

THE APOLLO SPACECRAFT

A CHRONOLOGY

VOLUME III

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

THE APOLLO SPACECRAFT

A CHRONOLOGY

VOLUME III

October 1, 1964—January 20, 1966

by

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FOREWORD

This third volume of the Apollo Spacecraft Chronology covers the sixteen-month period from October 1, 1964, to January 20, 1966. During this period the major emphasis of the program was on the detailed engineering of the three spacecraft being manufactured by North American and Grumman. All major decisions had been made and now within the confines of these decisions spacecraft must be designed and built that would safely provide transportation for men and equipment to the lunar surface and back. One of the most confining of these decisions was the agreed-upon payload of the Saturn V. It was initially agreed that the design allowable weight for the Apollo spacecraft was 90 000 pounds. Included within this were the Command and Service Module, the Lunar Excursion Module, and the adapter structure. Although some relief was obtained when the conservatism in the Saturn V design was converted into additional useful performance, spacecraft weight was a continual concern in the Apollo program. This was particularly true during the period reported upon in this volume; concepts were being translated into hard design and the solution of numerous details took their toll in an upward revision of weight estimates. Weights were reported weekly in an attempt to curtail and control weight growth. Programs were instituted to reduce weight by the elimination of nonessential "niceties" and, when practical, by redesigning elements to lighter weight.

Work on the Command Module had progressed to the point where some full-scale testing was initiated. The launch escape system was tested for off-the-pad aborts at White Sands, New Mexico. A special test vehicle, "Little Joe II," built by Convair, San Diego, was employed at WSMR to accelerate the Command Module to "maximum q" conditions for tests of the launch escape system under this most difficult situation. At El Centro, California, the parachute system was undergoing extensive testing. Back at Downey, California, North American built a large trapeze-like structure over an artificial lake to certify the Command Module structure for water impact loads. At yet another site, the White Sands Test Facility, located on the other side (west) of the Organ Mountains from the Little Joe II launch area, the testing of the Service Module propulsion system and the ascent and descent propulsion stages for the Lunar Module was started. As might be expected in the initial development testing of advanced design hardware, a number of disappointing failures were experienced. For instance the Command Module structure ruptured and the test article sank during the first water impact test.

Considerable analytical and experimental work was underway on

engineering problems associated with landing the LEM on the Moon. Landing loads and stability were studied by dropping dynamically scaled models on simulated lunar soil and by computer runs which utilized mathematical models of both the LEM and the lunar surface. At the same time an effort was underway to deduce in engineering terms the surface characteristics and soil mechanics of the lunar surface. Only the sparse photographic information from Ranger was available to the engineers, yet later data from Surveyor and Orbiter led to no significant change in the LEM design. In addition to lack of definition of the lunar surface, uncertainty about the cislunar space environment also handicapped design progress. The intensity of the radiation flux during solar flares was not fully understood. In addition to worry about radiation sickness, a particular concern was possible damage to the eyes (in the form of cataracts) of the astronauts. Thick transparent plastic eye shields were proposed. A program was instituted to learn more about predicting solar events and a network of H-alpha telescopes and radio frequency detectors was planned for this purpose. At the same time much effort was expended to assure that neither the spacecraft nor the astronauts' space suits would be damaged by micrometeors. In this regard help came from the data obtained by the Pegasus micrometeor detection satellites orbited by the last two Saturn I launch vehicles.

During this same period the Gemini program entered into its operational phase with a launch rate averaging once every two months. Significant to the Apollo mission were the development of operational procedures for orbital rendezvous, "shirtsleeve" operation by the crew in orbit, and exposure to fourteen days of weightlessness with only incidental physiological effects.

Finally, important scientific aspects of the mission were defined. Studies of lunar sample return and back contamination had progressed to the point that the essential features of the Lunar Receiving Laboratory were established. Further definition of the lunar geological surveys was achieved. With a goal of better precision in selection of Apollo landing sites, a coordinated activity was instituted with the Orbiter project. The Apollo Lunar Science Experiment Package (ALSEP) design progressed to the point of commitment to a 56-watt radioisotope power generator. Thus these small automated science stations would be assured an extended lifetime of operation after departure of the astronauts. It was also during this period that NASA recruited its first group of scientist astronauts.

In summary, during this period the Apollo program settled into the substance and routine of making the lunar landing a reality. The tremendous challenge in scope and depth of the venture was unmistakably clear to the government-industry team mobilized to do the job.

Maxime A. Faget
*Director of Engineering and
Development, Johnson Space Center*

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THE KEY EVENTS

1964

October 5-8: NASA conducted formal review of LEM mockup M-5 at Grumman factory.

October 12: U.S.S.R. launched *Voskhod I*, world's first multi-manned spacecraft.

October 14: AC Spark Plug reported first Apollo guidance system completed and shipped to NAA.

October 27: NASA announced appointment of Maj. Gen. Samuel C. Phillips as Director of Apollo Program.

November 23: NASA gave NAA a formal go-ahead on the Block II spacecraft.

December 7: Douglas Aircraft Company delivered first S-IVB stage to MSFC for testing.

December 8: Apollo Mission A-002 was flown at WSMR, with BP-23 launched by a Little Joe II booster.

1965

January 14-21: NAA completed acceptance tests on the CSM sequential and systems trainers.

January 21-28: Space Technology Laboratories was named sole contractor for the LEM descent engine.

February 9: NAA completed the first ground test model of the S-II stage of the Saturn V.

February 17: *Ranger VIII* was launched by NASA from Cape Kennedy. It transmitted pictures back to earth before lunar impact.

March 2: MSC decided in favor of an "all-battery" LEM rather than the previously planned fuel cells.

March 17: Crew Systems Division recommended "shirtsleeve" environment be retained in CM.

March 18: U.S.S.R. launched *Voskhod II* on a 17-orbit mission. Lt. Col. Aleksey Leonov performed man's first "walk-in-space."

March 21: NASA launched *Ranger IX*, last of series. It transmitted 5814 pictures of lunar surface to earth.

March 23: *Gemini III* was launched from Cape Kennedy with astronauts Virgil I. Grissom and John W. Young aboard; the first U.S. multi-manned mission lasted three orbits.

March 23-24: Part I of the Critical Design Review of the CM Block II crew compartment and docking system was held at NAA.

April 1: The first stage of the Saturn IB booster underwent its first static firing at MSFC.

April 9: Control over manned space flights, after liftoff, was transferred from the Cape Kennedy Control Center to Mission Control Center, Houston.

April 14: Final beam was emplaced in the structural skeleton of the Vertical Assembly Building at KSC.

April 16: MSFC conducted first clustered firing of Saturn V's first stage (S-IC).

April 27-30: Part II of the Block II CM crew compartment and docking system Critical Design Review was held at NAA.

April 28: ASPO Manager Joseph F. Shea approved the Crew Systems Division recommendation to retain "shirtsleeve" environment in the CM.

