision to "proceed at once" with the development of the Space Shuttle. At a news conference following the announcement NASA Administrator Dr. James C. Fletcher said that by the end of the decade the United Stated will have "a means of getting man and equipment to and from space routinely on a moment's notice if necessary, and at a small fraction of today's cost." MSC had been designated the lead center with program management responsibility, overall engineering and systems integration, and basic performance requirements for the Shuttle. MSFC had been given responsibility for the booster stage and the Space Shuttle main engine. KSC would be responsible for the design of launch and recovery facilities. Development costs were estimated at $5.5 billion over a 6-year period, or about one-fourth the cost of the Apollo program. In commenting upon President Nixon's announcement, the *Huntsville Times* in a lead front page story on January 6 said,

> President Nixon's approval of a $5.5 billion Space Shuttle Wednesday has opened a new era in the U.S. space agency and promises years of work ahead for Marshall Space Flight Center here. The President gave the green light during a conference at the Western White House with chiefs of the National Aeronautics and Space Administration. Spokesmen at Marshall Center said today that the Presidential action is not expected to cause any significant increases at the center, but should relatively stabilize the workload . . . unlike earlier considerations, both the orbiter and the booster will be developed in parallel. Both are expected to be ready for flight before 1980 . . . with the Presidential go-ahead, the space agency intends to issue final design proposal requests to industry within two or three months, with hardware contracts expected to be let this summer.

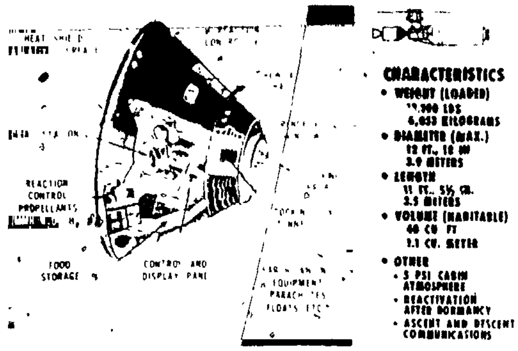
At the news conference, Dr. Fletcher said, "This decision by the President is a historic step in the nation's space program. It will change the nature of what man can do in space" [765].

On January 10 NASA Administrator Fletcher approved the establishment of the Shuttle Program Office as one of a number of changes to the Marshall Space Flight Center organization [766].

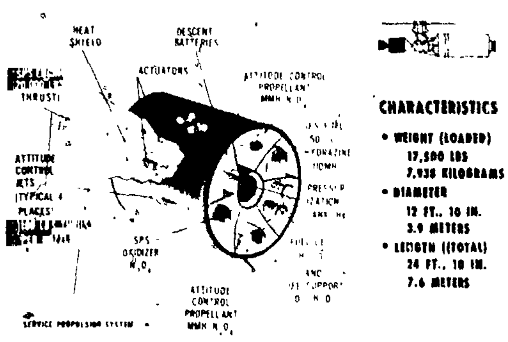
On January 12 NASA announced that the Apollo mission to the moon would not occur until April 16, 1972. Apollo 16 was rescheduled from a March 17 launch after problems were discovered with a suit fitting, a lunar module battery, and the docking ring jettison device on the command module. Spacecraft commander would be Navy Captain John W. Young, command module pilot would be Navy Lieutenant Commander Thomas K. Mattingly II, and the lunar module pilot would be Lieutenant Colonel Charles M. Duke [767].



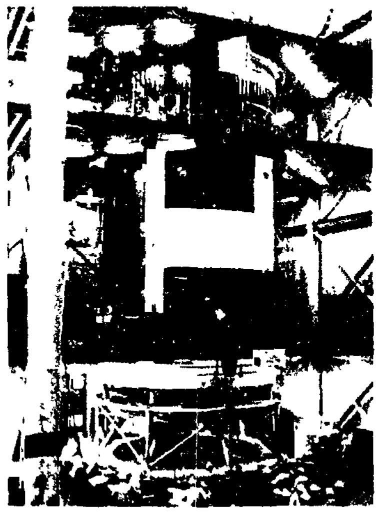
In January 1972, Apollo 16 Astronauts Charles Duke (left) and John Young practiced driving the Lunar Roving Vehicle during training exercises at the Kennedy Space Center.



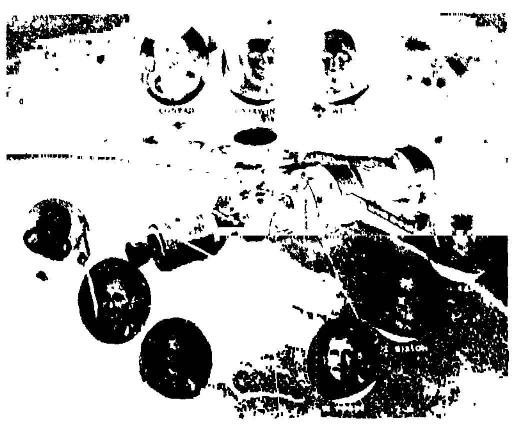
Skylab Command Module



Skylab Service Module



Orbital Workshop flight unit at Huntington Beach



Skylab prime crews

Preliminary concept of HEAO-A

On January 13 MSFC added a Phase III modification to its contract with the National Bureau of Standards in Washington, D.C., under which the National Bureau of Standards was conducting cryogenic testing at its Boulder Facility to determine dynamic performance of the pressure sensors at cryogenic temperatures. This modification increased to a total of $105 000 the contract to the National Bureau of Standards for its work with a Space Shuttle pogo pressure measuring system [768].

On January 18 and 19 Dale D. Myers, NASA Associate Administrator for Manned Space Flight, visited MSFC for briefings and discussions relating to a number of MSFC projects, including the Space Shuttle, Skylab, and HEAO. Accompanying him were Harry H. Gorman, Deputy Associate Administrator, OMSF, and Robert C. Littlefield, executive assistant to Myers [769].

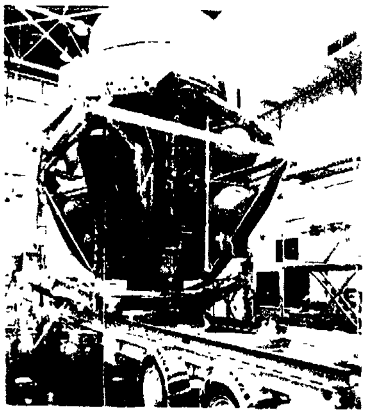
On January 18 NASA named the Skylab astronaut prime and backup crews: for Skylab Mission 1, Charles Conrad, Jr., Joseph Kerwin, and Paul Weitz; for Mission 2, Alan Bean, Owen Garriott, and Jack Lousma; and for Mission 3, Gerald Carr, Edward Gibson, and William Pogue. Backup astronauts for Mission 1 would be Russell Schweickart, Story Musgrave, and Bruce McCandless; backup astronauts for Missions 2 and 3 would be Vance Brand, William Lenoir, and Don Lind [770].

On January 25 and 26 MSFC issued four contracts for the study of solid rocket motors for the Space Shuttle booster. On January 25 a $150 000 contract went to Lockheed Aircraft Corporation, Redlands, California; a $150 000 one went to Aerojet General Corporation, Sacramento, California; and a $145 200 contract went to Thiokel Chemical, Bringham City, Utah. On January 26 a $147 565 contract went to the United Aircraft Corporation, Sunnyvale, California [771].

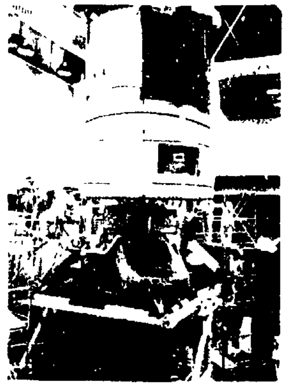
"March 23, 1972, marks Dr. Wernher von Braun's sixtieth birthday," wrote MSFC Director Eberhard Rees to MSFC Employees. "We believe it would be appropriate to observe the occasion with an interesting and lasting momento of the anniversary from the former Director's erstwhile co-workers. . . . We have decided that this remembrance should take the form of a bound volume of letters from people with whom Dr. von Braun worked closely throughout his years in the United States. The volume is to be entitled, 'X+60 and Counting.' This is your invitation to participate if you so desire by writing a letter for inclusion in the book." Understandably this request brought a response from hundreds of workers in the space program [772].

On January 31 MSFC extended the interim contractual arrangements with North American Rockwell Corporation, Rocketdyne Division, Canoga Park, California, for 1 month. NASA hoped that this extension, covering the period February 1 through February 29, would assist North American Rockwell in holding together the pool of skilled manpower it had been utilizing in designing the Space Shuttle main engine. The contract extension cost $1 million. This action was pending completion of a General Accounting Office review of a "Contract award protest" by Pratt and Whitney Division of United Aircraft Corporation, East Hartford, Connecticut [773].

On January 31 and February 1 nearly 50 persons participated in a series of HEAO meetings at MSFC relating to the experiments scheduled to fly on the first HEAO in

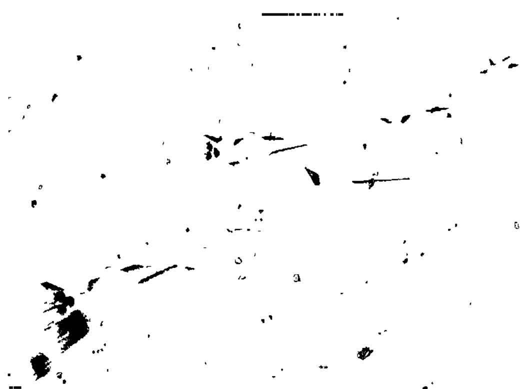


Airlock Module flight unit prior to mating with MDA flight unit



Mating of Airlock and MDA flight units at MDAC-ED

Four prize winners among the 300 Marshall Center employees' children who searched for Easter eggs and rabbits in the 1972 Easter hunt were, left to right: Ina Gail Pierce, Tracy Stevens, Tommy Morris, and Greg Tashbar.

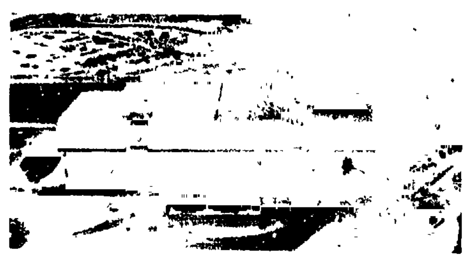


Shuttle launch trajectory

Apollo 16 crew, (l to r) Astronauts John Young, Charles Duke, and Thomas Mattingly

Launch of Apollo 16

Saturn V in flight as viewed from KSC



Launch Control Center at KSC

1975. Hans Fichtner was chairman during the first session, and Joe Jones, Jr., was chairman during the second session. Others present included Richard Halpern, HEAO program manager in NASA's Office of Space Sciences; Dr. Al Opp, a program scientist in OSS; and Dr. Frank McDonald, project scientist of Goddard Space Flight Center [774].

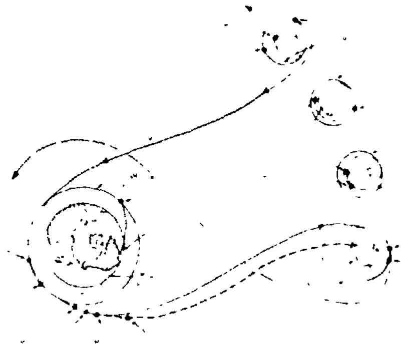
Several personalities known to many MSFC personnel were in the news at the start of 1972. In mid-January Dr. Robert R. Gilruth, Director of the Manned Spacecraft Center, was appointed to the newly created position of Director of Key Personnel Development for NASA. Dr. Christopher C. Kraft, Jr., Deputy Director of MSC, succeeded Dr. Gilruth as Center Director. On January 17 burial services were held at Arlington National Cemetery for Lt. Gen. August Schomburg who died in Phoenix, Arizona, after a brief illness; he was 63. He commanded the U.S Army Ordnance Missile Command, predecessor to the Army Missile Command, from February 1, 1960, to March 24, 1962. On January 19 NASA Associate Administrator for Manned Space Flight Dale D. Myers visited MSFC for briefings and discussions on a number of Marshall Center projects, including Space Shuttle, Skylab, and HEAO [775].

After NASA's selection in late 1971 of the TRW Systems Group for negotiations leading to a $70 million contract for development of the High Energy Astronomy Observatory, TRW submitted an updated proposal on February 14, 1972. This updating was necessitated because of a change in launch dates and in order to correct deficiencies identified during the selection process. NASA was expected to complete negotiations with TRW by April 1, 1972, for this 7-year contract for two spacecraft, a contract scheduled to extend through launch and mission support for orbital operations [776].

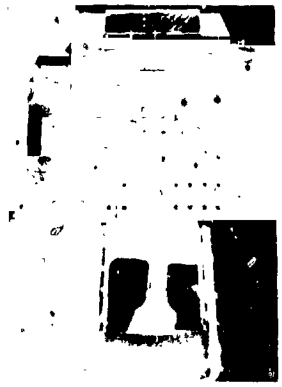
On February 18 vibration testing began on the ATM prototype at MSFC. After vibration testing, the prototype was scheduled for disassembly and refurbishment to become the backup ATM flight unit [777].

On February 22 Skylab Program Director William C. Schneider outlined the program's progress: "Manufacture is largely complete, test and checkout are progressing satisfactorily, delivery of certain components has occurred with delivery of the remainder in sight, and operating of Skylab in orbit will begin before the end of the coming Fiscal Year."

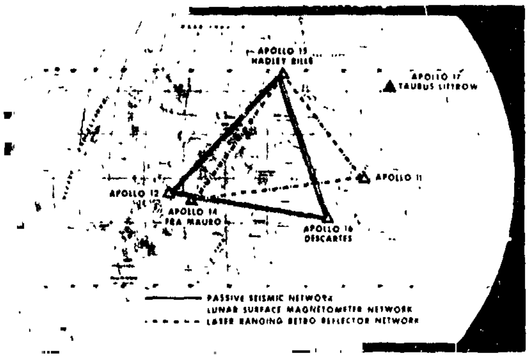
Skylab offered "an Earth observation capability never before available" to U.S. manned spacecraft. During an 8-month mission, Skylab would fly over entire U.S. except Alaska, over much of Europe, all of Africa, Australia, China, and almost all of South America -- covering 75 percent of earth's surface and passing over each point every 5 days. By the end of 1971, 388 investigations requiring Skylab data had been submitted, 249 U.S. and 39 foreign. Of these, 164 had been identified for further study. Skylab was "first manned space flight program designed specifically to carry activities and equipment explicitly aimed at improving man's life on earth. It will contribute significantly to the increase of knowledge of pure science and is also a primitive Space Station, a forerunner of permanent Space Stations of the future." Earth-oriented sensors would test technology for synoptic surveys of many environmental and ecological factors and give preliminary data for management of ecological systems. Solar and astronomical observations and other science experiments would expand knowledge of solar system, universe, and



Apollo 16/AS-511 mission profile



LRV control and display console



Lunar science stations set up during Apollo missions

Astronaut Charles M. Duke, LM pilot for Apollo 16, collecting rock samples in the Descartes area of the moon

Apollo 16 CM descent

Apollo 16 Astronauts John Young, Charles Duke, and Thomas K. Mattingly aboard recovery ship USS Ticonderoga following splashdown in the Pacific Ocean

Sam Hobbs (holding camera), head of the Photographic Lab at the Marshall Center, retired April 18, 1972, after 25 years of federal service. Mr. Hobbs succumbed to a heart attack a few days later.

near-earth space. Biomedical experiments would inform how man's well-being and ability to function were affected by living in space [778].

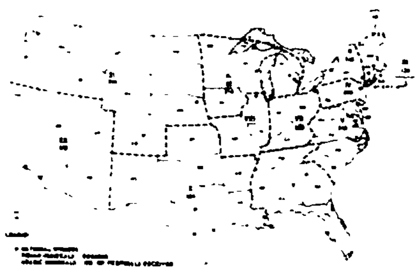
By February 24 deployment tests of Skylab Workshop meteoroid shield were under way at Marshall Space Flight Center. The meteoroid shield, a thin sheet of aluminum wrapped around the outer wall, would protect Skylab crewmen from micrometeoroids and ensure confortable temperature in space [779].

The dedication of MSFC employees and management was indicated in a February 28 letter written by a young engineer to Dr. von Braun:

> On the night of February 9, 1966, Mr. Gillespie and I flew with you and other key MSFC personnel to MSC on the Gulfstream. The purpose of our trip was to make a presentation to MSC on a new program being discussed by NASA entitled the 'S-IVB Spent Stage;' this project eventually evolved into our present Skylab Program. It was a very rough and stormy evening when we took off for MSC, the same night the plane carrying Ryan DeGraffenreid, candidate for governor, crashed because of the bad weather. During our flight I was told to brief you on my presentation, entitled 'Suggested Experiments for the Spent Stage.' I was very nervous, and during my dry run told you that because of time I had not seen my viewgraphs. You just looked at me and said that was okay, just don't tell MSC and do your best. Since that night I have made other presentations where time was critical and have always remembered your advice. On this happy occasion I want to thank you for your help and guidance, and know that you will be helping other young engineers during the years ahead [780].

The U.S. Department of Agriculture began moving approximately 1000 employees into Buildings 350 and 103 at the Michoud Assembly Facility in February 1972. The agricultural department began occupation of 175 000 square feet of Building 350, and the engineering office building, and an additional 20 000 square feet in the manufacturing area, Building 103 [781].

"... We will again be involved in a reduction-in-force to achieve an on-board count of 5341 by June 30, 1972," wrote Dr. Rees to MSFC employees on March 3, 1972. "Based on our current strength, the necessary reduction-in-force will total approximately 190 people. This reduction, together with normal attrition, will bring us to the required 5341 on-board strength on June 30, 1972. Concurrent with the RIF, each NASA Center has been directed to reduce its average grade.... The FY-72 reduction of 190 will be effective June 30, 1972. Notices will be sent to affected employees on or before May 15. Personnel actions for all permanent personnel involving hiring, promotions, and reassignment will be frozen effective March 6, 1972. As I have said in previous letters of this type, this is one of the most unpleasant duties imposed upon me.... unsettled situations like this cause everyone much concern. They give rise to rumors and half truths which can cause unnecessary anxiety.... I ask that all of you continue to carry on our programs in the excellent manner that we have in the past."

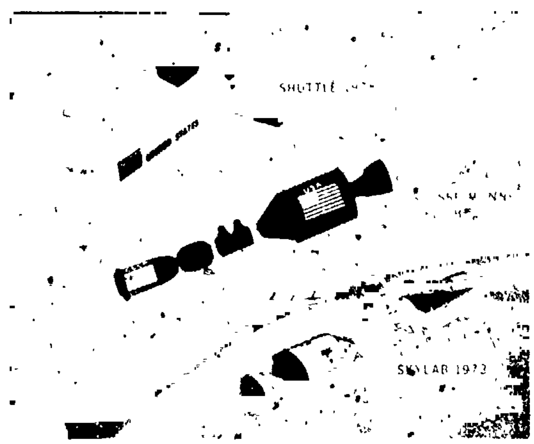


Skylab student experiment project, location of 25 national winners

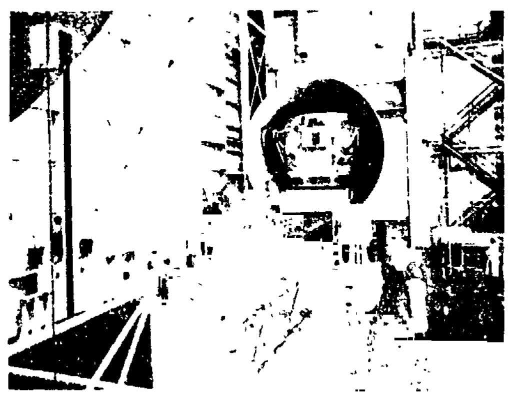
The 25 students whose proposed experiments for Skylab were selected from among more than 3600 submitted posed for a group portrait in the spring of 1972 on the steps of Building 4200. The students were at MSFC for briefings, tours, and discussions with NASA personnel on how their experiments could be set up on Skylab and conducted during the mission in 1973.

In the spring of 1973 a test model of the Command Module arrived at MSFC from JSC for use in the Neutral Buoyancy Simulator. It was used in testing hardware proposed for providing a solar shield around the Skylab.

NASA's first 1973 Skylab flight was on the horizon as the U.S. and U.S.S.R. sign their historic May 24, 1972, space agreement in Moscow



Post-Apollo milestones of the 1970's



ATM flight unit in shipping container in preparation for delivery to MSC

Ten days after Dr. Rees wrote MSFC employees concerning the forthcoming RIF, he felt it necessary to put down a new rumor. "The *Houston Post* published a story on Saturday morning which claims to quote a Manned Spacecraft Center source about a change in Space Shuttle plans which would affect Marshall Space Flight Center employees," wrote Dr. Rees to MSFC employees on March 13. "The story quotes 'the source' as estimating that 1000 MSFC employees will be transferred from MSFC to MSC. I want to assure all of you that no such plans have been made. . . . When the Space Shuttle configuration is decided, and we expect it in the very near future, I will inform you about the extent of the MSFC roles in this program. Until then I intend to regard all reports of Shuttle configurations and personnel impacts as speculation and rumors. I hope you will do the same."

Also on March 13 the MSFC Manpower Office issued a memorandum relative to Civil Service retirement possibilities. The memorandum stated, "The Civil Service Commission had incorporated in the Federal Personnel Manual (Supplement 831-1, Subchapter S-11) a policy and procedure statement providing more flexibility in permitting retirement in situations where those retirements will help meet needed reductions in personnel strength." The memorandum went on to outline the possibilities of early retirement for MSFC employees [782].

Erich W. Neubert, for Dr. Eberhard Rees, sent the following special announcement to all MSFC employees on March 15, 1972: "Because of the high interest in the Shuttle configuration decision, I thought you might like to have your own copy of the information released this morning." The MSFC announcement was as follows:

> NASA announced today that the Space Shuttle booster stage will be powered by solid rocket motors in a parallel burn configuration. The booster stage will be recoverable. Requests for proposals for design and development of the Space Shuttle are expected to be issued to industry about March 17. The booster decision settles the principal question left open for further study at the time the decision to proceed with the development of the Space Shuttle was announced by President Nixon in January. In announcing this decision, NASA Administrator, James C. Fletcher, stated that it means that the Space Shuttle will cost less to develop than forecast in January. Development cost is now estimated at $5.15 billion compared to the earlier estimate of $5.5 billion. While this reduction is accompanied by some increases in the estimated cost per mission, the estimate of $10.5 million for the configuration selected is well within the acceptable range for economical use of the Space Shuttle system, Dr. Fletcher said.

This booster decision settled the principal question left open for further study at the time the decision to proceed with the development of the Space Shuttle had been announced by President Nixon the preceding January. NASA's booster studies since January had shown that both solid and liquid propelled configurations would have been feasible from a technical point of view. Dr. Fletcher's decision was based on the lower cost and lower technical risks shown in the studies for the solid rocket system. At the time of Dr. Fletcher's announcement, schedules called for a Space Shuttle to be

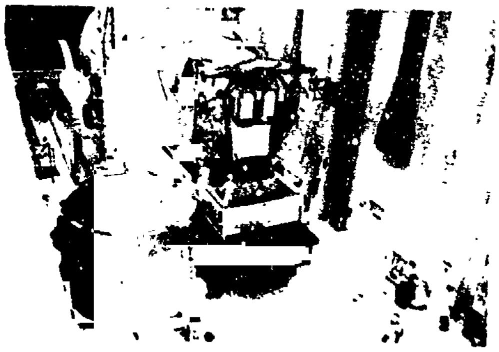
ATM flight unit leaving Quality Laboratory prior to delivery to MSC

Unloading ATM from Super Guppy at KSC

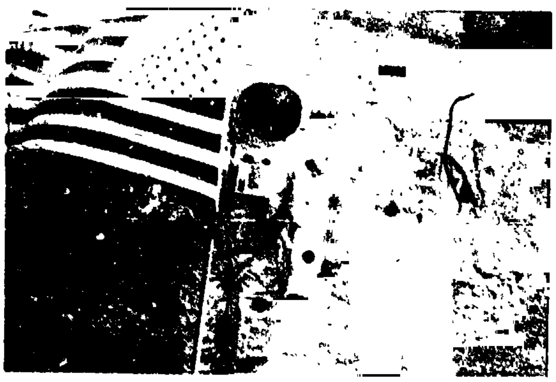
Transfer of OWS, payload shroud, and aft interstage from Point Barrow to KSC dock at VAB

Unloading AM/MDA from commercial Guppy at KSC

Workshop turnover ceremony at MDAC-W (left to right: W. Shapley, C. Weinberger, Dr. J. Fletcher, Dr. E. Rees, W. Burke, and D. Myers)



Removing ATM from transportation container at O&C Bldg



"An you boys be careful, you heah" – Sheriff Joe Higgins of television fame was mighty upset when he heard that a bunch of boys had been speeding to the moon and back, hitting speeds up to 25 000 miles per hour. Striking a familiar pose, he admonishes an "astronaut" that he can get in "a heap of trouble if you ain't careful." Higgins was in Huntsville to promote the Jaycee fair.

developed over the next 6 years. Horizontal test flights would begin in 1976, and manned orbital test flights in 1978. The complete Shuttle system would be operational before 1980. Overall management of the Space Shuttle program would be in the Headquarters Office of Manned Space Flight which would be responsible for detailed assignment of responsibilities, basic performance requirements, control of major milestones, and funding allocations to the various NASA field centers. MSC would have program management responsibility for program control, overall systems engineering and systems integration, and overall responsibility and authority for definition of those elements of the total system which would interface with other elements, such as total configuration and combined aerodynamic loads. MSC would also be responsible for the orbiter stage of the Shuttle. Kennedy would be responsible for design of launch and recovery facilities. MSFC would be responsible for the development, production and delivery of the orbiter main engine, the solid booster, and the hydrogen-oxygen propellant tank. MSFC would also accomplish and/or manage certain Shuttle tasks where the Center would have unique capabilities [783-785].

By March 27 more than 87 946 application forms for participation in the Skylab Student Project had been requested of the National Science Teachers Association, which was managing the activity for NASA. NASA estimated that approximately 50 000 applicants were requesting theses forms. From this number NASA received 3409 proposals. The Skylab Student Project was designed to stimulate interest in science and technology by directly involving U.S. school students in grades 9 through 12. Entries consisted of proposals by students or groups of students for experiments, demonstrations, or activities to be performed by astronauts during Skylab missions in 1973 [786].

"Copies of the MSFC retention register being used to conduct the announced reduction-in-force will be made available to all MSFC employees beginning Monday, April 3, 1972," wrote MSFC's Deputy Director of Management, R.W. Cook, to MSFC employees on March 30, 1972 [787].

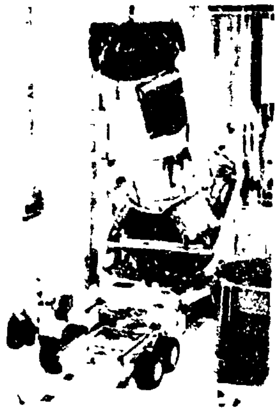
Faced with the continuing problem of the forthcoming RIF, MSFC Director Rees wrote employees on April 3, 1972, as follows:

> The Manpower Office has informed me that late last week the retention registers in connection with our forthcoming directed reduction-in-force had been distributed to all major elements of the Center. This will give employees a chance to learn where they stand in relation to others in the same competitive level. I hope this will serve to resolve some of the uncertainty that many of you have felt. If you feel that the register might be in error in any way, you are, of course, at liberty to call it to the attention of the Manpower Office. It was heartening to learn also from your superiors that despite uncertainties you are doing your customary good job in a most professional way.

On April 3 a new staff office, the Equal Opportunity Office, was established at MSFC, reporting directly to Dr. Rees. Creation of the office was subject to formal approval of NASA Headquarters. Arthur Sanderson, Deputy Director of the MSFC Manpower Office,

It was family day with something for the young and old at the Marshall Center picnic grounds. The Hoyle Beam family (top) had lunch. Kathy Ferrell (bottom) tried to stand up a soft drink bottle.

A nighttime launch of Marshall Space Flight Center's giant Saturn V launch vehicle.



Removing AM/MDA from transporter in O&C Bldg.

Lift-off of Apollo 17 — the final mission in the Apollo Program.

Docking test of AM/MDA to CSM in O&C Bldg.

Apollo 17 astronauts (l-r) Lunar Module Pilot, Harrison Schmitt, Command Module Pilot, Ron Evans, and Commander, Gene Cernan during the rollout of the Apollo 17 rocket.

Apollo 17 Mission Commander Cernan addresses personnel and guests aboard the recovery ship USS Ticonderoga.

Scientist-Astronaut Harrison H. Schmitt was photographed standing next to a huge, split lunar boulder during the third Apollo 17 EVA at the Taurus-Littrow landing site.

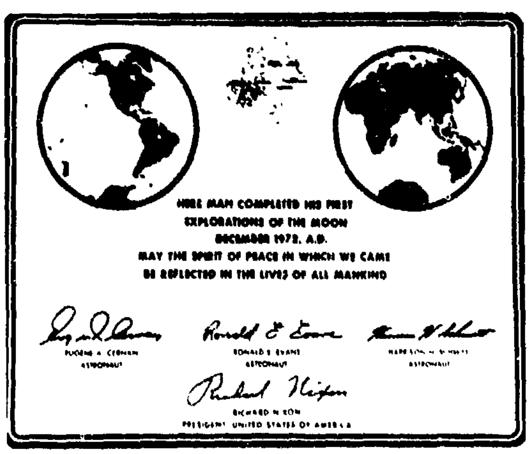
was scheduled to become director of the new office in June 1972, when he returned to MSFC from post-graduate study at the University of Oklahoma [788].

On April 4 NASA awarded a 90-day letter contract to the Rocketdyne Division of North American Rockwell Corporation, Canoga Park, California, for the initiation of development and production of the rocket engine for the Space Shuttle orbiter stage. NASA estimated the value of this letter contract at $9 800 000. The contract would permit work to begin while NASA and Rocketdyne negotiated a cost-plus-award-fee contract for the engine. NASA estimated that the total cost of the negotiated contract would be in the vicinity of $450 000 000. This contract award followed a March 31 decision by the General Accounting Office upholding NASA's disputed selection of North American for this contract [789].

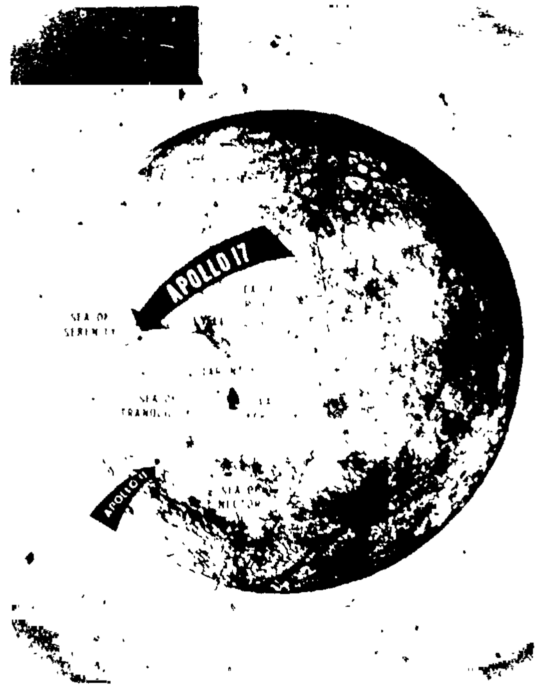
NASA Administrator Dr. James C. Fletcher announced on April 14 the selection of KSC and Vandenberg Air Force Base in California as the sites from which the Space Shuttle would be operated. The initial launch and landing site would be at the Kennedy Space Center. This site would be used for research and development launches, expected to begin in 1978, and for all operational flights launched into easterly orbits. NASA would provide the facilities for all Shuttle utilization at KSC and would do so primarily through modifying the existing facilities used in the Apollo and other programs. The role of Vandenberg Air Force Base in the Shuttle program would begin near the end of the decade with NASA scheduled to phase in the base for Shuttle operations at that time. Shuttle flights from the base would be those requiring high inclination orbits. According to schedules, the Department of Defense would provide the basic Shuttle facilities required at Vandenberg. The Department of Defense had concurred in the decisions announced on this date by Dr. Fletcher. In referring to Dr. Fletcher's decision, the *Huntsville Times* headlined that "Shuttle Bases Were Technical Choices Alone." The Times went on to state that geography, not politics, led to the decision for West Coast and East Coast launch sites. The paper stated that the decision came as no real surprise to those persons who were technically versed, "although during the earlier battle to select a site for Shuttle launchings the label of political favoritism had been loosely bantered about. But the facts are irrefutable that neither Cape Kennedy nor Vandenberg alone would have been satisfactory for launchings. Together they are unbeatable. Two bases, bluntly, are a technical must" [790, 791].

The Apollo 16 mission began on April 16, 1972, and ended 11-days later on April 27 with splashdown in the Pacific. Astronauts for the flight were John W. Young, Charles M. Duke, Jr., and Thomas K. Mattingly. Preparations for the flight had pointed to a highly successful mission. A month earlier NASA Headquarters officials and officials from NASA Centers had attended a successful Flight Readiness Review for Apollo 16 held at KSC. This had been followed by the dry portion of the Countdown Demonstration Test (CDDT), held on March 20, three weeks before the April 16 lift-off. Two days later saw the beginning of the wet portion of the CDDT, and countdown preparations began on April 7, nine days prior to launch. The Apollo 16 mission began at 11:45 a.m. Sunday, April 16, when the Saturn V (AS-511) vehicle lifted off from Launch Complex 39A at the Kennedy Space Center. All three stages performed as expected, and the Apollo spacecraft entered translunar trajectory about 2 hours 35 minutes after launch. The spacecraft transposition and docking took place as scheduled. On their way to the moon

A total of 72 twenty kilowatt Xenon searchlights and 2 sixty kilowatt Xenon searchlight banks producing approximately 225 foot candles of light were set up for the night launching of Apollo 17 from Complex 39. The final lunar landing mission in the Apollo Program was the first mission to require a nighttime launch of the giant Saturn 5 launch vehicle.



This is a photographic replica of the plaque which the Apollo 17 astronauts left behind at the Taurus-Littrow landing site. The plaque is made of stainless steel measuring 9 by 7 5/8 inches, and 1/16 inch thick.



This photo, taken by the Apollo 11 crew on their way home from the moon, shows both the first lunar landing site and the last one in the Apollo program. The first manned lunar landing, Apollo 11 on July 20, 1969, was made in the southwestern part of the Sea of Tranquility. Apollo 17 landed in the Taurus-Littrow area, a combination of mountainous highland and lowlands valley region. This view of the Moon from a distance of 16 000 km was photographed after the Apollo 11 crew had fired their engines on the back side of the Moon to place them in the correct trajectory for return to Earth. Approximately one-half of the Moon's far side (which cannot be seen from Earth) is the lighter shaded, right side of the sphere to the right of the Seas of Crises and Fertility. To the left, of the dotted line, the darker side of the sphere is visible from Earth as the right half of the Moon.

on the first day of their mission, the Apollo 16 crew discovered that some paint was flaking off the Lunar Module. NASA officials at Houston made the decision to allow the crewmen to move into the Lunar Module a day earlier than scheduled to check their landing vehicle. Commander Young reported that the vehicle was operating well. The Apollo 16 crew seemed well on its way to perform its mission that would find Young and Duke driving their Lunar Roving Vehicle about 16 miles on the lunar surface, deploying scientific experiments, photographing lunar landmarks, and returning soil and rock samples for analysis on Earth. Meanwhile, according to schedule, Mattingly would be conducting experiments in lunar orbit while preparing the spacecraft for the return trip home during the 3 days he would spend alone in orbit.

It was on April 20, the fourth day of the Apollo 16 flight, that problems developed that almost aborted the $400 million dollar Apollo 16 mission. It began quietly and routinely soon after 1:00 p.m. Mattingly was running down his check list before firing up his spacecraft engine when he discovered that his backup system for swiveling the 20 000 pound-thrust-engine was not working properly. The spacecraft engine nozzle showed on his cabin indicator that it worked fine enough in the upward and downward motion, but it wobbled from left to right. That was enough to abort the landing at that time, and it sent NASA engineers hurrying to simulators to try and work out the problem on Casper. At North American Rockwell at Downey, California, space scientists hurried aboard simulators there. For more than 4 hours, Mattingly aboard Casper, and Young and Duke aboard Orion, looped the moon in their same positions and waited. Meanwhile, prospects for a lunar landing seemed dimmer by the hour, although space officials refused to give up, but officials were equally determined that they would not send Young and Duke onto Descartes unless there was certainty that Mattingly aboard Casper had both an operative primary and secondary guidance system for his spacecraft engine. However, at 5:55 p.m. on April 20 officials at the MSC Control Room decided that the oscillation was a "limited" one rather than a "divergent" one and would stay within an acceptable maximum of 1 degree, and therefore it was safe to go for the lunar landing.

Duke and Young touched down on the mountain-ranged plateau in the highest region on the front side of the moon at 9:24 p.m. on April 20, and Duke exclaimed, "Orion is finally here Houston! Fantastic!" They originally were to have started their first of three 7-hour excursions 4 hours after touchdown. But the long exhaustive day was taking its toll, and mission control told them to start a sleep period, delaying the exploration until Friday, April 21. During the three EVA's that followed on the moon the astronauts gathered a record 245 pounds of moon rocks, exciting earthbound scientists apparently more than any "moon haul" to date. In addition to their record scientific haul, the astronauts set some kind of a record for animated and intriguing conversation between themselves and Mission Control as they performed three forays of scientific experiments on the moon. They stayed on the moon longer than any previous group - a total of 71 hours 2 minutes. The Lunar Roving Vehicle performed satisfactorily during all three Apollo 16 extravehicular activities. The LRV was driven a total of 3 hours 17 minutes during the more than 20 hours the crewmen spent outside the Lunar Module. The total distance traversed was 16.7 miles. Astronauts Young and Duke reported that a maximum speed of 10.5 miles per hour was achieved while the two men were descending a steep slope around North Ray Crater. The two astronauts lifted off from the lunar surface at 7:26 p.m. on Sunday, April 23. The Lunar Module docked with the Apollo spacecraft at

APOLLO MISSION EMBLEMS– Apollo, the Greek God of the Sun, dominates the emblem designed for the final lunar landing mission in the space program which bears his name. The Apollo 17 crew, in selecting their mission emblem, chose not to emphasize finality but rather the beginning of the golden age of space flight that their flight would usher in. In the emblem, Apollo gazes toward Saturn and a galaxy which symbolixes man's gouls in space will someday include the planets and perhaps even the stars. The crews for the Apollo missions, beginning with Apollo 7 are:

Apollo 7
Cmdr, Walter M. Schirra, Jr.
CMP, Donn F. Eisele
LMP, Walter Cunningham

Apollo 8
Cmdr, Frank Borman
CMP, James A. Lovell, Jr.
LMP, William A. Anders

Apollo 9
Cmdr, James A. McDivitt
CMP, David R. Scott
LMP, Russell L. Schweickart

Apollo 10
Cmdr. Thomas P. Stafford
CMP, John W. Young
LMP, Eugene A. Cernan

Apollo 11
Cmdr, Neil Armstrong
CMP, Michael Collins
LMP, Edwin Aldrin

Apollo 12
Cmdr, Charles Conrad
CMP, Richard Gordon
LMP, Alan Bean

Apollo 13
Cmdr, James A. Lovell
CMP, John L. Swigert, Jr.
LMP, Fred W. Haise, Jr.