May 19: Apollo mission A-003 was flown at WSMR. Little Joe II booster disintegrated 25 sec after launch but launch escape system worked perfectly.

May 22: NASA launched Project Fire II from Cape Kennedy to obtain test data on heating during reentry.

June 3: Northrop-Ventura began qualification testing of the Apollo earth landing system.

June 3: NASA launched *Gemini IV* from Cape Kennedy on a Titan II booster. Astronauts

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- James A. McDivitt and Edward H. White II were crew members for the four-day mission. During the flight White made America's first "space walk."
- June 7:* George E. Mueller, NASA Associate Administrator for Manned Space Flight, approved procurement of lunar surface experiments package.
- June 7-13:* NAA's Rocketdyne Division began qualification testing on the CM's reaction control system engines.
- June 14:* A Technical Working Committee was appointed at MSC to oversee the design of the Lunar Sample Receiving Laboratory.
- June 29:* NASA launched pad abort (PA)-2, a test of the launch escape system at WSMR.
- June 29:* NASA formally announced the selection of six scientist-astronauts for the Apollo program.
- June 30:* Langley Research Center put its Lunar Landing Research Facility into operation.
- July 4-10:* NASA approved a Grumman subcontract to Eagle-Picher for the LEM batteries.
- July 19:* MSC directed Grumman to implement changes to limit the total LEM weight to 14 515 kg (32 000 lbs).
- July 30:* NASA launched SA-10 from Cape Kennedy, marking the end of the Saturn I program and its 10 successful launches.
- August 5:* The Saturn V's first stage made a "perfect" full-duration firing at MSFC by burning for the programmed 2.5 min at full thrust.
- August 9:* Two Saturn milestones occurred: (1) NAA conducted first full-duration captive firing of S-II stage; and (2) Douglas Aircraft Co. static-tested first flight model S-IVB stage.
- August 12:* Apollo Program Director Samuel C. Phillips listed six key checkpoints in development of Apollo hardware.
- August 18:* Grumman put "Operation Scrape" into effect in an effort to lighten the LEM.
- August 21:* *Gemini V* was launched from Cape Kennedy with astronauts L. Gordon Cooper, Jr., and Charles Conrad, Jr., as crew members. The eight-day flight was the first in which fuel cells were used as primary electrical power source.
- August 27:* NAA reported ground testing of service propulsion system had been concluded.
- September 10:* NASA announced a plan to recruit additional pilot-astronauts.
- September 13:* ASPO Manager Joseph F. Shea announced a new plan to control Apollo spacecraft weight.
- September 16-23:* Grumman established final design parameters for the LEM landing gear.
- September 20:* MSC recommended to NASA Hq that International Latex Corp. be awarded a contract for development and fabrication of space suits and associated equipment.
- September:* A total of 13 flights were made in the LLRV, including one in which the lunar simulation mode was flown for the first time.
- October 15:* Recovery requirements for the Apollo spacecraft were specified by ASPO.
- October 20:* NASA accepted spacecraft 009 in ceremonies at NAA, first of the kind that would be used on lunar missions.
- October 21:* MSC announced that the bubble-type helmet designed by Crew Systems Division engineers had been adopted for use in the Apollo extravehicular mobility unit.
- November 1:* MSC established a Lunar Sample Receiving Laboratory Office pending development of a permanent organization to operate the facility.
- November 5:* NASA announced it would negotiate a contract with International Latex Corp. for fabrication of the Apollo space suit, and a contract with Hamilton Standard for continued development and manufacture of the portable life support system.
- November 30:* Apollo Mission Simulator No. 1 was shipped by Link Group, General Precision, to MSC.
- December 4:* *Gemini VII*, manned by astronauts Frank Borman and James A. Lovell, Jr., was launched from Cape Kennedy on a 14-day mission.
- December 5:* Hamilton Standard successfully tested a life support back pack designed to meet the requirements of the lunar surface suit.
- December 6-17:* The Block II CSM Critical Design Review was held at NAA.
- December 15-16:* *Gemini VI-A* was launched from Cape Kennedy with astronauts Walter M. Schirra, Jr., and Thomas P. Stafford aboard. The spacecraft rendezvoused with *Gemini VII* less than six hours after liftoff.
- December 31:* The SM reaction control system engine qualification was completed.

THE KEY EVENTS

1966

January 3: OMSF listed operational constraints for Apollo experimenters in order to prevent experiment-generated operational problems.

January 7: MSC outlined the general purpose and plans for the Lunar Sample Receiving Laboratory.

January 8-11: The first fuel system test was successfully conducted at WSTF.

January 20: Apollo mission A-004 was successfully accomplished at WSMR. It was the final suborbital test in the Apollo program.

PREFACE

Project Apollo, America's premier space effort during the 1960's, had a twofold objective. The more immediate goal, as proclaimed by President John F. Kennedy before Congress on May 25, 1961, was to land men on the moon and return them safely to Earth before the end of the decade. But a second and far broader objective was to make the United States pre-eminent in space, taking a leading role in space achievement and ensuring that this nation would be second to none in its ability to explore and use the vast new ocean.

Apollo therefore served as the spearhead for NASA's overall program during the sixties. Although the lunar landing generally overshadowed other important activities—critics of the agency often saw the near-term goal as an end in itself—the program stimulated phenomenal progress in aerospace technology. Building upon the pioneering achievements of Mercury and Gemini, Apollo produced dramatic advances in launch vehicles, spacecraft, and operational techniques. But the moon provided only the essential focus, the clearly identifiable and attainable target to channel this immensely diverse technological momentum.

As NASA spokesmen often pointed out, of all the hardware being developed for Apollo only the lunar module was narrowly conceived. The other components represented tangible advances in space flight technology essential to space preeminence, irrespective of the formal moon landing program *per se*.

In essence, that is the thrust of this third installment of *The Apollo Spacecraft: A Chronology*. Spanning October 1, 1964, through January 20, 1966, this volume traces the development of "Apollo's Chariots," the lunar spacecraft—along with the Saturn V a paramount ingredient in America's campaign to secure preeminence in space. That period encompassed the detailed engineering design and exhaustive testing to qualify both the command and service modules and the lunar module for manned flight. Although other significant events elsewhere in Apollo are not ignored, the detailed work on the spacecraft—which thus served directly to foster America's spacefaring capabilities—forms the chief focus of this book. By the end of this sixteen-month period, Apollo had clearly shifted to manufacturing and flight testing, steppingstones to manned operations.

Like the two previous volumes in this series (Volume I covers the origins of the program and conceptual development through the selection of Grumman in November 1962 to build the lunar module; and Volume II the period of fundamental configurational work on both vehicles, culminating in the mockup review of the Block II version of the command and

service modules at North American on September 30, 1964), and like similar works on Mercury and Gemini, this volume is intended as a reference and a guide. In addition, the several volumes serve as the foundation for a narrative history of the Apollo spacecraft underway as part of the NASA Historical Series, providing tools for more in-depth interpretive and analytical study. Unlike the first two volumes, this volume is not divided into sections, since its content is similar and related throughout.

As far as possible primary sources were consulted, with chief reliance being placed on records held at the recently renamed (February 1973) Lyndon B. Johnson Space Center in Houston. These primary sources included congressional documents, official correspondence, government and contractor status and progress reports, memorandums, working papers, minutes of meetings, and in some cases interviews with participants. In addition, the authors also drew upon press releases, newspaper accounts, and magazine articles. Indeed, the staggering amount of documentation for Apollo is sufficient to give pause to even the most dedicated historical researcher. A principal methodological problem has therefore been to cover adequately relevant events throughout the program without departing from the tactical aim of the book. Inevitably, subjective evaluation became the ultimate criterion for inclusion or rejection of specific events.

The authors are indebted to many individuals, both within NASA and among many of its supporting contractors, who contributed additional materials and commented on draft portions of the manuscript. Historians, editors, and archivists of the NASA Historical Office in Washington gave valuable assistance: Eugene M. Emme, Frank W. Anderson, Jr., Thomas W. Ray, Lee D. Saegesser, and Carrie Karegeannes. Likewise, Loyd S. Swenson, Jr., of the University of Houston and James M. Grimwood and Sally D. Gates of the JSC Historical Office made useful suggestions. And in particular, Corinne L. Morris, now at the Smithsonian Institution, helped immeasurably in assembling scattered documentation, weeding out trivia and "engineeringese," and editing and typing comment drafts. To these and many other informants, readers, and critics, the authors wish to express sincere and appreciative thanks.

C.G.B.
I.D.E.

April 1974

Advanced Design, Fabrication, and Testing

October 1, 1964, through January 20, 1966

Advanced Design, Fabrication, and Testing

October 1, 1964–January 20, 1966

Ceremonies in Washington marked the sixth anniversary of the National Aeronautics and Space Administration (NASA). Administrator James E. Webb reminded those present of NASA's unique contribution to America's mission and destiny, then read a message from President Johnson: "We must be first in space and in aeronautics," the President said, "to maintain first place on earth. . . . Significant as our success has been, it is but indicative of the far greater advances that mankind can expect from our aeronautical and space efforts in the coming years. We have reached a new threshold . . . which opens to us the widest possibilities for the future." Two days later, in an address in White Sulphur Springs, W. Va., Webb observed that "as the national space program moves into its seventh year, the United States has reached the half-way point in the broad-based accelerated program for the present decade." America was halfway to the moon.

Astronautics and Aeronautics, 1964: Chronology on Science, Technology, and Policy (NASA SP-4005, 1965), pp. 335, 338.

Representatives from Grumman Aircraft Engineering Corporation, North American Aviation, Inc., and Massachusetts Institute of Technology's (MIT) Instrumentation Laboratory, three of the Manned Spacecraft Center's (MSC) principal contractors, met with radar and guidance and navigation experts from Houston and Cape Kennedy. They formulated a detailed plan for testing and checkout of the lunar excursion module (LEM) rendezvous and landing radar systems both at the factory and at the launch site.

MSC, "Minutes of Implementation Meeting #3, Apollo LEM G&D Systems, September 29, 1965"; MSC, "ASPO Weekly Management Report, October 1-8, 1964."

North American switched to a spring-activated pop-up antenna for the command module (CM) high-frequency recovery radio.

"ASPO Weekly Management Report, October 1-8, 1964."

On the basis of new abort criteria (failure of one fuel cell), extended operating periods, and additional data on fuel cell performance, Grumman recommended a 20.4 kg (45-lb), 1800 watt-hour auxiliary battery for the LEM.

1964
October
1

1-2

1-8

1-8

1964

October

MSC approved the recommendation and Grumman completed the redesign of the electrical power distribution system and resizing of the battery during late October and early November.

MSC, "Consolidated Activity Report for the Office of the Associate Administrator, Manned Space Flight, September 20–October 17, 1964," p. 54; MSC, "ASPO Weekly Management Report, September 17–24, 1964"; "ASPO Weekly Management Report, September 24–October 1, 1964"; "ASPO Weekly Management Report, October 1–8, 1964"; "Monthly Progress Report No. 21," LPR–10–37, p. 26.

- 2 MSC submitted a Request for Proposals to General Electric Company (GE) for two additional spacecraft acceptance checkout ground stations. Eight million dollars was the estimated cost of the added equipment.

MSC, "Consolidated Activity Report for the Office of the Associate Administrator, Manned Space Flight, September 20–October 17, 1964," p. 40.

- 2 MSC's Apollo Spacecraft Program Office (ASPO) approved a plan (put forward by the MSC Advanced Spacecraft Technology Division) to verify the CM's radiation shielding. Checkout of the radiation instrumentation would be made during manned earth orbital flights. The spacecraft would then be subjected to a radiation environment during the first two unmanned Saturn V flights. These missions, 501 and 502, with apogees of about 18 520 km (10 000 nm), would verify the shielding. Gamma probe verification, using spacecraft 008, would be performed in Houston during 1966. Only Block I CM's would be used in these ground and flight tests. Radiation shielding would be unaffected by the change to Block II status.

Memorandum, Joseph F. Shea, MSC, to Assistant Chief for Space Environment, "Apollo Radiation Shielding Verification," October 5, 1964.

5–8

NASA conducted a formal review of the LEM mockup M–5 at the Grumman factory. This inspection was intended to affirm that the M–5 configuration reflected all design requirements and to definitize the LEM configuration. Members of the Mockup Review Board were Chairman Owen E. Maynard, Chief, Systems Engineering Division, ASPO; R. W. Carbee, LEM Subsystem Project Engineer, Grumman; Maxime A. Faget, Assistant Director for Engineering and Development, MSC; Thomas J. Kelly, LEM Project Engineer, Grumman; Christopher C. Kraft, Jr. (represented by Sigurd A. Sjoberg), Assistant Director for Flight Operations, MSC; Owen G. Morris, Chief, Reliability and Quality Assurance Division, ASPO; William F. Rector III, LEM Project Officer, ASPO; and Donald K. Slayton, Assistant Director for Flight Crew Operations, MSC.

The astronauts' review was held on October 5 and 6. It included demonstrations of entering and getting out of the LEM, techniques for climbing and descending the ladder, and crew mobility inside the spacecraft. The general inspection was held on the 7th and the Review Board met on the 8th. Those attending the review used request for change (RFC) forms to propose space-

craft design alterations. Before submission to the Board, these requests were discussed by contractor personnel and NASA coordinators to assess their effect upon system design, interfaces, weight, and reliability.