Apollo 14
Cmdr, Alan B. Shepard, Jr.
CMP, Stuart A. Roosa
LMP, Edgar D. Mitchell

Apollo 15
Cmdr, David R. Scott
CMP, Alfred M. Worden
LMP, James E. Irwin

Apollo 16
Cmdr, John W. Young
CMP, Thomas K. Mattingly, II
LMP, Charles M. Duke

Apollo 17
Cmdr, Eugene A. Cernan
CMP, Ronald E. Evans
LMP, Harrison H. Schmitt

9:17 p.m. The Apollo 16 crewmen jettisoned their Lunar Module ascent stage at 2:53 p.m. the following day, April 24. Transearth Injection (TEI) occurred at 8:16 p.m. Monday, April 24, as the Apollo 16 spacecraft came from behind the moon. En route home to Earth, Casper's hatch was opened, and Mattingly walked in space and retrieved film cassettes from high resolution and mapping cameras he had operated while orbiting the moon as Young and Duke made their lunar surface exploration. Young, Duke, and Mattingly splashed down in the Pacific on Thursday, April 27, 1000 miles south of Hawaii and just 3300-feet from the carrier *Ticonderoga*. After talking with doctors on board ship, Dr. Charles A. Berry, NASA's director of life sciences, told newsmen in Houston that the three spacemen were in excellent health. "They were in much better shape than the Apollo 15 crew." The physician said that each had lost between 5½ and 7½ pounds and that their heart beats during exercise and other tests on the ship were only slightly elevated. Preliminary reports indicated that the 245 pounds of materials brought home by the astronauts represented perhaps the oldest and most significant samples yet collected on the lunar surface. Locked inside were secrets of how the moon was born more than 4 billion years ago [792-795].

The matter of retirement of MSFC employees received tragic prominence with the death of a popular MSFC employee. Samuel H. Hobbs, 61, head of the Photographic Laboratory at MSFC until he retired on April 28, was honored by about 70 close friends and co-workers at a farewell retirement party a few days before his unexpected death. He had completed 25 years of federal service [796].

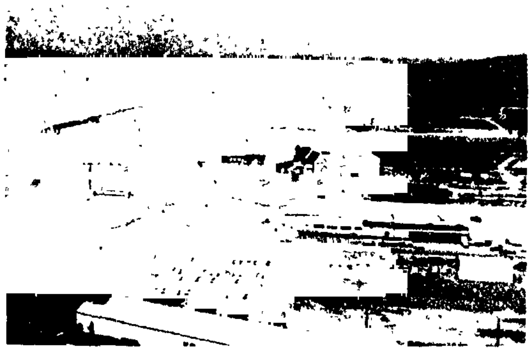
On May 1 MSFC announced completion of the largest solar-cell-array system for electric power ever devised for spacecraft. Two arrays, with almost 236 square meters (2540 square feet) of surface area, would use sunlight to power electrical systems of Orbital Workshop, Apollo Telescope Mount, and other major components of Skylab cluster scheduled for launch in 1973. Each array could provide 10 500 watts of power – more than twice the average level needed for a three-bedroom house – at 328°K (130°F) during the 58- to 69-minute portion of each 94-minute orbit [797].

On May 8 NASA officials met with 25 national winners in the Skylab Student project competition at Marshall Space Flight Center to discuss design of student's space experiments and demonstrations. During the visit students toured MSFC laboratories and the Alabama Space and Rocket Center [798].

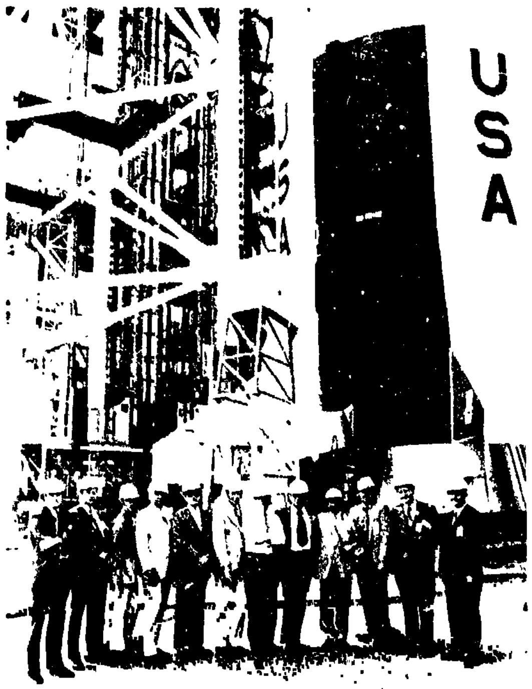
On May 15 Dr. Rees wrote the following to MSFC employees:

> Today it is my most unpleasant task to inform you of the details of the reduction in force required of Marshall Space Flight Center. I have tried to keep you informed of the progress of the RIF in my letters of January 25, March 3, and March 30. . . . The NASA/Marshall Space Flight Center today notified employees of the details of the current reduction-in-force and delivered notices to all who were affected. One hundred and ninety-eight notices of separation were issued. They become effective June 29, 1972. . . . Two hundred and twelve MSFC employees received notices of reduction in grade. This is mainly the result of employees accepting lower grade positions by exercising their rights to "bump" into other

The MARS Women's Club decorated an attractive Christmas tree in the lobby of Building 4200 at MSFC in 1972. Those who spent a day working on the project are (left) Mary Helen Smith and Betty Strickland and on the ladder (from top to bottom) Roberta Landers, Betty Smith, Faye McPeak, and Mary Driver.



Space Orientation Center at Marshall Space Flight Center



NASA officials by SL-1 launch vehicle

> positions for which they are qualified; or "retreating" into positions previously held. . . . I fully realize and deeply regret that affected employees will suffer everything from inconvenience to anguish. I wish it were in my power to change things. I only hope that as a matter of pride and principle you will continue to do your very best work.

On May 19 Skylab statistics were released by NASA. Spacecraft, to be launched by a two-stage Saturn V rocket in spring 1973, would contain 370 cubic meters (13 000 cubic feet) of working and living space. More than 13 000 individual items weighing a total of 5000 kilograms (11 000 pounds) for long-duration space mission would be stowed, including 910 kilograms (2000 pounds) of food; more than 2700 kilograms (6000 pounds) of water; 60 changes of astronaut jackets, shirts and trousers; 210 pairs of shorts; 30 constant-wear garments; 15 pairs of boots and gloves; 55 bars of soap; 96 kilograms (210 pounds) of towels; 1800 urine and fecal bags; 156 rolls of teleprint paper; 104 film magazines; medical kit; 108 pens and pencils; and vacuum cleaner [799].

On May 22 the MSFC Manpower Office reminded personnel, "Employees involved in the current reduction-in-force will be separated on June 29, 1972, and if eligible for retirement, they will receive [a] cost of of living increase" [800].

On May 24 in Moscow, President Richard M. Nixon and Premier Alexei N. Kosygin formally signed a 5-year agreement between the Government of the United States of America and the Government of the Union of Soviet Socialist Republics on cooperation in the fields of science and technology. The Space Agreement included the rendezvous and docking in earth orbit of an American and a Soviet spacecraft and a coordinated effort to explore and share information on space [801].

NASA Administrator James Fletcher and Deputy Administrator George Low joined Apollo 16 astronauts John Young, Thomas Mattingly, II, and Charles Duke, Jr., on June 22 for the presentation of 50 awards at MSFC in connection with last April's successful lunar landing mission. The visitors made short talks and the astronauts signed autographs. Dr. Fletcher and other NASA officials observed Skylab mockups through a viewing port at the Neutral Buoyancy Simulator during the visit [802].

On June 23 the ATM flight unit was delivered to MSC by the Super Guppy aircraft for thermal vacuum testing. A configuration turnover review was conducted prior to delivery [803].

On June 29 the Federal District Court in Washington, D.C., issued a Temporary Restraining Order which had the effect of preventing MSFC from implementing the reduction-in-force scheduled for June 29. The order was issued on the petition of the American Federation of Government Employees [804].

On July 1 Dr. Wernher von Braun, NASA Deputy Associate Administrator, retired from NASA to join Fairchild Industries as corporate vice-president for engineering and development. Dr. von Braun had served as MSFC Director from July 1960 to March 1970 [805].

JULY 1972

As a further indication of budgetary restraints MSFC announced on July 7 that it had received $700K for travel fo the first quarter of FY 1973. "Based on NASA's FY 1973 Budget submission and discussions with MSF representatives, MSFC will be allocated $2.604 million for the year. These levels are far below projected organizational requirements which means MSFC organizational units must institute travel controls now and conform strictly to the attached MSFC travel priorities . . . to assure maximum utilization of travel funds available" [806].

On July 11 MSFC informed its employees that "The Federal District Court, in Washington, late Monday declined to issue an injunction to prevent the Marshall Center from carrying out the planned reduction-in-force. The court dissolved the temporary restraining order issued June 29, 1972, freeing MSFC to continue as previously planned. The RIF actions will be effective at the close of business, July 12, 1972. Those who are being reassigned, or changed to a lower grade, should report to their new organization at the beginning of business, July 13, 1972" [807].

Changes in MSFC's roles and missions as well as increasing budgetary restraints led to realignment of MSFC personnel. MSFC officials announced on July 17 that "The recent changes in Center organization and establishment of new functions will require the relocation of a significant number of employees. Due to the limitations on outside hiring and promotions, the majority of actions would necessarily be within-grade reassignments, although there will be a limited number of opportunities for promotions" [808].

On July 18 the Skylab menu, in addition to being the most palatable menu carried into space, was also designed to meet the requirements and objectives of an important series of medical investigations. There were a number of preflight, inflight, and postflight medical experiments which would be dependent on a detailed, quantitative knowledge of what each crew member consumed throughout his exposure to orbital flight. The food system for Skylab was designed to maintain a calorie level of between 2000 and 2800 calories. It was baselined to provide at least the minimum dietary allowances of protein, carbohydrate, fat, minerals, and vitamins recommended by the National Academy of Science. The menu included such items as tomato soup, scrambled eggs, turkey and gravy, prime rib of beef, lobster Newburg, desserts, and beverages [809].

On July 26 NASA selected the Space Division of North American Rockwell Corporation of Downey, California, for negotiation of a contract to begin development of a Space Shuttle System. This was a major contract award in terms of manpower and money, and the Associated Press aviation writer Vern Haugland headlined his story in papers across the country, "Shuttle Contract to Mean 60 000 Jobs in California." As prime contractor, North American Rockwell Corporation would be responsible for design, development, and production of the orbiter vehicle and for integration of all elements of the Space Shuttle System. The contractor's proposal estimated cost of orbiter development and shuttle integration at $2.6 billion over a period of about 6 years. The contractor's estimate of the cost of the first increment covering a period of approximately 2 years was $540 million. NASA Administrator James C. Fletcher made the selection following an intensive evaluation by NASA of proposals submitted by four major aerospace corporations: Grumman Aerospace Corporation; Lockheed Missiles and Space Company, Inc.; McDonnell Douglas Corporation; and North American Rockwell Corporation. Overall program management responsibility for the Space Shuttle System within NASA would remain with the Office of Manned Space Flight and its Manned Spacecraft Center, Houston, Texas. Project offices would be at MSC for the orbiter vehicle; at MSFC for the shuttle main engine, the external tank, and the solid rocket boosters; and at KSC for the launch, landing, and turnaround operations. NASA estimated that employment generated by the orbiter development and shuttle integration portion of the project would build up to a maximum of roughly 15 000 by 1975 and 1976 and would gradually decrease thereafter [810, 811].

As a followup to its selection of North American Rockwell Corporation for development of the Space Shuttle System, NASA on August 16, 1972, awarded a definitive contract to that firm for development and production of the main engine of the Space Shuttle Orbiter. MSFC's Space Shuttle Main Engine Project Office would manage the project [812, 813].

On September 7 the Skylab Program reached one of its final milestones with the completion of the Orbital Workshop, the main section of the Skylab Space Station. As of this date, the Workshop was ready for shipment to Cape Kennedy from the McDonnell Douglas Astronautics Company, Huntington Beach, California. For the previous several days, NASA inspectors had been busy in California making last-minute inspection of the 9550-cubic-foot Workshop, in final configuration resembling that of a Saturn V moon rocket third stage, which is 22 feet in diameter and 48 feet long. A special ceremony at McDonnell Douglas commemorated completion of this largest manned spacecraft component the U.S. had produced to date, a flying laboratory with a volume equivalent to that of a five-room house [814].

The Communications Division, Management Services Office, on September 14 completed the Huntsville Operation Support Center (HOSC) changeover from the Apollo to the Skylab configuration in support of the Center's mission operation. Estimated cost of equipment involved in this changeover was $1 million [815].

A crowd of more than 3000 MSFC employees, retirees, and their families turned out for the annual MSFC picnic and awards ceremony on September 16, according to Ed House, chairman of the picnic committee. Dr. Rees presented Director's Commendation Certificates to a representative group of award recipients at the awards ceremony [816].

On October 6 the Airlock Module-Multiple Docking Adapter flight units reached KSC onboard the commercial Guppy from MDAC-F in St. Louis. This was the final major piece of Skylab hardware to be delivered to KSC in preparation for the April 30, 1973, launch [817].

President Nixon on October 9 announced a policy whereby the United States would provide launch assistance to other countries and international organizations for satellite projects which were for peaceful purposes and which would be consistent with obligations under relevant international arrangements. Launches would be provided on a nondiscriminatory, reimbursable basis This global launch assurance policy further manifested United States faith that, in the language of the 1967 Outer Space Treaty, ". . . the exploration and use of outer space shall be carried out for the benefit and in the interest of all countries . . . and shall be the province of all mankind" [818].

DECEMBER 1972

Climax of the successful Apollo program came with yet another successful Saturn launch as Apollo 17 (AS-512) rose from the earth on December 7, 1972. Aboard for this sixth and last flight in the Apollo program were Astronauts Eugene A. Cernan (Commander), Ronald E. Evans (Command Module Pilot), and Dr. Harrison H. Schmitt (Lunar Module Pilot and Geologist, the first scientist-astronaut in space). The three astronauts had waited for lift-off during 2 hours 40 minutes of holds at the Kennedy Space Center, Launch Complex 39, Pad A. Reason for the holds had been failure of the terminal countdown sequencer to command pressurization of the S-IVB liquid oxygen tank. But after problem investigation by MSFC personnel, workmen at KSC used a jumper to bypass the interlock, and the rocket once more was space-worthy. Cernan, Evans, and Schmitt left the earth at 12:33 a.m. EST on December 7 as huge Saturn engines illuminated the night sky. An estimated crowd of half a million observed the lift-off from the Cape, and it was also visible to the naked eye as far as South Carolina to the north and Cuba to the south. In addition to the viewers who watched the climactic launch live, there were television viewers nationwide and overseas.

CSM separation from the LM/S-IVB-IU came at 3:42 ground elapsed time (GET), and docking with the LM at 3:47 GET as shown on TV. But docking maneuvers revealed a possible ring latch malfunction when it was discovered that three latches were unlocked. Later, one of the latches was locked by pushing on the handle, and the two others were locked and manually fired to lock the handles. The CSM/LM combination was ejected successfully from the S-IVB stage at 4:45 GET, leaving the S-IVB targeted to strike the moon's surface on December 10, 1972. The planned trajectory of the CSM/LM was modified continually because of the late lift-off, and the coast toward the moon was accelerated to ensure the arrival of the spacecraft at lunar orbit insertion at the scheduled time. Meanwhile, Cernan reported continuing gas pains during private consultation by way of separate radio link with Dr. W. Royce Hankins, MSC Deputy Director for Medical Operations, and was told to continue taking anti-gas pills and to alter his diet.

Evans described the crew's excitement at reaching the vicinity of the moon: "We're breathing so hard, the windows are fogging up." Cernan, who had orbited the moon during the May 18-26, 1969, Apollo 10 mission, described the site as "still just as impressive." The CSM and LM undocked and separated, leaving Evans to orbit the moon as Cernan and Schmitt in Challenger descended to the moon. Challenger touched down at 2:55 p.m. EST December 11. Cernan descended the LM ladder 4 hours later and said, "As I step off at the surface of Taurus-Littrow, I'd like to dedicate the first step of Apollo 17 to all those who made it possible." Cernan unfurled the U.S. flag.

While preparing to traverse to the Apollo lunar surface experiment package site, Cernan inadvertently knocked the extension off the LRV right rear fender, and repairs were made with tape. During two EVA's Cernan and Schmitt visited several lunar stations and deployed explosive packages, obtained photos, and collected and documented soil samples. At Shorty Crater, Schmitt shouted, "There is orange soil! It's all over!" Schmitt described the soil to Mission Control scientists on the ground, and they immediately speculated that the soil might have originated from volcanism on the moon as recently as 100 million years earlier. If so, it would contradict the "dead moon" theory that the moon had always been cold and inert. During EVA-3 by astronauts on the moon Evans, orbiting in the CSM above the lunar surface, identified a series of volcanic domes in Aitken Crater, on the moon's far side.

Before entering Challenger for the last time Cernan and Schmitt uncovered a plaque that read, "Here man completed his first exploration of the moon, December 1972 A.D. [*sic*] May the spirit of peace in which we came be reflected in the lives of all mankind." As the astronauts boarded the LM, Cernan said, "I believe history will record that America's challenge of today has forged man's destiny of tomorrow. And, as we leave the moon at Taurus-Littrow we leave as we came, and God willing, as we shall return with peace and hope for all mankind. God speed the crew of Apollo 17." Total time for the three EVA's was more than 22 hours during which Cernan and Schmitt traveled 22 miles in the LRV, collected 250 pounds of samples, and took 2120 photos. Good quality TV transmission was received throughout the EVA's. The astronauts in the LM lifted off the lunar surface at 5:55 p.m. EST, December 14.

The CSM and the LM docked in lunar orbit, and Cernan and Schmitt rejoined Evans, transferring to the CSM with samples and equipment. During the trip back to earth Evans left the CSM at 3:27 p.m. EST on December 18 for a 1 hour 7 minute inflight EVA to retrieve the lunar sounder film, panoramic camera, and the mapping camera cassettes in three trips. Following that space walk, the astronauts settled down for the final 2 days of the mission. The drogue and main parachutes deployed normally, and the CM splashed down in the mid-Pacific precisely 4 miles from the prime recovery ship *USS Ticonderoga* at 2:25 p.m. EST December 19. A recovery helicopter dropped swimmers, who installed the protection collar and attached a life raft. The astronauts were transported to the recovery ship for post-flight examination. Accomplishments of Apollo 17 included the sixth manned lunar landing and return, first geologist-astronaut on the lunar surface, longest lunar surface stay (74 hours 59 minutes 38 seconds), longest single lunar surface EVA (7 hours 37 minutes 22 seconds), longest total lunar surface EVA time (22 hours 5 minutes 4 seconds), longest total lunar distance traversed with an LRV (22 miles), and most samples returned to earth (250 pounds). Apollo 17 was the 14th and last scheduled mission in the Apollo series and the 11th manned Apollo mission [819-822].

On December 15 the last two ATM flight solar array wings went to KSC from MSFC by Super Guppy. The first two wings went on December 13. These wings were scheduled for installation on the ATM in min-January 1973 [823].