The inspection categories were crew provisions; controls, displays, and lighting; the stabilization and control system and the guidance and navigation radar; electrical power; propulsion (ascent, descent, reaction control system, and pyrotechnics); power generation (cryogenic storage and fuel cell assemblies); environmental control; communications and instrumentation; structures and landing gear; scientific equipment; and reliability and quality control. A total of 148 RFCs were submitted. Most were aimed at enhancing the spacecraft's operational capability; considerable attention also was given to quality and reliability and to ground checkout of various systems. No major redesigns of the configuration were suggested.

As a result of this review, the Board recommended that Grumman take immediate action on those RFC's which it had approved. Further, the LEM contractor and MSC should promptly investigate those items which the Board had assigned for further study. On the basis of the revised M-5 configuration, Grumman could proceed with LEM development and qualification. This updated mockup would be the basis for tooling and fabrication of the initial hardware as well.

MSC, "Lunar Excursion Module, Project Apollo, Board Report for NASA Inspection and Review of M-5 Mockup Lunar Excursion Module, October 5-8, 1964," pp. 1-7, 10-27.

Radio Corporation of America's (RCA) Aerospace Systems Division received a \$9 million contract from Grumman for the LEM attitude translation control assembly (ATCA). The ATCA, a device to maintain the spacecraft's attitude, would fire the reaction control system motors in response to signals from the primary guidance system.

8

Space Business Daily, October 9, 1964, p. 210.

On the basis of reentry simulations, North American recommended several CM instrument changes. An additional reaction control system display was needed, the company reported. Further, the flight attitude and the stabilization and control system indicators must be modified to warn of a system failure before it became catastrophic. The entry monitor system for Block I spacecraft would have to be replaced and the sample g-meter was not wholly satisfactory.

8-15

MSC, "ASPO Weekly Management Report, October 8-15, 1964."

Analysis by MSC of the performance of the environmental control system radiators for Block I CM's placed their heat rejection capability at 4000 Btus per hr, far below the anticipated mission load of 7220. Water boiled

8-15

1964

October

at the rate of 1.46 kg (3.22 lbs) per hr would be needed to supplement the radiators. This, in turn, would limit the mission to 45 hrs duration, at which time all of the spacecraft's water supplies (both that in the water tanks at launch and that collected as a byproduct from the fuel cells) would be exhausted.

As MSC saw it, potential solutions were to redesign the radiators themselves, to increase the size of the tanks to hold another 194 kg (428 lbs) of water, or to reduce the operating power level.

Memorandum, Owen E. Maynard, MSC, to Chief, Operations Planning Division, "Limited mission duration capability for Block I Command and Service Modules," October 21, 1964.

8-15

MSC established the configuration of the reaction control system engines for both the service module (SM) and the LEM, and informed North American and Grumman accordingly. The Center also directed North American to propose a design for an electric heater that would provide thermal control in lunar orbit and during contingency operations. The design would be evaluated for use in Block I spacecraft as well.

MSC, "Minutes, Apollo/E and D Technical Management Meeting No. 8, 10/5 and 10/12, 1964," pp. 4-5; letters, W. F. Rector III, MSC to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Temperature control for the RCS engines in the Service Module and LEM," October 19, 1964.

8-15

RCA reduced the weight of the LEM rendezvous radar from 39.9 to 31.98 kg (88 to 70.5 lbs).

Memorandum, Robert C. Duncan and Ralph S. Sawyer, MSC, to Manager, ASPO, "Apollo Radar Systems Design Review," September 16, 1964, with enclosure: "Apollo Radar Design Review," undated.

8-15

North American representatives visited the Grumman plant to discuss design features and to inspect the electroluminescent lighting on the LEM. North American intended to adopt this same feature on Block II CMs.

"ASPO Weekly Management Report, October 8-15, 1964."

9

NASA and Grumman representatives discussed a weight reduction program for the LEM. Changes approved at the M-5 mockup review portended an increase in LEM separation weight of from 68 to 453 kg (150 to 1000 lbs). Both parties agreed to evaluate the alternatives of either resizing the spacecraft or finding ways to lighten it about nine percent, thus keeping the improved LEM within the present control weight.

GAEC, "Monthly Progress Report No. 21," LPR-10-37, November 10, 1964, p. 6.

NASA approved Grumman's selection of Airite to supply the LEM helium tanks, and the two firms started negotiations.

1964

October

9

Ibid., pp. 7, 16.

Grumman completed contract negotiations with Arma Division, American Bosch Arma Corporation, for the LEM caution and warning electronics assembly.

11–November 10

Ibid., p. 22.

Grumman lighting experts evaluated self-luminous materials produced by the Minnesota Mining and Manufacturing Company and found them feasible for use in docking lighting.

11–November 10

Ibid., p. 4.

The U.S.S.R. launched the world's first multi-manned spacecraft, *Voskhod I*, the first to carry a scientist and a physician into space. The crew were Col. Vladimir Komarov, pilot; Konstantin Feoktistov, scientist; and Boris Yegorov, physician. According to Tass, orbital parameters of the spacecraft were 409 by 177 km (254 by 110 mi) with a 90.1 minute period and a 65 degree plane. Purposes of this flight, according to the Russian source, were to prove the operational compatibility of the spacecraft and crew and to conduct scientific and medical investigations during actual space flight. The mission featured television pictures of the crew from space. The trio landed after 16 orbits of the earth, 24 hrs and 17 min after they had left it. The flight had a significant worldwide impact. In the United States, the "space race" was again running under the green flag. NASA Administrator James E. Webb, commenting on the spectacular, called it a "significant space accomplishment." It was, he said, "a clear indication that the Russians are continuing a large space program for the achievement of national power and prestige."

12

Astronautics and Aeronautics, 1964, pp. 348, 350.

At a North American–Grumman interface meeting on September 23–24, two possible relative role alignments for CSM-active docking were agreed upon. The major item blocking final selection was the effect of the SM's reaction control system engines upon the LEM antennas. ASPO requested Grumman to investigate the problem, to analyze the design penalties of the two-attitude docking mode, and to report any other factors that would influence the final attitude selection.

12

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, October 12, 1964.