Equal Employment Opportunity continued to receive increasing emphasis at MSFC as elsewhere in the Government. On December 22 MSFC Director Rees wrote to MSFC employees, "This is to inform you that the U.S. Civil Service Commission will begin an evaluation survey of the Equal Opportunity Program at Marshall Space Flight Center on January 8, 1973. The period to be covered in this evaluation will be January 1, 1972, through December 31, 1972" [824].

A major artifacts and exhibits program at MSFC gave way to a new major program in December 1972. The old Space Orientation Center in Building 4471 was renovated into office space to house Skylab contractor personnel. MSFC's Space Orientation Center had been the first major space exhibits center in the South. It was closed after much of the government equipment was moved out of it and placed in the Alabama Space and Rocket

Center outside the Arsenal. The Skylab Program was destined to be MSFC's major program between the Saturn and the Space Shuttle [825].

William Schneider, Skylab Program Director, and a group of Marshall Center officials, headed by Dr. Rees, reviewed the Skylab checkout activity at KSC in early December. In the group were Dr. William Lucas, Hermann Weidner, James Shephard, Leland Belew, Jack Lee, Harry Johnstone, Erich Neubert, Ed Williams, and Richard Smith [826].

1973

MSFC began 1973 faced with new program reductions. On January 5 Dr. Rees wrote MSFC employees, "Quoted below is a statement released by NASA Headquarters today. Your Center management is studying the impact of the adjustments reflected in it to determine their effect on this Center. We will keep you informed." The Headquarters statement referenced by Dr. Rees stated:

> NASA is starting today (January 5, 1973) to make a number of program reductions to adjust its activities in space and aeronautics to a lower spending level. These reductions are necessary as part of all the actions required to reduce total Government spending to the $250 billion target set by the President for fiscal year 1973. . . . The following is a list of major actions being taken by NASA:
>
>> In Manned Space Flight, the manpower buildup on the Space Shuttle will be slowed down, with some resulting delay in the Shuttle's first orbital flight.
>>
>> In Space Science, work on the HEAO project is being suspended for the time being.
>>
>> In Research and Technology, work on nuclear propulsion will be discontinued and work on nuclear power will be sharply curtailed. The Plum Brook station will be closed.
>>
>> In Aeronautics, an experimental Short Takeoff and Landing (STOL) aircraft will be cancelled. However, STOL technology will continue to be developed [827].

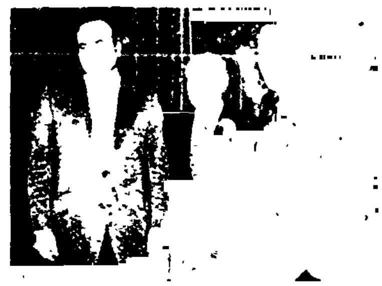
Impending reductions in NASA programs continued to claim attention from MSFC officials. Acting Director David H. Newby wrote on January 10, "The recently announced reductions in NASA programs are being reviewed to determine the impact on the Marshall Center civil service personnel. . . . As previously announced, the Center must reduce to a strength of permanent civil service personnel of 5214 by June 30, 1973. The present Center strength is 5348. This reduction will be obtained through a combination of attrition and reduction-in-force procedures. Whatever reduction-in-force is required is now planned for the month of June 1973. We will keep you advised, as we have in the past, of information as it becomes available that will have a bearing on the future operations of the Center" [828].

MSFC began 1973 with the arrival of its third Director in 13 years. An organizational announcement stated, "Dr. Rocco A. Petrone, currently Director of the Apollo/ASTP Program, Office of Manned Space Flight, becomes the Director of MSFC upon Dr. Rees' retirement on January 26, 1973" [829].

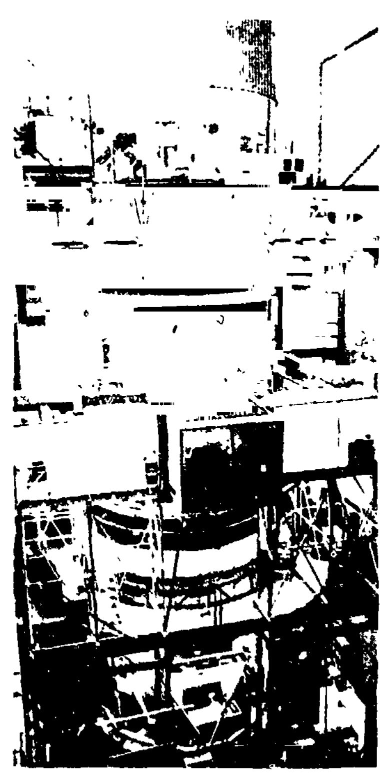
Dr. Rocco A. Petrone succeeded Dr. Rees as Director of MSFC in January 1973

Astronaut Pete Conrad gets some help with his space suit from technicians at the Neutral Buoyancy Simulator at MSFC just prior to entering the big tank for Skylab EVA simulations.

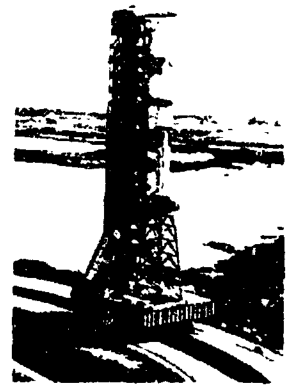
Student experiment ED52 Web Formation (Student Judith Miles next to Dr. Gause, NASA advisor)



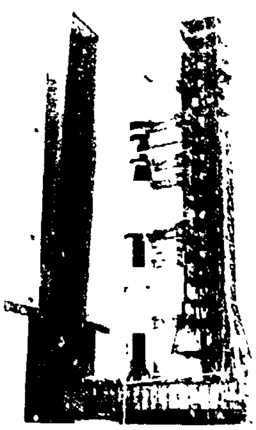
In Huntsville in January 1973 the three directors of the Marshall Center – present, past, and future gathered for a series of consultations and for a retirement dinner for Director Rees From left to right Dr. Rocco A Petrone, Dr Rees, and Dr Wernher von Braun



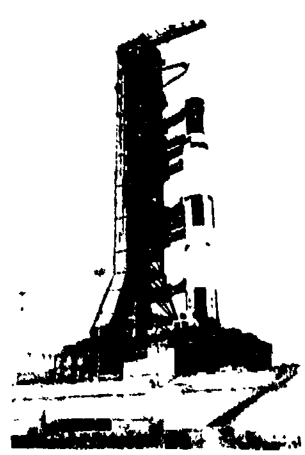
Installations in OWS backup unit at MDAC-W



Rollout of SL-2



Rollout of SL-1 at KSC



SL-1 on launch pad 39A at KSC

An early unpleasant task of new MSFC Director Rocco A. Petrone was dissemination of information concerning the reduction-in-force. Dr. Petrone wrote MSFC employees on January 29, 1973,

> I want to continue the past practice of MSFC management keeping you all informed promptly of conditions, situations, or events which directly affect you. In all cases I want to be sure that you get the straight story officially from management. My only regret is that this first opportunity for communicating with you officially brings unpleasant news. The President presented his Fiscal Year 1974 budget to the Congress at noon today. The NASA portion of the budget is significantly below the 1973 budget. . . . Of more immediate concern to all of us is that the 1974 budget will require a major reduction in the personnel ceiling throughout the agency. To us, it means a reduction in the authorized ceiling for MSFC of 650 personnel spaces by the end of FY 74. This is in addition to the adjustment which must occur this fiscal year in order to reach the personnel ceiling of 5214 by June 30. 1973. Achieving the new FY 74 ceiling will, of course, take advantage of normal attrition from resignations, transfers, and retirements to reduce the number. Additional personnel actions required to reach the new ceiling will be initiated in the second half of FY 74 or between January 1 and June 30, 1974. This will insure that the Skylab Program will be properly supported by the Center as we go into the operational phase of this most important program. I plan on a series of memoranda such as this to keep you currently informed on the subjects of our budget, cost ceiling, and personnel ceilings [830].

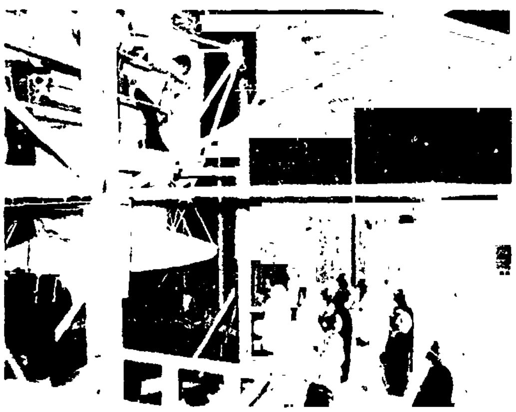
At the February 14 Management Council Meeting it was decided that the SL-1 and SL-2 launches would not meet the April 30 and May 1 launch dates due to delays caused by unexpected checkout activities involving the modules at KSC. Tentative launch dates were set for May 14 and 15, respectively [831].

On February 21 Dr. Petrone informed MSFC employees of the impending visit of Apollo 17 Astronauts.

> On February 21, 1973, the Apollo 17 astronauts will arrive at MSFC to offer their thanks for the support employees provided to the mission. I think this will provide an excellent opportunity for MSFC to pay tribute, in return, for the fine job these three astronauts did in successfully drawing the Apollo Program to a close. . . . MSFC played a major role in providing several pieces of major Apollo hardware and critical support during the Apollo Program. The success NASA has enjoyed from this effort is one in which we can be very proud. An enthusiastic response to the Apollo 17 astronauts will be a fitting end to the program [832].

MSFC Skylab press conference briefing

Part of the press corp in the Neutral Buoyancy Simulator at MSFC during a Skylab press conference



Reporters in engineering mockup area during press conference

There were a number of "old timers" at MSFC by 1973. In April Dr. Rocco A. Petrone presented a certificate for 35 years of service to John C. Goodrum, Advanced Projects Office, Program Development, and 30 year awards to 17 other MSFC employees. Left to right are Dwight J. Locke, Astronautics Lab; Leonard A. Smith, Process Engineering Lab; Hollis B. McElyea, ASTN; William W. Clough, Technical Services Office; Frederick J. Beyerle, PE; Robert E. Smith, Aero-Astrodynamics Lab; Foch P. Bruce, Sr., Saturn Program Office; Edmund F. Ogozalek, Planning and Resources Office; Goodrum; Dr. Petrone; Curtis E. Lee, Quality and Reliability Assurance Lab; James G. Sidick, TSO; Fred L. Moffitt, QUAL; Edward S. Schorsten, Public Affairs Office; Marvin L. Jensen, Astrionics Lab; Owen E. Hitt, Manpower Office; Eugene B. Collier and John D. McLemore, TSO; and Alex F. Dorche, Procurement Office.

An estimated 500 MSFC employees and family members turned out for the 1973 Easter egg hunt at the MSFC picnic area. The Shriner clowns were also on hand to help make the day a success.

The Apollo 17 crewmen, America's last men to the moon in the Apollo program, visited MSFC on February 21 mainly to tell employees about their trip and to say thanks for the role MSFC played. Eugene A. Cernan, Ronald E. Evans, and Harrison H. Schmitt arrived at the Redstone Airstrip, following a visit earlier in the day to the Michoud Assembly Facility. At MSFC the astronauts made brief talks and later signed autographs [833].

On February 26 the SL-2 Saturn IB vehicle was moved at KSC to the LC 39B from the VAB. The vehicle would remain on the pad undergoing final checkout activities until launch [834].

On April 5 the last Student Experiment flight hardware ED31, Bacteria and Spores, for the SL-1 and SL-2 missions was delivered to KSC. The 25 experiments selected to fly in the Skylab mission were [835, 836]:

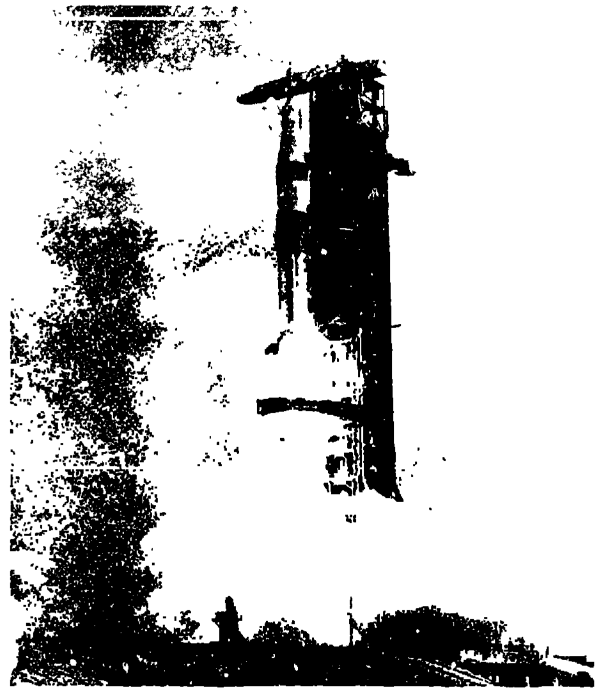
	Experiment	Student	Home
ED11*	Atmospheric Absorption of Heat	Joe Zmolek	Oskosh, WI
ED12*	Volcanic Study	Troy Crites	Kent, WA
ED21*	Libration Clouds	Alison Hopfield	Princeton, NJ
ED22*	Objects Within Mercury's Orbit	Daniel Bochsler	Silverton, OR
ED23*	UV From Quasars	John Hamilton	Aiea, HI
ED24*	X-Ray Stellar Classes	Joe Reihs	Baton Rouge, LA
ED25*	X-Rays from Jupiter	Jeanne Leventhal	Berkeley, CA
ED26*	UV From Pulsars	Neal Shannon	Atlanta, GA
ED31**	Bacteria and Spores	Robert Staehle	Rochester, NY
ED32**	In-Vitro Immunology	Todd Meister	Jackson Heights, NY
ED41**	Motor Sensory Performance	Kathy Jackson	Houston, TX
ED52**	Web Formation	Judith Miles	Lexington, MA
ED61**	Plant Growth	Joel Wordekemper	West Point, NB
ED62**	Plant Phototropism	Donald Schlack	Downey, CA
ED63**	Cytoplasmic Streaming	Cheryl Peltz	Littleton, CO
ED72**	Capillary Study	Roger Johnston	St. Paul, MN
ED74**	Mass Measurement	Vicent Converse	Rockford, IL
ED76**	Neutron Analysis	Terry Quist	San Antonio, TX
ED78**	Liquid Motion in Zero-G	Brian Dunlap	Youngstown, OH
ED33***	Microorganisms in Varying G	Keith Stein	Westbury, NY
ED51***	Chick Embryology	Kent Brandt	Grand Blanc, MI
ED71***	Colloidal State	Keith McGee	Garland, TX
ED73***	Powder Flow	Kirk Sherhart	Berkley, MI
ED75***	Brownian Motion	Gregory Merkel	Springfield, MA
ED77***	Universal Gravity	James Healy	Bayport, NY

* Data only from existing hardware.
** New hardware developed.
*** Could not be developed in time or made compatible to Skylab environment in time. Student reassigned to another experiment.

Dr. James C. Fletcher and Apollo 17 Astronauts Eugene Cernan, Ron Evans, and Jack Schmitt returned to MSFC, this time on April 6 for an Apollo 17 Awards Ceremony. More than 40 MSFC and contractor employees received awards [837].

On April 16 one of the last major milestones prior to launch occurred at 7 a.m. EST, when the United States first space station, SL-1, left the VAB and started roll out to Launch Complex 39A. Final checkout would be continued on the pad until the May 14 launch. The Skylab payload mounted on the first two stages of a giant Saturn V rocket would be launched into a 270 statute mile orbit. Astronauts Charles Conrad, Jr., Paul J.

Crowds at Cape Kennedy observed the first Skylab launch, May 14, 1973.



Skylab astronauts Conrad, Kerwin, and Weitz lift off aboard the Saturn IB rocket from Complex 39B on May 25. Among the cargo was a parasol thermal shield to cool onboard temperatures of the ailing Skylab Workshop. Also included were tools which might be used to free the undeployed solar array.

Personnel in the Huntsville Operations Support Center (HOSC) stayed busy before, during, and after the launches of Skylab I and Skylab II

Dr. William R. Lucas would succeed Dr. Petrone as Director of MSFC in July 1974

Weitz, and Dr. Joseph P. Kerwin aboard a Saturn IB rocket would be launched into space on May 15 for rendezvous and docking to the Skylab [838].

MSFC Director Petrone informed MSFC employees of a new reduction-in-force. On April 23, 1973, he wrote as follows:

> As you know from past announcements, the Marshall Space Flight Center must undergo a reduction-in-force before the end of this fiscal year. Today it becomes my unpleasant task to inform you of the details. I believe the best way of doing this is to give you the attached information which we are releasing today to the news media. . . . "The Marshall Space Flight Center today announced a number of personnel actions necessary to reduce the total onboard count of civil service personnel to 5214 by June 30 of this year. This reduction in manpower at Marshall was assessed in early 1972 and announced to Marshall employees on January 25 of this year. A total of 108 separation notices were [*sic*] delivered to NASA employees this morning. Eighty-seven of these notices affected Huntsville-based employees and 21 were issued at MSFC installations elsewhere. Those leaving civil service positions at Marshall as a result of the reduction-in-force will have their employment terminated June 1, 1973. In addition to the reduction-in-force notices, 67 Marshall employees will receive notices of change to a lower grade. Of these 67, 52 will suffer no reduction in salary for the statutory period of two years. The balance, 15, will lose some salary as a result of the reduction. Reassignment of 57 Marshall employees will be made concurrently with the reduction-in-force. . . . Based on current plans, no additional reduction-in-force for MSFC is anticipated until after January 1, 1974" [839].

MSFC continued its policy of informing employees concerning retirement advantages. On May 2 Manpower Office Director Howell R. Riggs issued Retirement Bulletin 73-5 in which he stated, "A cost-of-living increase of at least 5.4% in the civil service annuities is in prospect for July 1, 1973. . . . If you meet the age in service requirement for voluntary retirement (age 62 or more with five or more years of service; or age 60 or more with 20 or more years of service; or age 55 or more with 30 or more years of service) and wish to take advantage of this increase contact the Retirement Coordinator at 453-3398" [840].

MSFC's phenomenal Saturn V moon rocket that successfully lofted man to the moon nine times – six times for landings – made history again on May 14. It was a triumphant climax to a successful Saturn V program. Saturn V rose from the Kennedy Space Center at 12:30 p.m., Huntsville time, lofting Skylab into a 270-mile, near-circular orbit, inclined 50 degrees to the equator. The Saturn V that launched the burgeoning Skylab flight program was the 13th Saturn V to fly since the Saturn V program began with an unmanned mission in November 1967. In cold storage in case of any future NASA need were the two remaining Saturn V rockets in the 15-Saturn-V flight program. Meanwhile, as Skylab rose into earth orbit on May 14, about a mile away the countdown continued for IB, the Saturn that would carry the crew.

Within an hour, however, after Saturn V's May 14 launch of Skylab, optimism lessened in relation to the mission. The world became aware of Skylab problems when a bulletin from the Associated Press stated that mission controllers at Johnson Space Center in Houston, Texas, "are studying indications that solar panels on the Apollo Telescope Mount or the main panels on the space station have not fully deployed. The solar panels supply all the electrical power to the space station. What effect this might have on the mission, or how the situation might be corrected, is not known at this time."

The bulletin was correct. Telemetry data flowing back to earth from the orbiting laboratory told engineers of serious problems. Trouble had struck just 63 seconds after launch. At the instant of maximum stress and vibration, a girdle of aluminum that was wrapped around the Workshop exterior had ripped off. Normally the aluminum would protect the Laboratory shell from punctures by micrometeoroids, and normally it would also serve as insulating paint to help stabilize temperatures inside the spacecraft. As the shield ripped away, it apparently damaged the mechanism that was to convert sunlight into electricity and thus provide the laboratory with about half its power. With the insulating shield gone, engineers reported that temperatures inside the laboratory were ranging up to 120° Fahrenheit and beyond as it passed from the dark to the sunny side of the earth.