- 1964**
October
12
- MSC notified Grumman of several additional LEM guidance and navigation ground rules that were applicable to the coasting phase of the mission. During this portion of the flight, the LEM abort guidance system must be capable of giving attitude information and of measuring velocity changes. Navigational data required to take the LEM out of the coasting phase and to put it on an intercept course with the CSM would be provided by the CSM's rendezvous radar and its guidance and navigation system, and through the Manned Space Flight Network back on earth.
- Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Additional Ground Rules for LEM Guidance and Navigation Operation and Monitoring," October 12, 1964.
- 13**
- North American and MIT Instrumentation Laboratory representatives met in Houston to discuss electrical power requirements for the guidance and control systems in Block II CMs. They had determined the additional electrical power needed for the guidance and control system (24 volts) was available.
- Jerold P. Gilmore, MIT/IL, "MIT/GN&C-Saturn Interfaces," prepared for Implementation Meeting #8, "Apollo CSM Block II Guidance & Control Systems," October 13, 1964.
- 14**
- Eagle-Picher Company completed qualification testing on the 25-ampere-hour reentry batteries for the CM. Shortly thereafter, Eagle-Picher received authorization from North American to proceed with design and development of the larger 40-ampere-hour batteries needed for the later Block I and all Block II spacecraft.
- MSC, "ASPO Weekly Management Report, October 15-22, 1964"; North American Aviation, Inc. [hereafter cited as NAA], "Apollo Monthly Progress Report," SID-62-300-31, December 1, 1964, pp. 15-16; MSC, "Project Apollo Quarterly Status Report No. 10 for Period Ending December 31, 1964," p. 12.
- 14**
- In a letter to Apollo Program Director General Samuel C. Phillips, ASPO Manager Joseph F. Shea pointed out that Bellcomm, under contract to NASA, had a subcontract with Space Technology Laboratories (STL) and that MSC had a contract with STL covering the same basic areas as the Bellcomm-STL subcontract. Shea told Phillips that STL was not allowed to use the information on the MSC contract which had been obtained on the Bellcomm contract, and requested that STL be permitted to use the information on the MSC contract.
- Letter, from Manager, ASPO, to NASA Headquarters, Attn: General Phillips, "Space Technology Laboratories Contract with Bellcomm Corporation," October 14, 1964.
- 14**
- In a letter to NASA Administrator James E. Webb, AC Spark Plug reported that the first Apollo guidance system completed acceptance testing and was shipped at 11:30 p.m. and arrived at Downey, California, early the following day. AC reported that in more than 2000 hours of operation they had found the system to be "remarkably reliable, accurate and simple to operate."

Letter, to NASA Administrator Webb, from B. P. Blasingame, Manager, Milwaukee Operations, October 19, 1964.

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A number of outstanding points were resolved at a joint MSC-Grumman meeting on LEM communications. Most significant, the VHF key mode was deleted, and it was decided that, during rendezvous, voice links must have priority over all other VHF transmissions. Further, the echo feature of the current configuration (i.e., voice sent to the LEM by the ground operational support system, then relayed back via the S-band link) was undesirable.

15

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Minutes of Lunar Excursion Module Communications Subsystem Review October 15 and 16, 1964," October 29, 1964, with enclosure: subject minutes, pp. 2-3.

MSC's Systems Engineering Division reported on the consequences of eliminating the command and service module (CSM) rendezvous radar:

15

- Coasting period: During this phase of the mission, the rendezvous radar on the CSM would be used to track the LEM and the rendezvous radar on the LEM would be used to track the CSM. With the use of Mission Control through the Manned Space Flight Network (MSFN), three sources of information could be used as a vote for guidance system monitoring. Without the CSM rendezvous radar, the monitoring task would become more difficult; however, this was not to imply that it was impossible. The conclusion was that CSM rendezvous radar was highly desirable, but not absolutely necessary.

- Lunar descent and ascent: During powered flight, the CSM would be tracking the LEM. This was desirable because if the LEM guidance computer (LGC) failed, it was very doubtful that the astronauts could manually acquire radar lock-on with the CSM. Also, if the LEM rendezvous radar failed, CSM lock-on would be highly desirable. There were several alternative solutions to this problem. First of all, Mission Control through the MSFN could relieve the problem. If this did not satisfy all requirements, it was possible for the LEM rendezvous radar to track the CSM during powered descent and ascent. If the LGC then failed, the tracking acquisition would no longer be a problem. In summary, there did appear to be other ways of fulfilling the functions of the CSM rendezvous radar during the powered phases.

- Lunar surface: While the LEM was on the lunar surface, it would be tracked with the CSM rendezvous radar in order to update launch conditions. This could be accomplished by the LEM tracking the CSM and the MSFN.

- Rendezvous: This was the most critical phase for the use of the rendezvous radar on the CSM. If the LEM primary guidance system should fail (i.e., the LGC, inertial measurement unit [IMU], and LEM rendezvous radar), navigation information for long-range midcourse corrections would be provided by the rendezvous radar on the CSM. The MSFN, however, could supply this information. The terminal rendezvous maneuver would become a problem if the LEM rendezvous radar failed and there was not a

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rendezvous radar on the CSM. It had not been established that the MSFN could supply the required terminal rendezvous information. If MSFN could, a restricted mission profile would have to be employed. There were other methods of supplying terminal rendezvous information such as optical tracking. The scanning telescope or sextant on the CSM could be used with the IMU and Apollo guidance computer on the CSM to derive navigation information, meaning that the LEM would require flashing lights. There was a ΔV penalty associated with using angle-only information in place of range/range rate and angle information, its importance depending on the accuracy of the angle data and the range/range rate data.

Memorandum, Aaron Cohen, MSC, to Chief, Operations Planning Div., "CSM Rendezvous Radar," October 15, 1964.

15

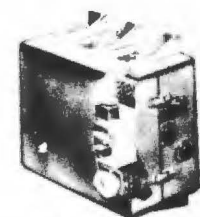
The Guidance and Control Implementation Sub-Panel of the MSC-MSFC Flight Mechanics Panel defined the guidance and control interfaces for Block I and II missions. In Block II missions the CSM's guidance system would guide the three stages of the Saturn V vehicle; it would control the S-IVB (third stage) and the CSM while in earth orbit; and it would perform the injection into a lunar trajectory. In all of this, the CSM guidance backed up the Saturn ST-124 platform. Actual sequencing was performed by the Saturn V computer.

Memorandum, Aaron Cohen, MSC, to Chief, Flight Technology Branch, "Flight Mechanics Panel's Activities," October 15, 1964.

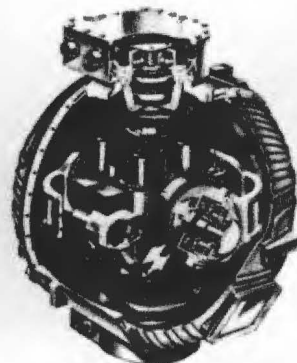
15

Remote operation of the CSM's rendezvous radar transponder and its stabilization and control system (SCS) was not necessary, ASPO told North American. Should the CSM pilot be incapacitated, it was assumed that he could

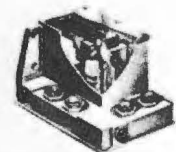
Components of Saturn V's ST-124 platform.



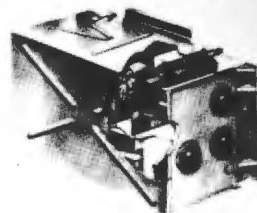
AC POWER SUPPLY



ST-124-M
INERTIAL PLATFORM ASSEMBLY



ACCELEROMETER SIGNAL
CONDITIONER



PLATFORM SERVO AMPLIFIER

SYSTEM FUNCTIONS

- A. Accelerometer sensing and reference.
- B. Vehicle attitude and programming.
- C. Guidance reference coordinates.

perform several tasks before becoming totally disabled, including turning on the transponder and the SCS. No maneuvers by the CSM would be required during this period. However, the vehicle would have to be stabilized during LEM ascent, rendezvous, and docking.

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Letter, C. L. Taylor, MSC, to NAA, Attn: E. E. Sack, "Contract NAS 9-150, Operations Groundrule and Disabled CSM Astronaut," October 15, 1964.

The Air Force Eastern Test Command concurred in the elimination of propellant dispersal systems for the SM and the LEM. Costs, schedules, and spacecraft designs, NASA felt, would all benefit from this action. ASPO thus notified the appropriate module contractors.

15-22

MSC, "ASPO Weekly Management Report, October 15-22, 1964."

Because they were unable to find a satisfactory means of plating the magnesium castings for the CM data storage equipment (to fulfill the one percent salt spray requirement), Collins Radio Company and the Leach Corporation were forced to use aluminum as an alternative. This change would increase the weight of the structure by about 2.3 kg (5 lbs) and, perhaps even more significant, could produce flutter when the recorder was subjected to vibration tests. These potential problems would be pursued when a finished aluminum casting was available.

15-22

Ibid.

Grumman completed the fuel cell assembly thermal study and was preparing a specific directive to Pratt and Whitney Aircraft Company which would incorporate changes recommended by the study. These changes would include the cooling of electrical components with hydrogen and the shifting of other components (water shutoff valves, and oxygen purge valve) so that they would operate at their higher design temperatures.

15-22

Ibid.

Representatives from the MSC Astronaut Office, and ASPO's Systems Engineering, Crew Systems, and Mission Planning divisions made several significant decisions on crew transfer and space suit procedures:

15-22

- Crew transfer, both pressurized and unpressurized, would be accomplished using the environmental control system umbilicals. The CM and LEM umbilicals would be designed accordingly. Crew Systems would request the necessary engineering changes.

- The requirement for "quick-don" capability for the space suit would be reevaluated by Systems Engineering people. If the probability of a rapid decompression of the spacecraft during "noncritical" mission phases was negligible, "quick-don" capability might be eliminated. This would ease several design constraints on the suit.

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- The question of a crossover valve in the CM, for ventilation during open-faceplate operation, was postponed pending the decompression study and ventilation tests at Hamilton Standard.

Ibid.

16

In a letter on August 25, 1964, the LEM Project Office had requested Grumman to define the means by which CSM stabilization and rendezvous radar transponder operation could be provided remotely in the event the CSM crewman was disabled.

In another letter on October 16, the Project Office notified Grumman that no requirement existed for remote operation of either the rendezvous radar transponder or the stabilization and control system. The letter added, however, that the possibility of an incapacitated CSM astronaut must be considered and that for design purposes Grumman should assume that the astronaut would perform certain functions prior to becoming completely disabled. These functions could include turning on the transponder and the SCS. No CSM maneuvers would be required during the period in which the CSM astronaut was disabled but the CSM must remain stabilized during LEM ascent coast and rendezvous and docking phases.

Letter, W. F. Rector III to GAEC, "Contract NAS 9-1100, Operations Groundrule for Disabled CSM Astronaut," October 16, 1964.

16–November 15

Three Pratt and Whitney fuel cells were operated in a simulated space vacuum at North American for 19, 20, and 21 hours. This was the first time three cells were operated as an electrical power generating subsystem.

"Apollo Monthly Progress Report," SID-62-300-31, p. 1.

16–November 15

North American and Honeywell reviewed the Block II CSM entry monitor subsystem's compatibility with the stabilization and control system. The proposed configuration, they found, combined maximum reliability with minimum size and weight and would provide adequate mission performance.

Ibid., p. 13.

17

MSC and International Business Machines Corporation (IBM) negotiated a \$1 500 000 fixed-price contract for the Apollo guidance and navigation system backup computer.

MSC, "Consolidated Activity Report for the Office of the Associate Administrator, Manned Space Flight, October 18–November 30, 1964," p. 39; MSC, "ASPO Weekly Management Report, October 15–22, 1964."

19

MSC ordered Grumman to halt work on the LEM test article (LTA) 10. The LTA-10's descent stage would be replaced with one cannibalized from LEM test mockup 5.

"Monthly Progress Report No. 21," LPR-10-37, pp. 12, 18.

On October 19, a supplemental agreement in the amount of \$115 000 000 was issued to North American, bringing the total funded amount of the CSM contract to \$1 136 890 000. 1964
October

MSC, "Consolidated Activity Report for the Office of the Associate Administrator, Manned Space Flight, October 18–November 30, 1964," p. 39. 19

In response to inquiries from General Samuel C. Phillips, Apollo Program Deputy Director, ASPO Manager Joseph F. Shea declared that, for Apollo, no lunar mapping or survey capability was necessary. Shea reported that the Ranger, Surveyor, and Lunar Orbiter programs should give ample information about the moon's surface. For scientific purposes, he said, a simpler photographic system could be included without requiring any significant design changes in the spacecraft. 22

TWX, Shea, MSC, to NASA Headquarters, Attn: Phillips, October 22, 1964; letter, J. A. Hornbeck, Bellcomm, to S. C. Phillips, NASA, November 5, 1964.

Heavy black deposits were discovered on the environmental control system (ECS) cold plates when they were removed from boilerplate 14. Several pinholes were found in the cold plate surfaces, and the aluminum lines were severely pitted. This was, as ASPO admitted, a matter of "extreme concern" to the ECS design people at North American, because the equipment had been charged with coolant for only three weeks. This evidence of excessive corrosion reemphasized the drawbacks of using ethylene glycol as a coolant. 22–29

MSC, "ASPO Weekly Management Report, October 22–29, 1964."

ASPO notified Grumman and North American that it had canceled requirements for Apollo part task trainers. 22–29

Ibid.

MSC's Crew Systems Division investigated environmental control system (ECS) implications of using Gemini suits in Block I missions. The results indicated that the ECS was capable of maintaining nominal cabin temperature and carbon dioxide partial pressure levels; however, this mode of operation always had an adverse effect on cabin dewpoint temperature and water condensation rate. 22–29

Ibid.

ASPO deleted the requirement for LEM checkout during the translunar phase of the mission. Thus the length of time that the CM must be capable of maintaining pressure in the LEM (for normal leakage in the docked configuration) was reduced from 10 hours to three. 23

Ibid.

Jet Propulsion Laboratory proposed a meeting on October 29 between 23

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representatives of NASA Headquarters, Bellcomm, MSC, MIT, and JPL to present the requirements and status of projects underway as they related to the landing aid problem. The Surveyor Block II study effort was concentrating on determining needs of obtaining data on the lunar surface and environment for Apollo.