Hard-working space agency officials increased their efforts to find solutions to the problem. One solution to the temperature problem might be for astronauts to envelope the spaceship with a giant sheet of Mylar insulation. This would block heat from the sun and allow the orbiting station to cool off. It was speculated that if the insulation shield was used, the Skylab II crew might have to install it. The tedious operation might require extensive training, and there was time before the Skylab II launch in August for such training. In this event, according to this speculation, the Skylab I flight of Conrad, Weitz, and Kerwin would probably be limited to an inspection trip lasting only a few days. Skylab Program Director Schneider acknowledged in a news conference Tuesday afternoon, May 15, that many options were being considered. Schneider, however, remained optimistic.

May 16 there was much speculation in Huntsville that the mammoth "in-door swimming pool" Neutral Buoyancy Simulator at MSFC might hold the key to salvaging the crippled Skylab space station and making the orbital laboratory habitable for crewmen. Because the Neutral Buoyancy Simulator housed a full-scale mockup of the Skylab station under water, it could be used by the Skylab I crew to learn space walk procedures if they were asked to repair the ripped thermal skin on the station. Director of NASA's Office of Manned Space Flight, Dale Myers, Skylab Director Schneider, MSFC Director Petrone, and MSFC Skylab Manager Leland Belew led teams at MSFC, JSC, and KSC working on the problem. The four involved themselves in in-depth discussions aimed at solving the dilemma.

Astronaut Joseph Kerwin arrived at Redstone Arsenal at 7:00 p.m. on Wednesday, May 16, preparatory to practicing his planned repair job on the sun-seared orbital lab – not in space – but deep under water in the Neutral Buoyancy Simulator. Already trained for a space walk to retrieve film from the station's sun telescope, this first physician slated to fly in space could put his space-walk training to unexpected use. Also arriving at

Redstone Arsenal airport Wednesday evening was backup astronaut Russell Schweickart who arrived in a separate jet at the same time. Kerwin and Schweickart, both under a modified quarantine, departed the Redstone Army airfield, with Schweickart driving a NASA van. The pair immediately was briefed by top space agency experts on the "sun bonnet" planned to be used to shield a portion of the Workshop wall from the sun to lower the desert-like heat inside the station. The astronauts later moved to the Neutral Buoyancy Simulator to inspect the sail-type awning. They were to unfurl it under water in order to place it in proper position on the mockup.

At 12:30 p.m. Thursday, May 17, NASA Assistant Skylab Director John H. Disher informed NASA personnel via closed circuit radio that Saturn IB SL-2 would fly at 8:00 a.m., Huntsville time, May 25, and that aboard SL-3 would be various proposed solutions to the Skylab problem. One of the solution devices accompanying the SL-2 astronauts involved deployment of a rectangular, 22 by 24 foot parasol sun shade, a deployment procedure already being practiced by Kerwin and Schweickart in the Neutral Buoyancy Simulator at MSFC.

By adjusting the unmanned laboratory's position each time that it rotated around the earth, space agency engineers were able to cool the cabin to an average temperature of about 100 degrees.

By May 18 a two-part salvage plan seemed to be the best solution:

1. Try to free the jammed solar panels.
2. Rig a make-shift awning to protect the craft from the sun's heat.

The Skylab Astronauts would have their work cut out for them. The Workshop still did not have its full power-generated capacity. Two of the electricity-producing solar panels still had not deployed. Temperatures inside the craft were still rising, at times reaching the blistering 120° Fahrenheit and beyond [841-843].

Don Lakey of the MSFC Historical Staff was elected to a full 2-year term as President of the Local 3434, American Federation of Government Employees, formed at the MSFC with 1196 members. Lakey thus became the first president of MSFC's largest local [844].

On May 22 NASA officially established a Skylab I investigation board for the purpose of determining the cause or causes of the anomalies that occurred during the launch and initial earth orbit of Skylab I and to recommend appropriate preventive measures for future NASA launches. Bruce Lundin, Director, Lewis Research Center, was named chairman of the board, with other members to be designated subsequently. In the course of this investigation the board would visit MSFC for extensive discussions, review of records, and inspection of equipment and facilities, and other efforts pertinent to the study. To assure maximum coordination of this interchange, MSFC Director Petrone named James T. Shepherd as the MSFC point of contact for the Skylab I investigation board. In this role Shepherd would report directly to the Director, and would have responsibility for arranging the "timely and orderly presentation of all data and verbal testimony and coordinating other matters relating to the investigation as requested by the

Board. Pursuant to the NASA Administrator's directions, and to assure a complete and impartial assessment of Skylab I anomalies, all involved MSFC elements are expected to cooperate fully with Mr. Shepherd in the Skylab I Investigation Board" [845, 846].

Skylab's crewmen had been originally scheduled to blast off on May 15 for a linkup with the laboratory orbited the previous day. But then came the problems with the laboratory. So it was not until May 25 that the first manned Skylab increment followed an ailing SL-1 into space as Saturn IB lofted Skylab Commander Charles Conrad, Dr. Joseph Kerwin, and Paul Weitz upward precisely at 8:00 a.m. Huntsville time. This SL-2 launch was the start of a 17 000 mile-per-hour chase through space to link up with the crippled space station and attempt to salvage the entire Skylab program. The Skylab "repairmen" hoped to save not only their 28-day mission but the two later 56-day missions as well. As this first Skylab crew left the earth, they carried with them the tools and know-how gained from the most historic repair project in the annals of the space program. At MSFC, as throughout NASA, this involved strenuous effort by hundreds of government and contractor employees. At MSFC many hundreds of workers had worked and were working around the clock in an integrated effort to overcome the problems of the Skylab Space Station. Most of the activity was in the development of materials for the proposed solar shields, design of shields, tool development, and mission operations. Active on launch day was a recently activated special task team formed within the Huntsville Operations Support Center (HOSC) at MSFC.

After the 8:00 a.m. launch, a 7½ hour chase through space followed, which ended as astronaut Conrad cited his objective and shouted, "Tallyho, the Skylab." The crew pulled up alongside the crippled space station and surveyed the damage. The meteoroid shield, which also was to serve as a sunshade, was completely ripped away. So was one of the electricity-generating solar panels, leaving severed pipes and wires dangling in space. A second solar panel had swung only about 10 degrees away from the side of the Workshop and appeared to be jammed in that position. The astronauts transmitted color-television pictures of the damage back to the Space Center in Houston, then pulled in behind Skylab for a "soft dock" and dinner.

Conrad then undocked the Apollo craft and flew it alongside the stuck solar panel while Weitz tried to free it with special tools. It did not work. The astronauts returned to the hatch for another docking with Skylab. After Conrad radioed that he could not redock with Skylab, ground controllers radioed advice while the astronauts disassembled the Apollo docking device and "hot-wired" it for another try. As the spacecraft and space station whirled across the earth's night side, Conrad made another try at docking by the light of the Apollo ship's powerful spotlight. He succeeded. After spending the night in the Apollo craft, the astronauts climbed into the Multiple Docking Adapter at 11:30 a.m. Saturday morning, May 26. As soon as they entered the Workshop at 3:30 p.m. Huntsville time that afternoon, they began preparations to unfurl the sunshade that was expected to cool the station down. The deployment of this umbrella-type shade was completed at 8:00 p.m., Huntsville time, May 26. Almost immediately temperatures inside the station, which often had been above 120° Fahrenheit, began dropping. Instead of a rectangular 22 by 24 foot parasol sunshade, however, the parasol took the shape of a trapezoid, and the astronauts said they believed it was deployed about 12 to 14 feet in the back, and perhaps 18 to 20 at the end.

Activation of the Workshop continued as temperatures continued to drop. During the 2 weeks following their May 26 entry into the Workshop, the astronauts began a strenuous program of Workshop repair, experimentation in space, and routine living in space that culminated in a hazardous space walk to free the jammed solar panel outside the Workshop. Problems within the Workshop, stemming from the accident of the jammed solar panel outside, ranged from loss of power to inadequate temperature control. For a while the Workshop was running on just a little over half power. For days, also, the temperature inside the Workshop refused to drop much lower than 80 degrees.

As Workshop problems continued, the astronauts made preparation for their hazardous space walk. Inside the Workshop they went through the "dry run" for freeing the panel, even as Astronaut Russell Schweickart and others at MSFC went through the same simulation in MSFC's Neutral Buoyancy Simulator. Meanwhile, the space riding astronauts went through the routine of daily living, sometimes before the eyes of millions of television viewers. They ate, shaved, and showered. They exercised, bounding sometimes as high as 40 feet up or down, as the case might be. Medical Doctor Weitz took a blood sample from Astronaut Conrad. The astronauts conducted almost all of their scientific experiments as programmed.

On Monday, June 4, top NASA officials, meeting in an all-day review and evaluation session at MSFC, gave a go-ahead for the Skylab crew to attempt an EVA to deploy the stuck solar array hardware. "The EVA would be conducted no earlier than Thursday, June 7," NASA officials announced.

On Wednesday, June 6, there was a full final rehearsal prior to the day of scheduled outside repair. Also at MSFC Astronaut Russell Schweickart and others practiced more in the Neutral Buoyancy Simulator. At the end of Wednesday's "dry-run" practice session, Schweickart and others at MSFC sounded more confident of tomorrow's walk than perhaps did the astronauts aloft in Skylab. But plans for the scheduled walks continued as programmed. Then at 10:30 a.m., Thursday morning, June 7, Huntsville time, Kerwin and Conrad left the Workshop and began mankind's first major repair mission in space. At the end of 2½ hours – at 1:00 p.m. – they had successfully cut the angle iron with their bolt cutter, thus permitting the stuck hardware to approach more normal deployment. The astronauts then went to the ATM to pry open the door on the S0-54 experiment. Approximately 1½ hours after the 1:00 p.m. deployment of the solar wing hardware, the astronauts reentered the Workshop. In a spectacular manner they had performed as nearly as humanly possible mankind's first major repair work in space. Meanwhile, NASA controllers on the ground were maneuvering Skylab so that the sun's rays could thaw the solar wing hardware completely and thus permit complete deployment of the solar array.

During their 28 days in space the Skylab I astronauts became known as the "fix-it" crew. Yet, while they carried out their salvage operation, the astronauts apparently remained in excellent health. Mission commander Conrad told reporters in a June 20 Space-II press conference: "The doctor's may make me eat my words, but I have the feeling that at the end of 28 days, I am going to be in better physical shape than when I came back from any of my first three previous flights." For the first time doctors were able to monitor closely deterioration of muscles and the heart caused by weightlessness. Medical experts expressed surprise concerning how well the crew seemed to have held up in spite of the fact that they had to live in temperatures ranging up to 125 degrees at times.

After a record breaking time in space, 28 days compared to 24 days set by the Soviet cosmonauts in 1971, the Skylab I astronauts splashed down in the Pacific Ocean at 8:59 a.m., Huntsville time, on June 22. The astronauts had traveled 11 million miles and made 395 revolutions around the earth. They had performed the first major repair job in space - the erecting of a sunshield to cool the interior of Skylab, then the dislodging of the jammed panel in a daring space walk, a feat that renewed the power supply of the capsule. Perhaps more than anything else NASA's first "We Fix Anything" astronaut crew had demonstrated the value of man in handling the uncertainties of space travel, giving new hope for manned journeys to Mars and other distant points in space.

Lift-off for the Skylab II crew was scheduled, as of June 30, 1973, for July 27. The Saturn IB rocket that would loft them into space was already poised at its Cape Kennedy launch pad. This second three-man crew would spend 56 days aboard the space station, according to schedule. Then, in October 1973, according to schedules, the third Skylab team would ride another Saturn into space for the final linkup with the Workshop. That flight also was scheduled to run 56 days [847-850].

After the May 14 launch of Skylab, news media began supplying Huntsville area citizens with the time during which they could see Skylab as it crossed the Huntsville sky. Over a period of several months the sighting times varied from day to night [851].

In a June 8, 1973, MSFC Organization Announcement MSFC Director Petrone wrote as follows concerning the current Skylab investigation: "On May 22, 1973, the NASA Administrator established the Skylab I Investigation Board, with Mr. Bruce Lundin as Chairman. On May 31, Mr. James T Shepherd was named as the MSFC point of contact to the Board. Effective June 8, Mr. John C. Goodrum is named as deputy to Mr. Shepherd for the duration of this special assignment."

Because several major components of the Skylab space station were jettisoned in orbit, as planned, these components were still visible on occasions to observers on the ground, MSFC announced on June 15. Flying in similar orbits to the Skylab were the S-II (second) stage of the Saturn V rockets and several shrouds (protective coverings) [852].

As of June 15, 50 MSFC employees had filed retirement applications with the Personnel Office, all to be effective the latter part of the month. Heading the list of retirees was Erich W. Neubert, Office of the Director, MSFC [853].

MSFC informed its employees on June 15, "The Civil Service Commission has authorized NASA to use the Voluntary Retirement – Major Reduction In Force provisions of Public Law 93-39. The authority extends through August 13, 1973. Any employee who is as least 50 years of age with at least 20 years of service, or who has at least 25 years of service, regardless of age may voluntarily retire during this period" [854].

In a June 15 memorandum to MSFC Employees, Director Petrone stated, "The Request for Proposals (RFP) for the Space Shuttle Solid Rocket Motor (SRM) will be released to industry on July 2, 1973. In preparation for the issuance of this RFP which opens the formal competitive phase for the Space Shuttle procurement, all communication with industry concerning the Space Shuttle Solid Rocket Motor will be concluded as of the close of business (MSFC) on Friday, June 15, 1973, effective for all NASA personnel" [855].

At the end of its 13th year MSFC personnel strength was down to 5160 from its peak of 7370 permanent Civil Service employees on April 30, 1965. The Center's authorized personnel ceiling for the end of June 1973 was 5214, but voluntary retirements had helped to lower the personnel figure to 54 below authorization. If the retirement trend continued, it should also help MSFC's personnel problems in 1974 [856, 857].

MSFC ended its 13th year at a time of "belt tightening" in terms of personnel and finance. The Center lacked the financial and personnel clout of the mid-1960's, for example. But, regardless of the current trend, MSFC director Petrone expressed a philosophy shared by many MSFC space veterans who had seen both good times and bad. "We cannot stand still on the frontier of space," in Dr. Petrone's words, "any more than our forefathers could have confined themselves to the eastern Seaboard with the whole continent before them or our ancestors stop at the European shoreline with the vast Atlantic Ocean before them. Civilization cannot exist without new frontiers; mankind needs them both physically and spiritually. What are barriers to some, become pathways to others; and so as we look to the future let us take hope in the fact that other barriers – now seemingly insurmountable – will also fall as long as men continue to dream 'the impossible dream'" [858, 859].

As MSFC's 13th year drew to a close, MSFC's role in the Skylab program drew increased accolades. In early June 1973 MSFC Director Petrone released to MSFC employees the contents of congratulatory letters received from NASA Administrator Fletcher and Frank E. Moss, Chairman, Aeronautics and Space Science Committee, U.S. Senate. In a letter to Dr. Petrone, Dr. Fletcher stated, "Dear Rocco: The work done by the Skylab team in preparing for the launch of Skylab II was absolutely fantastic. This team turned what would have been a very serious failure into an outstanding success. . . ." Senator Moss wrote, "Dear Dr. Fletcher: Please accept for yourself and NASA and convey to the Skylab Director and team including the astronauts who are presently in Skylab my hearty congratulations on the superb job of recovering from what appeared to be a disaster following the launch. . . " [860].

Postscript

Although this chronology ends on June 30, 1973, it seems appropriate to add a few words about Skylab after that date and prior to chronology publication. On July 28, 1973, Skylab II astronauts (SL-3 Second Manned Mission) went into space and after a successful 59-day flight returned safely to earth on September 25. Finally, Skylab III (SL-4) astronauts, in the last flight mission in the Skylab program, rose successfully from earth on November 16. As of January 1, 1974, Skylab III astronauts had successfully completed 6 weeks in space and were scheduled to stay aloft at least until January 11, 1974, (56 days) or possibly as long as February 8 (84 days) before returning to earth to end the Skylab flight missions. The final Skylab mission proved to be the longer one – 84 days.

A final postscript concerns major changes at MSFC subsequent to its first 13 years. On March 5, 1974, NASA announced that Dr. Rocco Petrone would go to Washington to become NASA associate administrator, the agency's third highest ranking official. Replacing Dr. Petrone as MSFC director would be Dr. William R. Lucas. Dr. Petrone would begin his new NASA duties in mid-March, although the official MSFC changeover from Petrone to Lucas was not scheduled until July 1, 1974. Concurrent with the announcement of these major personnel changes at MSFC, NASA also announced a major reorganization of MSFC to become effective May 30, 1974, paralleling an MSFC reduction-in-force that would be effective that date. The Center issued layoff notices to 397 persons and downgrading notices to 259. This new pared-down MSFC work force was considered a more efficient organization for carrying on the future MSFC roles.