JPL proposed the following agenda items:

- LEM requirements and specifications on a Surveyor deployed transponder
- MSC planned active and passive landing aids study program
- Landing aids capabilities under consideration by the Surveyor study:
 1. Active RF device
 2. Passive RF device—corner reflector or other
 3. Visual markers—visible during terminal phase and landing only; visible during terminal phase and landing as well as from lunar orbit; or visible during terminal phase and landing from lunar orbit as well as photographically from the unmanned Lunar Orbiter
- Landing aids lifetime and checkout problems
- LEM–Surveyor mission interface problems

MSC personnel would present a summary of results to date on the first two items and JPL personnel would present similar results on items three and four.

TWX from JPL to NASA Hq., MSC, Bellcomm, Inc., and MIT, "Surveyor Employed Landing Aids for Apollo," signed Lou Divone, October 23, 1964.

26

The trajectory summary of the Design Reference Mission (DRM) prepared by the Apollo Mission Planning Task Force was sent to Grumman by the LEM Project Office with a note that the operational sequence-of-events would be forwarded in November.

It was acknowledged that a single mission could not serve to "completely define all the spacecraft functional requirements" but "such a mission has considerable value as a standard for various purposes on the Apollo Program."

Specifically, the DRM would be used for weight reporting, electrical power reporting, reliability modeling, engineering simulation, crew task analyses, mission-related Interface Control Documents, and trade-off studies.

Letter, MSC, W. F. Rector III, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Transmittal of the Apollo Lunar Landing Design Reference Mission Trajectory," October 26, 1964.

27

ASPO requested Grumman to list all single-point failures that would cause loss of the crew during a lunar orbit rendezvous mission. Grumman was to consider only the equipment that it was responsible for.

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, October 27, 1964.

NASA announced the appointment of Major General Samuel C. Phillips as Director of the Apollo Program. Phillips thus assumed part of the duties of George E. Mueller, Associate Administrator of Manned Space Flight, who had been serving as Apollo Director as well. Phillips had been Deputy Director since January 15.

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NASA News Release 64-267, "General Phillips Appointed Director of Apollo Program," October 27, 1964.

MSC ordered North American to halt procurement of a CM simulator. Instead, the company was to begin a simulator program using the two existing evaluator-type CMs in conjunction with the digital-analog computer facility. These evaluators would be used to verify the guidance and navigation and stabilization and control system software, and to analyze crew tasks and failure effects.

27

Letter, H. P. Yschek, MSC, to NAA, Space and Information Systems Div., "Contract Change Authorization No. 263," October 27, 1964.

Because of the redesign of the portable life support system that would be required, MSC directed Grumman and North American to drop the "buddy system" concept for the spacecraft environmental control system (ECS) umbilicals. The two LEM crewmen would transfer from the CM while attached to that module's umbilicals. Hookup with the LEM umbilicals, and ventilation from the LEM ECS, would be achieved before disconnecting the first set of lifelines. MSC requested North American to cooperate with Grumman and Hamilton Standard on the design of the fetal end of the umbilicals. Also, the two spacecraft contractors were directed jointly to determine umbilical lengths and LEM ECS control locations required for such transfer.

27

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, October 27, 1964; TWX, C. L. Taylor, MSC, to NAA, Attn: E. E. Sack, October 27, 1964; TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, October 29, 1964; MSC, "ASPO Weekly Management Report, October 29–November 5, 1964."

Testing of the first flight-weight 15-cell stack of the LEM fuel cell assembly began. Although the voltage was three percent below design, the unit had a 980-watt capability. Earlier, the unit completed 150 hours of operation, and single cell life had reached 662 hours.

28

MSC, "ASPO Weekly Management Report, October 29–November 5, 1964."

ASPO's Operations Planning Division defined the current Apollo mission programming as envisioned by MSC. The overall Apollo flight program was described in terms of its major phases: Little Joe II flights (unmanned Little Joe II development and launch escape vehicle development); Saturn IB flights (unmanned Saturn IB and Block I CSM development, Block I CSM

28

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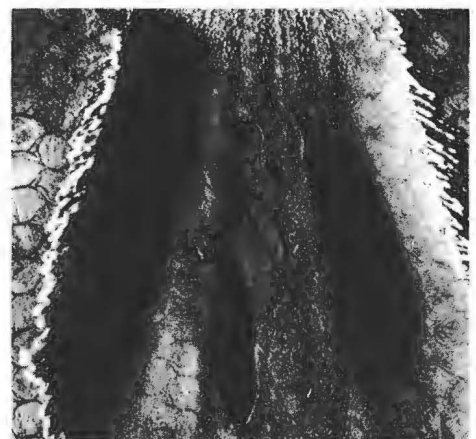
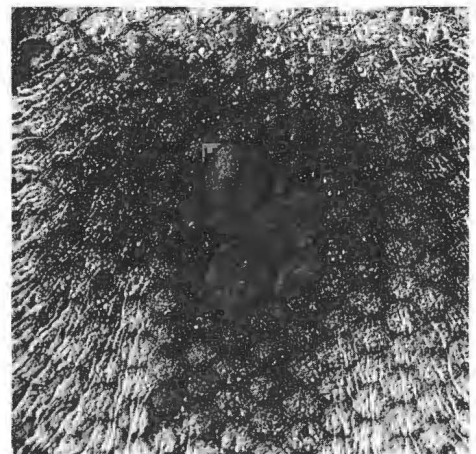
earth orbital operations, unmanned LEM development, and manned Block II CSM/LEM earth orbital operations); and Saturn V flights (unmanned Saturn V and Block II CSM development, manned Block II CSM/LEM earth orbital operations, and manned lunar missions).

Memorandum, William A. Lee, MSC, to Distr., "Apollo Spacecraft Flight Development Mission Program," October 28, 1964.

28

At Langley Research Center, representatives from Langley, MSC, Ames Research Center, Avco Corporation, and North American met to discuss their independent conclusions of the data gathered from the Scout test of the Apollo heatshield material and to determine whether a second test was advisable. Langley's report revealed that: the heatshield materials performed as predicted within the flight condition appropriate to Apollo; the

Results of wind tunnel tests at Ames Research Center are shown in the accompanying four pictures. Top left shows a piece of Apollo heatshield material in place for test; top right is a closeup of the material shortly after the test started; bottom left, shows the same material further into the test; and the photo at bottom right shows the material at the end of the test.



excessive recession rates occurred during flight conditions which were more severe than those considered for the design of the heatshield or expected during Apollo reentries.

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Each group represented had a different interpretation of the reasons for the excessively high surface recession. The conclusion was that a second flight of the heatshield materials on the Scout would not particularly improve the understanding of the material's performance because of the limited variation in reentry trajectory and flight conditions obtainable with the Scout vehicle.

Memorandum, Owen E. Maynard, MSC, to Mgr., ASPO, "Significance of Langley Working Paper on Scout Test of Apollo Heat Shield Material," December 11, 1964.

North American conferred with representatives from Shell Chemical Company, Narmco, Epoxylite, and Ablestick on the problems of bonding the secondary structure to the CM. They agreed on improved methods of curing and clamping to strengthen the bond and prevent peeling.