APPENDICES

APPENDIX A

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APPENDIX B

ABBREVIATIONS AND ACRONYMS

A

AA	Apollo Applications (Program)
AAP	Apollo Applications Program
ABMA	Army Ballistic Missile Agency
ACE	automatic checkout equipment
AEC	Atomic Energy Commission
AEDC	Arnold Engineering Development Center
AEROJET	Aerojet General Corporation
AF	Air Force
all-systems vehicle	nonflight stage used to check out flight-worthiness of systems
AIAA	American Institute of Astronautics and Aeronautics
ALSA	astronaut life support assembly
AM	Airlock Module
AMR	Atlantic Missile Range
AOMC	Army Ordnance Missile Command
Apollo	Project designation for manned lunar landing, also spacecraft for manned lunar landing
APS	auxiliary propulsion system
ARA	Automatic Retailers of America
AS	Apollo/Saturn (specific payload and vehicle with a number as AS-203)
AS&E	American Science and Engineering
ATM	Apollo Telescope Mount

B

battleship stage	nonflight stage replica for engine tests
BP	boilerplate
"Bug"	Lunar excursion module, landing unit of the Apollo spacecraft

C

C-1	Saturn C-1, early nomenclature for Saturn I
C-3	Saturn C-3, Saturn configuration considered but not used
C-5	Saturn C-5, configuration adopted for lunar Apollo flights (renamed Saturn V in February 1963)
C-IB	Saturn C-IB, vehicle selected in 1962 for manned earth orbital flights with full Apollo spacecraft (renamed Saturn IB)
Cape Canaveral	launch site in Florida, name changed to Kennedy Space Center in 1963
CCSD	Chrysler Corporation Space Division
CBTT	common bulkhead test tank
CDDT	countdown demonstration test
CDR	critical design review
CDT	central daylight time
Chance-Vought	Saturn tank manufacturer, Dallas, Texas
Centaur	vehicle for support of unmanned moon probes and other missions
C^2F^2	crew compartment fit and function test
CM	command module

CMG	control moment gyro
Compromise	later changed to *Promise*—barge transporter for Saturn boosters
CPFF	cost-plus-fixed-fee contract
CPIF	cost-plus-incentive-fee contract
CSM	Command/Service Module

D

DA	deployment assembly
DAC	Douglas Aircraft Corporation
DOD	Department of Defense
Downey	S&ID-SII stage component fabrication and testing facility location
Douglas	Douglas Aircraft Corporation
Dyna Soar	Air Force spacecraft for earth orbital flight featuring "glider reentry"
DX rating	highest national priority

E

ECS	environmental control system
EDS	emergency detection system
EFL	Edwards Field Laboratory
EPCS	experiment pointing and control subsystem
EPS	electrical power system
EREP	Earth Resources Experiment Package

ESE	electrical support equipment
EST	eastern standard time
EVA	extravehicular activity
EVA/IVA	extravehicular and intravehicular activity

F

FAA	Federal Aviation Agency
Fairchild Stratos	meteoroid satellite contractor
FAS	fixed airlock shroud
F-1 engine	Saturn V booster (S-IC stage) engine
FRT	flight rating tests

G

GSE	ground support equipment
GSFC	Goddard Space Flight Center

H

HAO	High Altitude Observatory
HCO	Harvard College Observatory
HEAO	High Energy Astronomy Observatory
HOSC	Huntsville Operations Support Center
H-1 engine	Saturn I booster (S-I stage) engine
High Water Project	SA-2 and SA-3 flight experiment in which water from the Dummy second stage was released into the ionosphere
Huntington Beach	DAC S-IVB assembly site in California

I

IBM	International Business Machines Corporation
IO	MSFC Industrial Operations organization
IU	instrument unit
IVA	intravehicular activity

J

J-2	Liquid hydrogen engine for S-IVB and S-II stages
JPL	Jet Propulsion Laboratory

K

K	thousands
KSC	Kennedy Space Center, in Florida, was Cape Canaveral until November 28, 1963
Kiwi-B	nuclear reactor

L

LaRC	Langley Research Center
LBNP	lower body negative pressure
LC	launch complex
LH_2	liquid hydrogen
LM	Lunar Module
LM-A	Lunar Module ascent stage
LN	liquid nitrogen
LOC	Launch Operations Center

lox	liquid oxygen
Lockheed	Lockheed Aircraft Company
LR-115	first Liquid hydrogen type engine (Pratt & Whitney), early designation of RL 10-A3 engine
LR-119	proposed uprated LR-115 engine (project was cancelled)
LRV	lunar roving vehicle
LSSM	Local Scientific Survey Module
LTV	Ling-Temco-Vought
LV	launch vehicle
LVDC	launch vehicle digital computer

M

McDonnell Douglas Corp.	Douglas Aircraft Company Merged with McDonnell Aircraft Corporation, April 1967, to become McDonnell Douglas Corporation
MAF	Michoud Assembly Facility (formerly Michoud Operations)
MARS	Marshall Athletic Recreation-Social Exchange
Martin	Martin Company
MDA	multiple docking adapter
MDAC-E	McDonnell Douglas Aircraft Corporation, Eastern Division
MDAC-W	McDonnell Douglas Aircraft Corporation, Western Division
ME	MSFC's Manufacturing Engineering Laboratory
Michoud	NASA's Michoud Operations
Minneapolis-Honeywell	Minneapolis-Honeywell, Incorporated name changed to Honeywell, Incorporated

ML	mobile launcher
MMC	Martin Marietta Corporation
MSC	Manned Spacecraft Center (now Lyndon B. Johnson Space Center)
MSFC	George C. Marshall Space Flight Center
MSS	mobile service structure
MSTS	Military Sea Transport Service
MTA	mobility test article
MTF	Mississippi Test Facility (at one time MTO) in Hancock County, Mississippi

N

NAA	North American Aviation, Inc.
NAR	North American Rockwell Corporation (name resulting from merger of NAA, Inc. and Rockwell-Standard Corp., Sept. 22, 1967)
NASA	National Aeronautics and Space Administration
n.mi.	nautical mile
NERVA	nuclear engine for RIFT stage
NOVA	proposed direct flight vehicle to the moon, later cancelled in favor of Saturn V
NRL	Naval Research Laboratory

O

OART	Office of Advanced Research and Technology
O&C	Operations and Checkout Building
OMSF	Office of Manned Space Flight
OSSA	Office of Space Science and Applications
OWS	Orbital Workshop

P

PDR	Preliminary Design Review
P&VE	Propulsion and Vehicle Engineering Laboratory at MSFC
PCS	pointing control system
Pegasus	meteoroid detection satellite
PFRT	preliminary flight rating test
PS	payload shroud
P&W	Pratt & Whitney Company, a division of United Aircraft

R

RAM	Research and Applications Module
R&D	research and development
RCA	Radio Corporation of America
RFP	request for proposals
Rocketdyne	Division of North American Aviation
RIF	reduction in force
RIFT	reactor-in-flight test stage (nuclear power)

RP-1	a kerosene-type fuel
RL10-A3	An engine developed by Pratt & Whitney for the Saturn S-IV stage. The stage was powered by six of these engines which burned lox and LH . The Pratt & Whitney lox/LH_2 engine produced 15 000 pounds thrust.

S

S&ID	Space and Information Systems Division of North American Aviation
SA	solar array
SA	Saturn (with number signifies a specific vehicle as SA-501) that does not have the Apollo command module attached
SAL	scientific airlock
S-I	Saturn I, originally Saturn C-1 first stage
S-II	Saturn V second stage
S-IVB	Saturn V third stage
S-IC	Saturn V first stage
S-IV	Saturn I second stage
SACTO	Douglas Aircraft's Sacramento Test Facility
Santa Susana	test site for S-II and S-IVB stage and J-2 engine
Santa Monica	Douglas Aircraft's fabrication facility at Santa Monica, California
Saturn I	A two-stage vehicle, with eight H-1 engines propelling first stage and six RL-10 engines propelling second stage
Saturn IB	a two-stage vehicle with eight H-1 engines propelling first stage and a single J-2 engine propelling second stage
Saturn V	a three stage vehicle, with five F-1 engines propelling first stage, five J-2 engine propelling second stage, and a single J-2 engine propelling third stage

Seal Beach	North American Aviation Assembly plant at Seal Beach, California
SL	Skylab
SLA	Spacecraft-Lunar Module Adapter
SLCC	Saturn launch control computer
Slidell	a computer center that serves Michoud in Slidell, La.
SM	service module
SOC	Space Orientation Center
SPS	service propulsion system
SRM	solid rocket motor
SSFL	Santa Susana Field Laboratory
SSESM	Spent Stage Experiment Support Module
SSO	Saturn Systems Office
STS	structural transition section
SWS	Saturn Workshop

T

TACS	thruster attitude control subsystem

U

UV	ultraviolet
Uprated Saturn	nomenclature used for S-IB for a short period of time

V

VAB	Vehicle Assembly Building
VCL	Vehicle Checkout Laboratory

APPENDIX C

HISTORICAL SUMMARY OF MSFC

TEXAS TO ALABAMA

After World War II the White Sands Proving Ground had top personnel from Peenemuende, as well as 300 freight car loads of V-2 components. White Sands' flat, isolated desert area, about 125 by 40 miles, also had the world's most massive building in 1946, the firing site blockhouse. Its concrete walls, from 10 to 27 feet thick, could withstand a 2000-mph rocket. The White Sands Proving Ground would be the U.S. center of rocket development for half a decade.

Early in 1946 White Sands readied its first V-2 for launching from American soil, to be followed by about two V-2 launchings a month until the last one on June 28, 1950. Dr. Wernher von Braun and his fellow scientists static-fired V-2 Number 1 on March 15, 1946; V-2 Rocket Number 17, first night firing of a V-2 in the United States, reached a record-setting altitude of 116 miles and a velocity of 600 mph on December 17, 1946. From these early firings came much of the American rocket knowledge of today.

Another pioneer rocket project at White Sands was ORDCIT (Ordnance-California Institute of Technology). This project began when Dr. Theodore von Karman in 1936 organized at Cal Tech a small group of scientists interested in rocketry. Project ORDCIT paralleled the V-2 and other rocket projects at White Sands, producing newer and improved rocket models such as Private, Corporal, Wac Corporal, and the more sophisticated Bumper-Wac. The Bumper-Wac was a multistage vehicle with a V-2 first stage the V-2's nose modified to accommodate a Wac Corporal rocket. Dr. von Braun and other top scientists from Peenemuende, JPL, Douglas Aircraft Company, General Electric Company, and Army Ordnance led in this Bumper-Wac multistage rocketry at White Sands. On February 24, 1949, Bumper-Wac No. 5 sent its upper stage about 250 miles high at a speed of about 5510 miles per hour. This was the highest velocity and altitude yet reached with an object made by man.

Those early days at White Sands Proving Ground were both hectic and historic. One V-2 strayed from its preset path, passed over El Paso, Texas, and disrupted a gay fiesta at Juarez, Mexico, before impacting harmlessly nearby. White Sands operations halted pending adoption of effective safety systems. Despite such growing pains, records achieved at White Sands lasted several years, such as the February 24 Bumper-Wac flight. Without White Sands, or its counterpart, the Explorers and Pioneers might still be on the drawing board.

Fort Bliss officials, seeking improved rocket facilities in September 1949, inspected Huntsville Arsenal, the Army's Chemical Corps installation in Alabama. These officials proposed the transfer to Huntsville of the White Sands rocket scientists and their equipment. On October 28, 1949, the Secretary of the Army approved. By November 1950, 500 military personnel, 130 German scientists, 180 General Electric contractor personnel, and 120 civil service employees had moved from Fort Bliss to Redstone Arsenal. They brought along their rocket scientific equipment. Thus, after traveling 3000 miles from Peenemuende through Texas to Huntsville, the nucleus of the present MSFC group was ready for business at Redstone Arsenal in Huntsville, Alabama, in the fall of 1950.

ARMY BALLISTIC MISSILE AGENCY

At Redstone Arsenal[1] from April 1950 to November 1952 Dr. von Braun was technical director of the Guided Missile Development Group. His group included the team from Peenemuende. In November 1952 that group became the nucleus of the Guided Missile Development Division, with Dr. von Braun as its chief. During these years, prior to the Army Ballistic Missile Agency, the group began research and development of the Redstone guided missile, an outgrowth of the V-2 and General Electric's Project Hermes. To develop a Redstone with 200 miles range the Army awarded North American Aviation's Rocketdyne Division a contract to modify its promising Navaho engine. In 1952 Rocketdyne delivered its first modified Navaho engine to Redstone Arsenal, a Redstone Project milestone. Army personnel began building this and later modified Navaho engines into rocket bodies and nicknamed this rocket the Ursa or Major. On April 8, 1952, the Army officially named the rocket the Redstone, after the Arsenal. In June of 1953 the Army awarded Chrysler Corporation a contract for Redstone research and development. Later in 1953 the Redstone Arsenal missilemen headed by Brig. Gen. H.N. Toftoy and Dr. Wernher von Braun, military and civilian chiefs on the Arsenal, completed fabrication and assembly of the first Redstone. On August 20, 1953, Dr. von Braun's firing personnel at Cape Canaveral, Florida, launched the first flight Redstone. There were guidance problems in this short flight of 8000 yards, but technicians assessed the flight as satisfactory for development purposes. These Redstones were 69 feet long and 70 inches in diameter, weighed 61 000 pounds at launch, and produced 75 000 pounds of thrust at sea level. Yet the Redstone, however small, pioneered this country's man-in-space program.

In 1954 Dr. von Braun published a plan for orbiting an earth satellite. The Army advocated Dr. von Braun's proposal, and requested Naval assistance. Project Orbiter evolved, a joint Army-Navy concept for launching an earth satellite. There was great space interest at Redstone, and satellite proposals accompanying Orbiter were Project Slug and Project Church Mouse. All of Redstone Arsenal's space proposals lost out when the Navy's Project Vanguard won.

However, while Arsenal scientists lost their satellite proposals they won their rocket development. The Jupiter A and the Jupiter C were improved Redstones. The Jupiter A program began at Redstone Arsenal late in 1955, and from it came the famous Jupiter C. With Jupiter C the Arsenal scientists perfected an ablation reentry heat shield principle, one of the von Braun group's major contributions to rocketry. Also, the Army was preparing to launch important space flights with Jupiter C. The first stage of the Jupiter C was an improved Redstone; the second and third stages had solid propellant rocket motors developed by Jet Propulsion Laboratory.

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1. Redstone Arsenal almost began as Sibert Arsenal, named for Army General Sibert. Instead, on August 4, 1941, the Army activated with the name Huntsville Arsenal a Chemical Corps installation occupying almost 40 000 acres southwest of Huntsville. Then on October 6, 1941, the Army activated Redstone Ordnance Plant in conjunction with and geographically adjoining the Huntsville Arsenal chemical installation. Redstone referred to the color of rocks and soil at Huntsville. On February 26, 1943, the Army redesignated the Redstone Ordnance Plant as Redstone Arsenal. On April 1, 1950, with the arrival of the von Braun Group from Texas, the Army merged the old Huntsville Arsenal chemical installation with the small Redstone Arsenal installation and called the 40 000-acre installation Redstone Arsenal.

Scientists or military officers named rockets, sometimes leaving the laymen confused. The Jupiter A and Jupiter C, improved Redstones, preceded Jupiter itself. This borrowing of names resulted from the Arsenal's need to borrow money from other projects to pay for the Redstone.

The Jupiter missile program began on November 8, 1955, when Secretary of Defense Charles A. Wilson authorized the Army to assist the Navy in developing an intermediate range ballistic missile. The Army saw in Wilson's directive a green light for rocket emphasis, and on February 1, 1956, established the Army Ballistic Missile Agency (ABMA) at Redstone Arsenal. The nucleus of this new super-streamlined rocket organization was the former Guided Missile Development Division of the Ordnance Missile Laboratory at Redstone Arsenal, familiarly "the von Braun Group." This group interpreted rocket emphasis to include space flight, and space proposals mushroomed, including Project Man Very High and Project Adam.

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WINS

Following Sputnik I on October 4, 1957, Secretary of Defense Charles A. Wilson directed the Army to prepare to attempt two satellite launchings during March of 1958. Secretary of the Army Wilbur Brucker recommended to Secretary Wilson that the Army launch the first satellite on January 30, 1958, and Wilson accepted.

Within four months after Sputnik I, ABMA's Jupiter C Number 29 on January 31, 1958, sent Explorer I into orbit; bad weather had postponed launching on January 29 and 30. On March 5, 1958, ABMA failed to orbit Explorer II, but on March 26 orbited Explorer III. Jupiter Missile 5, on May 18, 1958, launched America's first tactical reentry nosecone. and within 5 hours the Navy recovered it from the sea. The first completely guided Jupiter flight, Jupiter Missile 6, was successful on July 17, 1958. ABMA orbited Explorer IV on July 26, with four radiation counters aboard. On December 6, still in 1958, ABMA's Pioneer III missed its target, the moon, but set an altitude record of 66 654 miles. ABMA's final important firing of 1958 was Jupiter Missile 13 carrying Gordo, a South American squirrel monkey, though searchers failed to recover the cone or its passenger.

Project Man Very High was ABMA's plan for Army-Navy-Air Force team-work in flying a living passenger and instrumentation "upward a hundred or so miles." Failing to enlist a team, the Army decided to "go it alone," forsook the name Man Very High, and named the Project Adam. Project Adam became ABMA's celebrated proposal for placing a man in space. Project Adam remained earthbound forever, giving way to the National Aeronautics and Space Administration (NASA) and its far-reaching Project Mercury.

Meanwhile, ABMA scientists, though losing their go-ahead for man-in-space projects, were improving their space potential with larger vehicles and larger vehicle proposals ranging from Juno I to June V. On February 3, 1959, the Advanced Research Projects Agency officially named ABMA's Juno V program the Saturn. This was ABMA's most ambitious flight program to date.

ABMA momentum increased in 1959, beginning with Pioneer IV's 37 000-mile miss of the moon before it continued to orbit the Sun. Pioneer IV was this country's first solar satellite. The next ABMA space shot in 1959, on May 28, carried two monkeys, Able and Baker, into and back from space. ABMA's last space shot in 1959, on October 13, orbited complex Explorer VII, the von Braun group's last satellite orbiting before joining NASA.

Throughout 1959 the von Braun group as usual sought more and bigger ways to reach space. Simultaneously the National Aeronautics and Space Administration sought more and more of ABMA. Ironically, NASA in 1958 had asked for, but failed to receive, part of the Development Operations Division of ABMA. In 1959 NASA received, without asking for it, the entire division. Later in this year Secretary of Defense Neil McElroy approached NASA Director T. Keith Glennan about NASA's interest in acquiring ABMA. NASA responded warmly. On October 7, 1959, the White House hosted a high-level "space meeting." As a result NASA fell heir to ABMA's Development Operations Division and the Saturn Project as well.

On January 14, 1960, President Eisenhower submitted a space-team transfer plan to Congress. On March 14, 1960, came Congressional concurrence. Mass transfer of personnel took place on July 1, 1960. Many detailed operating agreements were still to be finalized.

MSFC's FIRST YEAR

July 1, 1960 – June 30, 1961

The George C. Marshall Space Flight Center, named for General Marshall, officially began on July 1, 1960. On that date, in a ceremony in front of the MSFC-ABMA joint headquarters, General August Schomburg formally transferred the agreed-upon missions, personnel, and facilities from the Army to Dr. Wernher von Braun, Director of NASA's new Center. Because most employees continued to work in the same physical area on Redstone Arsenal, the move from the Army to NASA was primarily a "paper transfer."

In the mass transfer, 3989 of 4179 employees left ABMA's Development Operations Division for NASA. Joining these 3989 were 311 employees from ABMA's Technical Materials and Equipment Branch (a warehousing operation). Thus MSFC began with 4670 employees. Then on July 3 MSFC's personnel strength grew to 4900 when 41 more employees transferred from ABMA and 178 from the Redstone Arsenal's Post Engineer Office. After 6 months, MSFC civil service employment was 5367.

MSFC began with 14 staff and project offices: Agena and Centaur Systems, Chief Counsel, Financial Management, Future Projects, Management Services, Operations Analysis, Patent Counsel, Procurement and Contracts, Public Information, Reliability, Technical Program Coordination, Technical Services, Saturn Systems, and Weapons Systems.

It had nine organizations responsible for technical functions. Aeroballistics, Computation, Fabrication and Assembly Engineering, Guidance and Control, Launch Operations Directorate, Quality, Research Projects, Structures and Mechanics, and Test. The Center's major programs when it began operation were the Juno and Saturn, the development of the Centaur launch vehicle, development of the Agena B stage of the Atlas-Agena B and Thor-Agena B boosters, supervision of the F-1 single engine program, and development of the Mercury-Redstone vehicle for NASA's Project Mercury.

Climax of the transfer to NASA was President Eisenhower's dedication ceremony on September 8, 1960. Here with President Eisenhower were Mrs. George C. Marshall, Dr. T. Keith Glennan, Alabama Governor John Patterson, and many other dignitaries. Dedicated was the $100 000 000 MSFC complex occupying 1200 acres.

President Eisenhower praised General Marshall as a "man of war, yet a builder of peace. . . the symbol of renewed hope for scores of millions of suffering people through his great plan for Europe that will forever bear his name." President Eisenhower praised the Army missile and space achievements at Redstone Arsenal and pointed to the scientists who today feel "as if Venus and Mars are more accessible to them than a regimental headquarters was to me as a platoon commander forty years ago."

Highlighting the occasion was the unveiling by Mrs. Marshall and President Eisenhower of General Marshall's bust, sculptured by Kalervo Kallio. The bust, 21 inches high and 18 inches wide, is in red granite. At the date of this chronology publication it was guarding the main entrance of the MSFC Headquarters Building

In MSFC's first payload launching for NASA, Explorer VIII on November 3, 1960, orbited the earth. But on November 21 MR-1 failed at launch because of improper separation of electrical connectors between the launching table and the vehicle. On December 19, 1960, the first Mercury-Redstone, unmanned, flew a suborbital trajectory as scheduled from Cape Canaveral. Then, on January 31, 1961, at Cape Canaveral NASA's Mercury-Redstone MR-2 sent the Chimpanzee Ham on a safe ride 155 miles high and 420 miles down range. But astronaut Alan Shepard's historic ride on May 5, 1961, climaxed MSFC's first year. Shepard went 115 miles high and 302 miles across the ocean, first man in space in NASA's astronaut program.

MSFC's SECOND YEAR
July 1, 1961 – June 30, 1962

On July 1, 1961, an estimated 50 000 visitors at MSFC, including NASA Administrator James E. Webb, celebrated the Center's first birthday. After this auspicious beginning, Mercury astronaut Virgil I. Grissom on July 21, 1961, rode "Liberty Bell 7" in our country's second manned space flight. In the fall of 1961 NASA made two significant facility decisions affecting MSFC. On September 7 NASA selected the Michoud Ordnance Plant near New Orleans as a site for industrial production of Saturn boosters. On October

25 NASA selected the Pearl River site in southwestern Mississippi, 35 miles from the Michoud plant, as a static test area for Saturn vehicles. MSFC would operate both facilities. But probably the most historic date in MSFC's second year was October 17, 1961, when Saturn vehicle SA-1 "on a perfect rocket day" flew as planned, pioneering the historically successful Saturn program. An important administrative decision was NASA's March 7 termination of the MSFC Launch Operations Directorate and establishment of a Launch Operations Center at Cape Canaveral, effective July 1, 1962. Further indication of NASA's expanding programs came later in March when about 60 MSFC management personnel began moving their families to Michoud Operations. When Saturns flew, they apparently flew right. On April 25, Saturn SA-2 left Cape Canaveral for a second successful Saturn flight in a row.

MSFC's THIRD YEAR
July 1, 1962 – June 30, 1963

In the fall of MSFC's third year, on September 11, 1962, President John F. Kennedy, Vice-President Lyndon B. Johnson, and NASA Administrator James E. Webb visited the Center and highly complimented the Center's Saturn program. Then on November 16, Saturn SA-3 flew upward 103 miles and outward 128 miles over the Atlantic Ocean for a third successful Saturn flight mission in a row. On November 28 nine new (second-generation) astronauts, accompanied by three of the original astronauts (John Glenn, Walter Schirra, and Donald Slayton), visited MSFC for a Saturn briefing. Early in February of 1963 NASA changed Saturn names. The Saturn C-I became Saturn I; the C-IB became Saturn IB; and the C-5 became Saturn V. NASA successes climaxed MSFC's third year. On March 28 NASA launched SA-4 for another perfect Saturn launch, the fourth in a row. Further indicating MSFC momentum, some 1200 MSFC employees in late June of 1963 began moving into Building 4200, the Center's new Headquarters Building. This 10-story modernistic building was perhaps a symbol of higher penetration of space.

MSFC's FOURTH YEAR
July 1, 1963 – June 30, 1964

Typically MSFC began its fourth year with expansion. In July 1963 the Army transferred to MSFC 202 acres of land adjoining the existing NASA area on Redstone Arsenal, this latest increment enlarging the MSFC complex to 1786 acres. The following month MSFC completed movement of more than 1000 personnel into the new Headquarters Building 4200. MSFC began calendar year 1964 with the fifth Saturn success in five flights. SA-5 on January 29 was the first Saturn to fly both the first and second stages live. Appropriate to the Center's expanding importance in space, Mrs. Lyndon B. Johnson visited MSFC on March 24. Accompanied by NASA Administrator James E. Webb and other dignitaries, Mrs. Johnson toured MSFC, viewed two static firings, and made three speeches. Then on May 28, Saturn SA-6 rose from Launch Complex 37B at Cape Kennedy, the sixth Saturn success in six flights. SA-6 carried an Apollo spacecraft model into earth orbit for the first time.

MSFC's FIFTH YEAR
July 1, 1964 – June 30, 1965

In its fifth year MSFC scheduled three Saturn flights and otherwise expanded the Saturn IB and Saturn V programs. On September 18, 1963, the Saturn SA-7 continued Saturn's successful record. The S-IV stage, instrument unit, and an Apollo model entered orbit. This seventh Saturn flight transmitted more measurements to earth stations than any previous U.S. spacecraft. Ninety-one "ground cameras" photographed the flight and on the craft were eight more cameras. After ejection from the Saturn these eight fell into the Atlantic; two were recovered and their valuable films studied by scientists.

MSFC began calendar year 1965 with still another successful Saturn flight, the eighth. NASA launched SA-9 instead of SA-8 on this date, February 16, 1965, because SA-9 had progressed through manufacture and testing more rapidly than had SA-8. Thus SA-9 rather than SA-8 orbited the first Pegasus satellite. The Pegasus, still attached to the S-IV stage, deployed its "wings" to a span of 96 feet and began its function of identifying meteoroid punctures. And MSFC neared the end of its fifth year with still another Saturn I success from the Cape. SA-8, on May 25, 1965, carried the second Pegasus meteoroid technology satellite into orbit in a dramatic predawn launch. SA-8 was the ninth successful Saturn I flight. A week later the final Saturn I booster, second one assembled at Michoud Operations, arrived at Cape Kennedy aboard the barge *Promise*.

MSFC's SIXTH YEAR
July 1, 1965 -- June 30, 1966

Saturn I's successful conclusion, and Saturn IB and V progress, highlighted MSFC's sixth year. On July 30, 1965, Saturn SA-10 ended the historic Saturn I program. SA-10 lifted into orbit the third Pegasus meteoroid technology satellite. Saturn I highlights included the largest rocket engines to date and orbiting of the heaviest earth satellites – more than 37 000 pounds on SA-5, SA-6, and SA-7. Hundreds of firms contributed to the Saturn I program. Chrysler Corporation, under contract to build all Saturn IB boosters, also built the last two Saturn I boosters. MSFC designed and built the first eight Saturn I boosters. Douglas Aircraft Company built the S-IV stages. North American Aviation built the engines for the booster, and Pratt and Whitney the engines for the second stage. Major suppliers of guidance equipment included IBM and Bendix. Fairchild-Hiller built the Pegasus satellites.

After SA-10 Dr. von Braun congratulated Center personnel by saying that the Saturn I proved that many of his leading scientists were correct in their "heavy duty launch vehicle theories." NASA Administrator James Webb sent this congratulatory message: "Dr. Dryden, Dr. Seamans, and the entire NASA team join me in congratulating you upon the successful completion of the Saturn I program with the launching of the tenth Saturn I and its Pegasus C payload. The Saturn I marks the first 100 per cent successful NASA launch vehicle program for which you and your associates can justly feel proud."

Appropriately MSFC approached the end of its sixth year with Saturn's most historic flight to date. On February 26 a NASA Saturn IB successfully pioneered a new series of Saturn flights. The Saturn IB lifted a 45 000-pound payload, heaviest launched by NASA to date. As millions watched on television the Saturn IB sent an Apollo spacecraft skyward on a journey 300 miles up and 500 miles out from Cape Kennedy. Over the Atlantic the Apollo's parachute lowered it gently into the Atlantic ocean near its recovery carrier, the *USS Boxer*. Asked about the possibility of flying a manned Apollo/Saturn IB in calendar year 1966, Manned Space Flight Director Dr. George Mueller said, "It is always possible, but the probability is reasonably good that we will fly the first man next year."

MSFC's SEVENTH YEAR
July 1, 1966 – June 30, 1967

Major items in MSFC's seventh year included two Saturn flights, the worst tragedy in the history of the U.S. space program, and a Vice-Presidential visit. The successes came first, and they were landmarks. On July 5, 1966, the 12th Saturn vehicle, AS-203, flew from KSC Complex 37B. AS-203 preceded AS-202 into space in order to allow more time for preparation and checkout of AS-202, which flew successfully from Launch Complex 34 on August 25. AS-202 was the 13th Saturn vehicle in a row to fly successfully through space. The worst tragedy in the nation's space program occurred on January 27, 1967, as a flash fire at KSC swept through the Apollo I spacecraft mated to the SA-204 launch vehicle on LC-34. Three astronauts within the capsule, Virgil I. Grissom, Edward H. White, and Roger B. Chaffee, perished from smoke inhalation. Space optimism at MSFC improved later in the year with the visit of Vice President Hubert H. Humphrey on May 22 and 23, 1967.

MSFC's EIGHTH YEAR
July 1, 1967 – June 30, 1968

Three flights in the Apollo program highlighted MSFC's eighth year. NASA reached a critical point in the Apollo program with the Apollo 4 flight (AS-501) on November 9, an "all-up" mission from Launch Complex 39 at KSC. Apollo 4's flight was the first of the missions designed to qualify Saturn V for manned flight. A Saturn IB followed the Saturn V Apollo 4 flight into space as Saturn IB (AS-204) orbited a lunar module on January 22. This was the first of a series of tests of the LM's ascent and descent propulsion systems, again preparatory to manned space flight. Still another flight leading to manned missions was that of Apollo 6 (AS-502) from KSC's Complex 39A on April 4, 1968. Apollo 6 successfully ended NASA's series of qualification flights preparatory to man in space in NASA's Apollo Lunar Landing Program. The next flight in the Apollo Lunar Landing Program later in the year would be that of NASA's first manned mission.

MSFC's NINTH YEAR
July 1, 1968 – June 30, 1969

A Huntsville tribute to three deceased astronauts, the death of a presidential friend of MSFC, and four flights in the Apollo program were the most significant events in MSFC's ninth year. The close relationship between Huntsville and MSFC and the nation's space program was shown by the Huntsville Board of Education on October 8, 1969, when it deci d to name three new city schools for astrcnauts who died in the Apollo 204 flash fire at Cape Kennedy on January 27, 1967. A new high school would be named for Virgil I Grissom, a junior high school for Edward H. White, II, and an elementary school for Roger B. Chaffee. The four successful flights during MSFC's ninth year were the flights of Apollo's 7, 8, 9, and 10. Apollo 7 on October 11, 1968, was NASA's first manned mission in the Apollo Lunar Landing Program. Manned also was Apollo 8 on December 21, 1968; Apollo 9 on March 3, 1969; and Apollo 10 on May 18, 1969. Meanwhile, during this exciting start of the Apollo manned lunar landing mission the nation went into mourning for a famed fan of the space program, General of the Army Dwight D. Eisenhower, the 34th President of the United States, who died on March 28, 1969. He had dedicated the Marshall Center on September 8, 1960.

MSFC's 10th YEAR
July 1, 1969 – June 30, 1970

On July 20, 1969, man first set foot on the moon, the most important date in MSFC's 10th year and undoubtedly in the history of the space program. From July 16 through July 24 the Apollo 11 manned lunar landing mission flown by NASA achieved an 8 year goal set by President Kennedy on May 25, 1961. MSFC employees joined in a Lunar Landing Celebration at the newly established MARS picnic area at the center, July 26, 1969, celebrating the Apollo 11 achievement by Neil Armstrong, first man on the moon, and his fellow astronauts Michael Collins and Edwin Aldrin. On November 16 mankind's second crew to the moon left the earth, this time in Apollo 12. Aboard were Charles Conrad, Richard Gordon, and Alan Bean. The three Apollo 12 astronauts followed their successful moon mission with a visit to Huntsville on January 8, 1970, where they thanked the many MSFC employees who had helped to make their lunar trip possible. They also established a pattern for astronaut visits to MSFC, a trend followed by subsequent manned Apollo crews. With space hearts palpitating after two successful lunar landings, it seemed appropriate that famed heart specialist Dr. Christian Barnard of the Grotte Shurr Hospital Staff, Johannesburg, South Africa, should visit the Center. On February 25, 1970, Dr. Barnard presented a lecture at the Center and met with Center leaders before touring the MSFC installation.

A strong heart was especially called for in the final Apollo flight in MSFC's 10th year. This was NASA's ill-fated Apollo 13 mission which began with a successful lift-off as scheduled but was nearly aborted during the flight. Various problems included that of inadequate crew temperature. The crew tried different ways to keep from getting too cold: wearing boots carried for walking on the moon, sleeping in the 3-foot-wide tunnel between the LM and the CM, and wearing extra clothing. The Apollo 13 mission objectives were not achieved, but the Apollo 13 flight crew performance proved outstanding throughout the mission and the crew returned safely to earth.

MSFC's 11th YEAR
July 1, 1970 -- June 30, 1971

MSFC's 11th year began and ended on a down note. The not-so-good beginning came on August 14, 1970, when MSFC Director Eberhard Rees informed MSFC employees of a probable major reduction-in-force throughout NASA. This reduction-in-force projection came within a year after NASA had successfully landed the Apollo astronauts on the moon. An international first at MSFC occurred on October 20, 1970, when Russian Cosmonauts Adrian Nikolayev and Vitali Sevastynov, crewmen for the Soviet Soyuz 9, arrived for a two-day visit, accompanied by U.S. Astronaut Edwin Aldrin. The one Apollo flight in this year was that of Apollo 14, the third successful lunar landing mission. The down note ending MSFC's 11th year came with a tragedy felt throughout the space world as Russia's worst space tragedy to date brought death to three Soyuz cosmonauts on June 30, 1971. Speaking for NASA Dr. George Low expressed condolences over the death of the three cosmonauts but stated that it was very unlikely that this tragedy would cause a delay in NASA's Shuttle or Skylab programs.

MSFC's 12th YEAR
July 1, 1971 – June 30, 1972

Highlights of MSFC's 12th year were two of the remaining three flights in the Apollo program. The first of these two remaining flights was that of Apollo 15 on July 26, 1971. Apollo 15 continued the successful lunar landing program, and was followed on April 16, 1972, by Apollo 16, also a successful lunar mission. Meanwhile, personnel reductions were still in the news, and on the next to the last day of MSFC's 12th year, June 29, 1972, the Federal District Court in Washington, D.C., issued a temporary restraining order which had the effect of preventing MSFC from implementing a reduction-in-force scheduled for June 29. The order was issued on the petition of the American Federation of Government Employees.

MSFC's 13TH YEAR
July 1, 1972 – June 30, 1973

Appropriately MSFC's final year in this 13-year summary was climaxed by the end of a major program and with two major new space programs looming larger on the horizon. Space Shuttle, a projected flight program with historic possibilities, made major news on July 26, 1972, when NASA selected the Space Division of North American Rockwell

Corporation of Downey, California, for negotiation of a contract to begin development of a Space Shuttle system. An indication of the projected impact of S : Shuttle came with an Associated Press report that the Shuttle program should eventually mean "Sixty thousand jobs in California." Benefits were predicted throughout the space program. Meanwhile, midway in MSFC's 13th year came the final flight of the Apollo program with yet another successful Saturn launch as Apollo 17 rose from earth on December 7, 1972. Space interests remained high as an estimated cr /d of half a million observed the lift-off from the Cape of this final successful lunar landing mission in the Apollo program. Then on May 14. 1973, the first Skylab flight occurred successfully as a Saturn V lifted Skylab into a 270-mile, near-circular orbit. Skylab's crewmen had been originally scheduled to blast off the next day, May 15, for a linkup with the laboratory orbited the previous day, but then came problems with the laboratory, and so it was not until May 25 that the first manned Skylab i crement followed the ailing SL-1 into space. The continuing Skylab problems taxed the ingenuity of astronauts and echnicians on the ground, but out of this adversity came proof within Skylab in space and on the ground and throughout NASA and contractor installations that mankind has the intelligence and ability to conquer major problems in space.

APPENDIX D

EARLIEST ORGANIZATIONAL CHARTS

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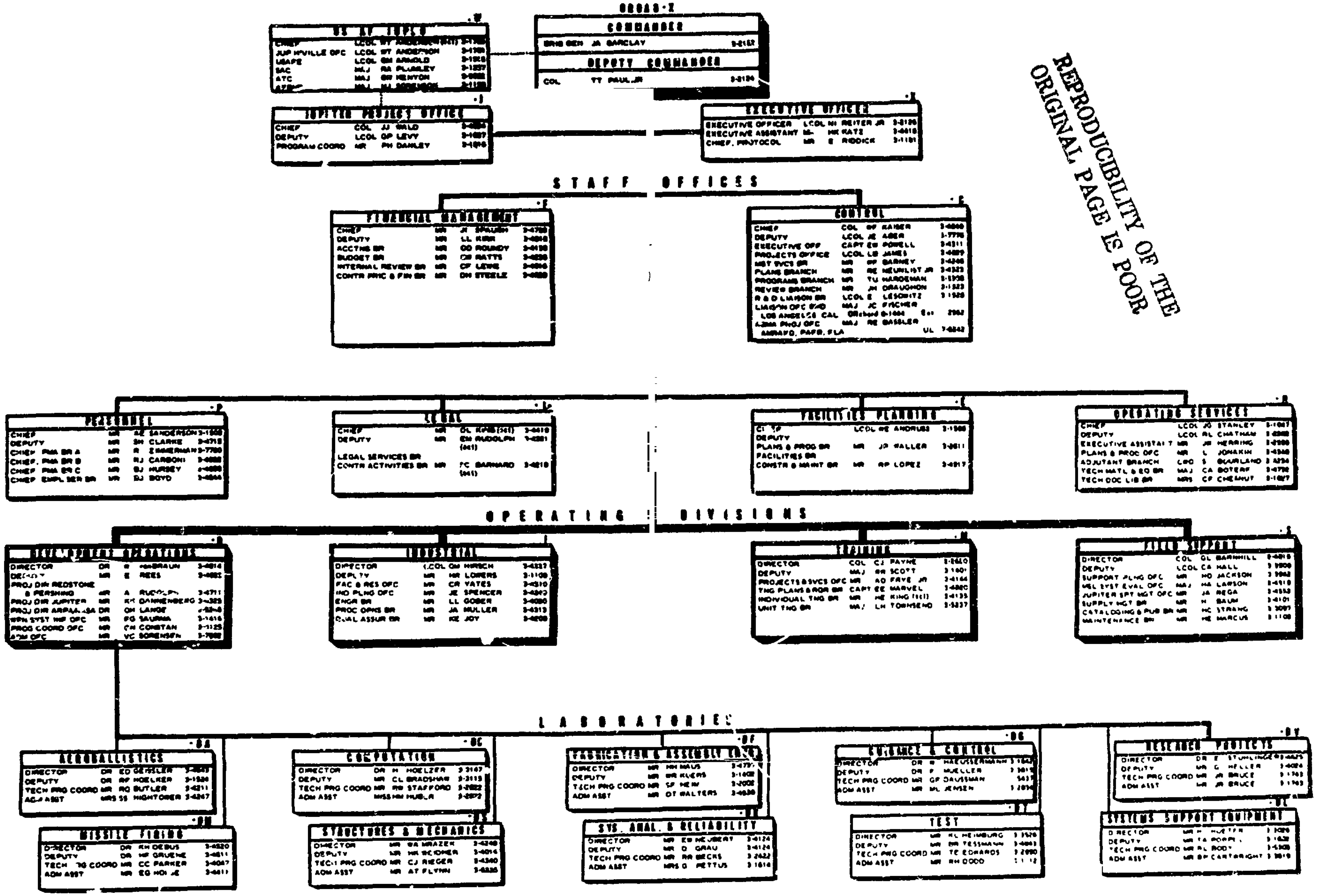
ARMY BALLISTIC MISSILE AGENCY

REDSTONE ARSENAL ALABAMA

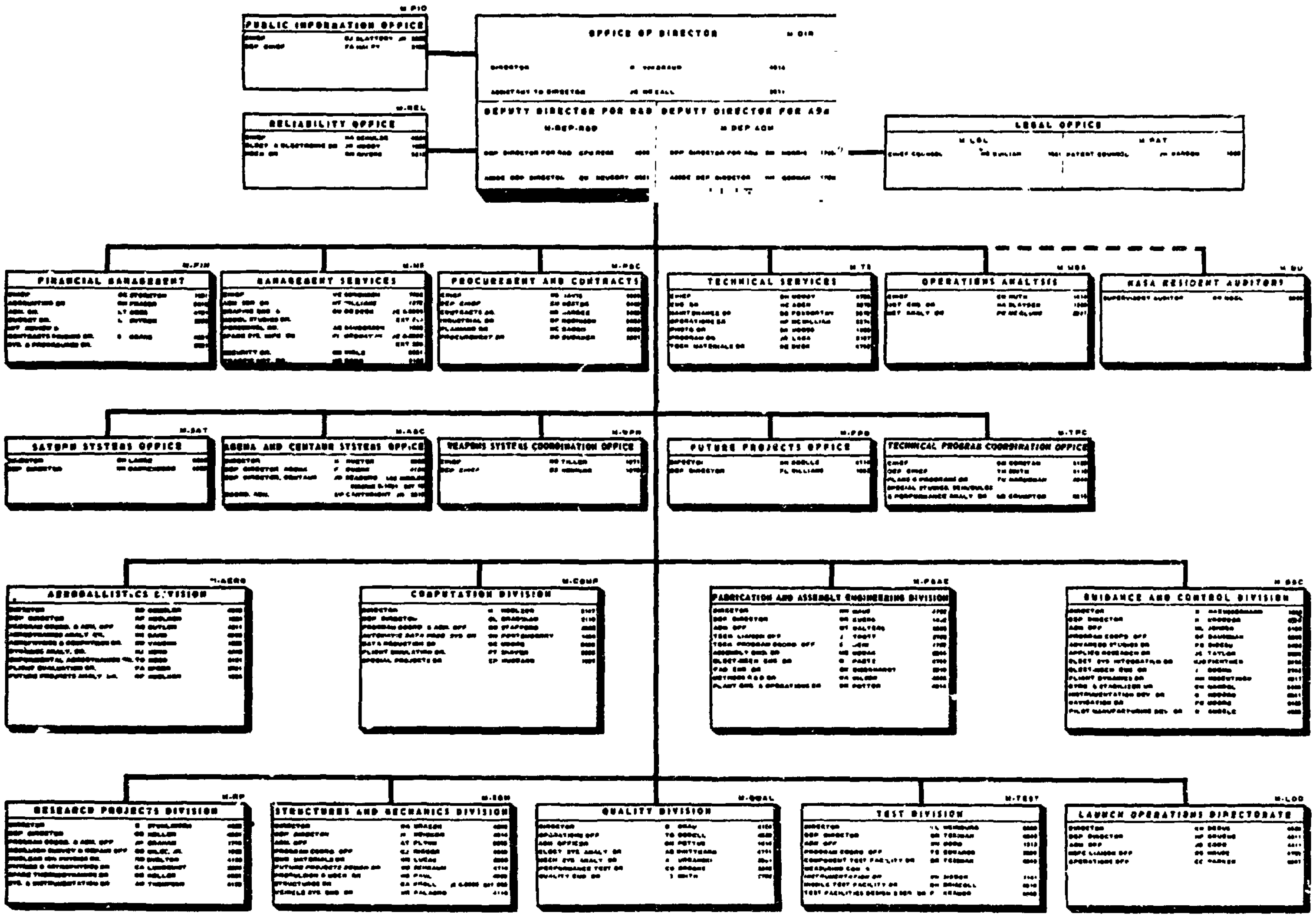
1 JAN 60

TEL: JEfferson 6-4411



GEORGE C MARSHALL SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA



November 28, 1960

APPENDIX E

MSFC's MANPOWER STATUS

AT END OF FIRST YEAR (June 30, 1961)

COMPILED BY:
OPERATIONS ANALYSIS
M-MGA 876-2931

GEORGE C. MARSHALL SPACE FLIGHT CENTER
MANPOWER STATUS SUMMARY
As of COB June 30, 1961

ORGANIZATION	Civil Service						Contractor		
	CEILING	ACTUAL: SUBJECT TO CEILING		ACTUAL: EXCLUDED FROM CEILING		COMMITTED	IN-HOUSE PERSONNEL ONLY AS OF - **		
		ASSIGNED *	POOL	CO-OP	SUMMER		R & D AUTH	R & D ACTUAL	SUPPORT ACTUAL
Director	6	5							
Deputy Director/R&D	5	5							
Deputy Director/Administration	4	4							
Industrial Relations Office	3	4							
NASA Resident Auditors	6	3							
Chief Counsel	7	7							
Patent Counsel	7	7							
Public Information Office	21	18				1			
Operations Analysis Office	16	14							
Financial Management Office	119	104	2	3		7			
Management Services Office	274	255	20	5	3	8			211
Technical Services Office	681	683	2	7	13	4			346
Procurement & Contracts Office	148	142		3		3			
Light & Medium Vehicles Office	85	70			4	5			
Future Projects Office	20	12							
Reliability Office	20	14				1			
Saturn Systems Office	63	52							
Technical Program Co-ord Office	39	35	1						
Weapons System Office	4	4							
Aero Division	245	226		12	19	8	40	40	
Computation Division	135	126		3	7	3	185	185	
F & AE Division	861	845		5	9	4	130	130	
G & C Division	825	809		26	31	10	170	171	
Launch Operations Directorate	500	458	5	8	17	9	156	163	
Research Projects Division	70	57	1	3	5	2			
S & M Division	737	690		13	27	26	275	277	
Quality Division	388	378		14	9	14	153	163	
Test Division	633	610		13	10	1	79	79	
Apprentices	21	20							
MSFC	5943	5657	31			*** 106	1188	1208	
NASA		5688					1189	1208	
Exclusions				115	154				557
Co-ops and Summer	(265)			269					
Consultants and Experts	(6)			7					
Total	(271)			276					
TOTAL MSFC STRENGTH		5964							

*Includes 19 military personnel detailed to Civil Service authorization.
**R&D Auth as of 6/30/61
R&D Act as of 5/31/61
Support as of 6/30/61

***July - 92; Aug - 4; Sept - 7.

MSFC - Form 824 (Rev. June 1961)

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ON DATE OF GREATEST EMPLOYMENT (April 30, 1965)

COMPILED BY:
E-R 876-1343

MSFC MANPOWER STATUS SUMMARY AS OF April 30, 1965

ORGANIZATION	CIVIL SERVICE: VOUCHERED CEILING	CIVIL SERVICE: Permanent Personnel: ON-BOARD PERMANENT	CIVIL SERVICE: Permanent Personnel: ON-BOARD CO-OPS	CIVIL SERVICE: Permanent Personnel: C&E	CIVIL SERVICE: Non-Perm. Personnel: 700 Hr On Bd.	CIVIL SERVICE: Non-Perm. Personnel: Summer On Bd.	CIVIL SERVICE: COMMITTED PERMANENT	BY LOCATION: ON RSA	BY LOCATION: MIC CLINTON ETC.	BY LOCATION: OUTSIDE H'VILLE AREA
Director & Deputies	28	28						28		
Assistant Directors	2	2						2		
Executive Staff	95	83			1		2	84		
Chief Counsel	23	20						20		
Labor Relations Office	5	5						5		
Public Affairs Office	30	30						30		
NASA Audit Office	20	19							12	7
Facilities & Design Office	108	104	3		2		1	107		2
Financial Management Office	197	183	3		3		1	194		
Management Services Office	·210	203			6			176	33	
Personnel Office	99	97		1	14			27	85	
Purchasing Office	224	222	6		31		1	115	144	
Technical Services Office	582	579	2		1			581	1	
UNALLOCATED										
SUB-TOTAL	1623	1580	14	1	58	0	5	1369	275	9
Director, R & D Operations	7	7						7		
Future Projects Office	33	31		1				32		
Resources Management Office	50	44						44		
Systems Office	40	35			1			33		3
Aero-Astrodynamics Lab	360	357	27	11	1		1	384	1	11
Astrionics Lab	944	948	32	2				936	44	2
Computation Lab	177	174	6	1			1	180		1
Manufacturing Engr Lab	832	832	1		2		2	803	22	10
Propulsion & Vehicle Engr Lab	817	828	30	7				748	112	5
Quality & Rel Assurance Lab	629	627	12					535	5	99
Research Projects Lab	99	87	5		1		6	89		4
Test Lab	741	753	19	1				773		
UNALLOCATED	21									
SUB-TOTAL	4750	4723	132	23	5	0	10	4564	184	135
Director, Ind. Opns	18	13						11		2
Sat IB Centaur Ofc	8									
Contracts Office	148	145			12		3	127		30
Facilities Project Office	46	44					1	33		11
Project Logistics Office	15	14					1	14		
Resources Management Office	31	30			2		1	32		
Saturn I/IB Program Office	157	145			5		2	106	6	38
Saturn V Program Office	208	206			5		5	192		19
Engine Program Office	117	110			2		9	78		34
Michoud Operations	282	280	2		2		4			284
Mississippi Test Operations	66	56	4		3		1	12		51
UNALLOCATED	20									
SUB-TOTAL	1116	1043	6	0	31	0	27	605	6	469
TOTALS	7489	7346	152	24	94	0	42	6538	465	613

ON-BOARD STRENGTH BY TYPE:	
MSFC Classification Act	6172
MSFC Wage Board	1444
MSFC Military Details	48

SUMMARY:	PERMANENT	CO-OPS	C&E's	Nonpermanents	Summer	TOTAL	MILITARY
Ceiling	7489	169	0	0	0	7658	
On-Board	7370	152	0	94	0	7616	48.
Committed	42					42	10
Vacancies	77	17		-94		0	

AT END OF 13th YEAR (June 30, 1973)

INTERNAL USE ONLY — Director, Manpower Office

COMPILED BY: A&PS-MA-M, 453-0894

MSFC MANPOWER STATUS SUMMARY

(Release of Manpower data outside MSFC requires approval of A&PS-DIR and DEP-M)

AS OF DATE: June 30, 1973

ORGANIZATION	Target Strg FY-73	Pend. Placement To:	On-Board Civil Service Personnel: Permanent: Total	Permanent: CA & PL	Permanent: WB	Non-Permanent: Total	Co-op: Prof.	Co-op: Voc	Temp	Pub Svc	Summer	S. Aide	C&E	Committed	LWOP	Military	By Location Estimated: On MSA	In HSV Area	Outside HSV Area
CENTER DIRECTOR	17		16	16		1	1							1			15		2
STAFF OFFICES:																			
Associate Dir. for Science			6	6													6		
Chief Counsel			11	11													11		
Public Affairs Office			18	18		4	2		1			1					22		
Equal Opportunity Office			10	10		1			1						1		11		
Safety & Manned Flight Award			21	21													21		
SUB-TOTAL STAFF	74		66	66	0	5	2	0	2	0	0	1	(0)	0	1	0	71	0	0
COMMUNICATIONS PROGRAM	0		2	2	0	0	0	0	0	0	0		(0)	0	0	0	2	0	0
Dir., Administration & Program			8	8													8		
Patent Counsel			6	6													6		
Technology Utilization Office			8	8													7		1
Shuttle Construction Office			10	10												1	8		2
Center Plans & Resources Cont		(1)	65	65		1						1					66		
Facilities Office			46	46		7	5		1			1					53		
Technical Services Office			352	334	18	15	4	7	1			3			3		367		
Management Services Office			118	105	13	10	5		2			3					128		
Financial Management Office			111	111		9	7		1			1					120		
Procurement Office			262	262		9	4		3			2			2		256		15
Manpower Office			81	81		16	4		2	9		1		1	1		97		
Logistics Office			6	6													6		
Slidell Computer Complex			8	8		3	1		2								0		11
SUB-TOTAL A&PS	1110	(1)	1081	1050	31	70	30	7	12	9	0	12	(0)	1	6	1	1122	0	29
Dir., Program Development			10	10													10		
Management Support Office			6	6		6			5			1					12		
Program Planning Office			29	29		1	1										30		
Advanced Systems Analysis			33	33		1	1										34		
Mission & Payload Planning			32	32		2	2									1	34		
Preliminary Design Office			91	91		7	7								1		98		
Advanced Projects Office			68	68													68		
SUB-TOTAL PD	240		269	269	0	17	11	0	5	0	0	1	(0)	0	1	1	286	0	0
Dir., Science & Engineering			12	12													12		
Planning & Resources Office			21	21		3			2			1					24		
Systems/Products Office		(1)	84	84													81		3
Research Planning Office			19	19		1						1					20		
Environmental Applications			12	12		1						1					13		
Astrionics Laboratory			598	598		15	13					2			3		613		
Astronautics Laboratory			745	743	2	18	16					2			7		757		6
Quality & Reliability Assurance		(1)	389	386	3	6	4					2			7		319	4	72
Process Engineering Laboratory			587	582	5	21	5	10	2			4			2	10	603		5
Computation Laboratory			150	150		8	5					3					157		1
Aero-Astrodynamics Laboratory			251	251		20	16					4					271		
Space Sciences Laboratory			154	154		20	19					1		1			167		7
SUB-TOTAL S&E	3097	(2)	3022	3012	10	113	78	10	4	0	0	21	(0)	1	19	10	3037	4	94
Mission Operations Office	50		48	48		1						1					41		8
Skylab Program Office	188		186	186		5	2		3								176		15
Space Science Projects Office	64		64	64		1			1								64		1
(HEAO)			(64)	(64)		(1)			(1)								(64)		(1)
Shuttle Projects Office	129	(6)	118	118		4			2			2					110		12
Saturn Program Office	171		163	163		3			1			2					97	4	65
(Michoud Assembly Facility)			(43)	(43)		(1)			(1)								0		(44)
SUB-TOTAL P/PO	602	(6)	579	579	0	14	2	0	[illegible]	0	0	5	(0)	0	0	0	488	4	101
MISSISSIPPI TEST FACILITY	70		70	70	0	1	1	0	0	0	0	0	(0)	0	0	0	0	0	71
PENDING PLACEMENT			9	9	0	0	0	0	0	0	0	0	(0)	0	0	0	9	0	0
TOTAL	5214 1/	(9)	5114	5073	41	221	125	17	30	9	0	40	(0)	3	27	12	5030	8	297

SUMMARY	Permanent: CA & PL	Permanent: WB	Non-Permanent: Co-op Prof.	Co-op Voc	Temp.	Public Service	Summer	S. Aide	C&E	Total Civil Service	Mil	LWOP	LWOP
CEILING	5214		127	25	32	10	0	75	(0)	5483	20	CA & WB	27
ON-BOARD TOTAL	5073	41										Co-op Prof	130
	5114		125	17	30	9	0	40	(0)	5335	12	Co-op Voc	12
VACANT	-100		-2	-8	-2	-1	0	-35	(0)	-148	-8	C&E	(4)
COMMITTED	3		0	0	0	0	0	0	(0)	3	0	TOTAL	
DIFFERENCE	-97		-2	-8	-2	-1	0	-35	(0)	-145	-3		169

AVERAGE GRADE	
DIR	9.5833
Staff	10.8125
A&PS	9.3473
PD	11.98[illegible]
S&E	11.2929
P/PO	11.8833
MTF	11.1014
CENTER	10.9784
Pending Placement	12.4444

		DIR	STAFF	A&PS	PD	S&E	P/PO	MTF	CENTER
AVERAGE SALARY	GOV PLANNING	-	-	-	-	-	-	-	$19,440
	ACTUAL	$17,221	18,850	16,291	22,293	19,908	22,372	19,615	19,550
2/ GS-14, 15, & 16	ACTUAL	3	18	102	97	589	222	13	1049

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1/ 4 IN DIRECTOR'S RESERVE.

2/ CENTER TOTAL INCLUDES 5 PENDING PLACEMENT.

APPENDIX F

REPRESENTATIVE PERSONNEL CHARTS

PRECEDING PAGE BLANK NOT FILMED

MARSHALL SPACE FLIGHT CENTER

PERMANENT CIVIL SERVICE AND CONTRACTOR MANPOWER DISTRIBUTION BY LOCATION

	7/15/60	FY-61	FY-62	FY-63	FY-64	FY-65	FY-66	FY-67	FY-68	FY-69	FY-70	FY-71	FY-72
Perm. Civil Service													
Huntsville Area	4824	5688	6469	6394	6749	6705	6594	6495	5918	5671	5578	5454	5098
Outside Huntsville	-	-	64	427	572	622	683	682	522	478	416	306	279
Subtotal	4824	5688	6533	6821	7321	7327	7277	7177	6440	6149	5994	5760	5377
Support/FOC Contractor													
Huntsville Area	1019	2440	3588	5808	6313	5895	5316	5087	4671	3213	2993	3048	3116
Outside Huntsville[a]	-	-	360	720	949	1741	2842	2559	2170	1790	1662	1213	1161
Subtotal	1019	2440	3948	6528	7262	7636	8158	7646	6841	5003	4655	4261	4277
Major Prime Contractor													
Huntsville Area[b]	-	1000[c]	2705[c]	4410[c]	6115[c]	6818	8116	6517	4755	3165	2393	2042	2122
Outside Huntsville	-	4100	8095	19690	23885	30082	31284	25183	18245	14952	10403	7416	6996
Subtotal	-	5100	10800	24100	30000	36900	39400	31700	23000	18117	12796	9458	9118
Total Manpower													
Huntsville Area	5843	9128	12762	16612	19177	19418	20026	18099	15344	12049	10964	10544	10336
Outside Huntsville	-	4100	8519	20837	25406	32445	34809	28424	20937	17220	12481	8935	8436
Grand Total	5843	13228	21281	37449	44583	51863	54835	46523	36281	29269	23445	19479	18772

a. End of Period Headcount except Michoud & MTF
b. From PM Qtly Rpt
c. Estimated   Data not available

MARSHALL SPACE FLIGHT CENTER

CIVIL SERVICE MANPOWER DISTRIBUTION BY PROGRAM (END OF FISCAL YEAR)

	7/15/60	FY-61	FY-62	FY-63	FY-64	FY-65	FY-66	FY-67	FY-68	FY-69	FY-70	FY-71	FY-72
Adm and Inst Support	983	1230	1495	1566	1645	1644	1585	1493	1309	1276	1316	1273	1191
SRT and Other	799	694	762	699	555	381	454	565	500	689	742	799	870
Apollo	3042	3764	4276	4556	5121	5302	5197	4593	3414	2162	1401	813	421
Skylab							41	526	1217	2022	2229	2121	2042
Space Station											146	165	305
Space Shuttle											160	540	505
Work for Other Agencies												44	43
Total	4824	5688	6533	6821	7321	7327	7277	7177	6440	6149	5994	5760	5377

MARSHALL SPACE FLIGHT CENTER

AVERAGE AGE OF PERMANENT EMPLOYEES

	FY-68	FY-69	FY-70	FY-71	FY-72
MSFC	40.4	41.4	42.3	42.8	43.4
MSC	36.1	37.2	38.2	38.8	39.8
KSC	39.0	39.8	40.8	41.4	42.1
GSFC	38.3	38.4	39.0	39.2	40.2

MARSHALL SPACE FLIGHT CENTER

CIVIL SERVICE MANPOWER

PERMANENT BY TYPE

	7/15/60	FY-61	FY-62	FY-63	FY-64	FY-65	FY-66	FY-67	FY-68	FY-69	FY-70	FY-71	FY 72	FY-73
GS	2732	3835	4775	5192	5783	5859	6000	6071	5563	5437	5710	5673	5297	5114
Wage Board	2055	1805	1704	1576	1482	1428	1239	1066	836	672	246	51	43	41
Excepted	37	48	54	53	56	40	38	40	41	40	38	36	37	34
Total Perm.	4824	5688	6533	6821	7321	7327	7277	7177	6440	6149	5994	5760	5377	5189
Military	8	19	25	31	46	44	32	26	22	16	12	10	13	12

APPENDIX G

MSFC FUNDING

MSFC FUNDING

Fiscal Year	Funding Levels (in millions of dollars)
1961	$ 378.7
1962	630.8
1963	1159.9
1964	1591.2
1965	1701.6
1966	1688.2
1967	1471.8
1968	1213.0
1969	682.6
1970	853.6
1971	761.7
1972	754.7
1973	612.5
1974 (Budgeted)	440.6

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