29

MSC, "ASPO Weekly Management Report, October 29–November 5, 1964"; "ASPO Weekly Management Report, November 5–12, 1964."

North American conducted the first operational deployment of the launch escape system canards. No problems were encountered with the wiring or the mechanism. Two more operational tests remained to complete the minimum airworthiness test program, a constraint on boilerplate 23.

29–November 5

MSC, "ASPO Weekly Management Report, October 29–November 5, 1964."

After studying the merits of three flush-mounted versus two scimitar VHF antennas for the Block II CSM, the MSC Instrumentation and Electronics Systems Division recommended the flush-mounted type.

29–November 5

Ibid.

MSC directed North American to halt development of a portable light assembly for the CM. It was not required, the Center said, because the spaceship's primary lighting system included extendable floodlights. Small lights on the fingertips of the space suit and a flashlight in the survival kit were also available if needed.

29–November 5

Ibid.

The MSC Meteoroid Technology Branch inspected a hard shell meteoroid garment built by the Center's Crew Systems Division. It was only a crude prototype, yet it in no way hampered mobility of the pressurized suit. The Meteoroid Technology people were satisfied that, should a hard garment be necessary for protection of the Apollo extravehicular mobility unit, this con-

29–November 5

- 1964**
- November**
- 2** Bellcomm, Inc., presented its evaluation of the requirement for a q-ball in the emergency detection system. [The device, enclosed in the nose cone atop the launch escape tower, measured dynamic pressures and thus monitored the vehicle's angle of attack, and was designed to warn the crew of an impending breakup of the vehicle.] Bellcomm's findings confirmed that the q-ball was absolutely essential and that the device was ideally suited to its task.
- Letter, P. R. Knaff, Bellcomm, to O. E. Maynard, MSC, November 6, 1964, with enclosure: Memorandum for File, "The Contribution of the Q-Ball to the Emergency Detection System," P. R. Knaff and M. M. Purdy, November 2, 1964.
- 3** International Telephone and Telegraph Corporation (ITT) Federal Laboratories' Astrionics Center received a \$125 000 contract from Collins Radio for the S-band acquisition receivers that position the ground-based dish antennas toward the spacecraft.
- Space Business Daily*, November 3, 1964, p. 11.
- 3** NASA announced the appointment of Brig. Gen. David M. Jones as Deputy Associate Administrator for Manned Space Flight (effective December 15). Most recently, Jones had been Deputy Chief of Staff, Systems, in the Air Force Systems Command. He would be "primarily concerned with major development problems in the Gemini and Apollo Programs, the planning for Advanced Missions and all Mission Operations." Further, Jones would "work with other NASA program offices to insure optimum use of other elements of NASA to accomplish program objectives."
- NASA News Release 64-277, "NASA Names Gen. Jones Deputy Associate Administrator for Manned Space Flight," November 3, 1964.
- 5** MSC authorized Grumman to proceed with procurement of a battery charger for the LEM, to replenish the portable life support system's power source. On the following day, Houston informed North American such a device was no longer needed in the CSM.
- TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, November 5, 1964; letter, H. P. Yschek, MSC, to NAA, Space and Information Systems Div., "Contract Change Authorization No. 269," November 6, 1964.
- 5** The Apollo Space Suit Assembly received a new designation, the Apollo Extravehicular Mobility Unit. The purpose of the change was to make it more descriptive of its function in the Apollo mission.
- Memorandum, Maxime A. Faget, MSC, to Distr., "Change in Designation of the Apollo Space Suit Assembly (SSA)," November 5, 1964.
- 5-12** Engineers from Grumman and the MSC Instrumentation and Electronics Systems Division (IESD) reviewed the coverage requirements for the LEM's

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S-band radio and the incompatibility of those requirements with the present location of the steerable antenna. Most observers felt that a deployable boom was the only feasible solution. The two groups therefore recommended that IESD verify with ASPO the S-band coverage requirements and that Grumman analyze the design effects of such a boom. In the meantime, Dalmo-Victor, the antenna vendor, should continue its design effort on the basis of the current location.

MSC, "ASPO Weekly Management Report, November 5-12, 1964."

During a mechanical loading test (simulating a 20-g reentry) the CM aft heatshield failed at 120 percent of maximum load. Structures and Mechanics Division engineers inspected the structure. They found that the inner skin had buckled, the damage extending three quarters of the way around the bolt circle that secured the heatshield to the spacecraft's inner structure. Their findings would be used along with data from the recent drop of boilerplate 28 to determine what redesign was necessary.

Ibid.

MSC informed North American that a flashing light on the CSM, as an aid for visual rendezvous, was not required. [A request for some such device had been generated at the Block II mockup review.] Houston's position was based on the current CSM/LEM configuration, which called for rendezvous radar on both spacecraft and the ability of both vehicles to effect the rendezvous using either its own radar or that in the target vehicle.

5-12

Ibid.

Engineers from the MSC Crew Systems Division and from North American discussed testing of the breadboard environmental control system. During all flights—both manned and unmanned—North American must monitor the cabin atmosphere by gas chromatography and mass spectrography. The company should also compare the materials for the breadboard with those for Mercury, Gemini, and other applicable space chambers.

5-12

Ibid.; memorandum, Frank H. Samonski, Jr., MSC, to R. C. Stults, "Transmission and coordination of Request for Engineering Change Proposal (RECP) to add a gas chromatograph in the North American Aviation environmental control system (ECS) breadboard test facility," November 18, 1964.

ASPO officials completed a preliminary evaluation of the design and weight implications of an all-battery electrical power system (EPS) for the LEM. Investigators reviewed those factors that resulted in the decision (in March 1963) to employ fuel cells; also, they surveyed recent technological improvements in silver-zinc batteries.

5-12

At about the same time, Grumman was analyzing the auxiliary battery requirements of the spacecraft. The contractor found that, under the worst

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possible conditions (i.e., lunar abort), the LEM would need about 1700 watt-hours of auxiliary power. Accordingly, Grumman recommended one 1700 watt-hour or two 850 watt-hour batteries (23 and 29.5 kg [50 and 65 lbs], respectively) in the spacecraft's ascent stage.

MSC would use both Grumman's and ASPO's findings in determining the final design of the LEM's EPS.

MSC, "ASPO Weekly Management Report, Nov. 5-12, 1964."

6 By this date, all major LEM subcontracts had been let.

"NASA Administrator's Apollo Program Review, LEM Program," November 6, 1964, item A-10.

6 NASA anticipated five significant milestones for the LEM during the forthcoming year:

- (1) A major review of the entire LEM program (with especial emphasis upon the fiscal picture for 1965 and 1966)
- (2) Start of production on LEM-1 (the first LEM flight article)
- (3) Delivery of LEM Test Article (LTA)-2 (a dynamic test article) to Huntsville
- (4) Start of vibration and static testing on the complete LEM structure
- (5) Sea level and altitude qualification testing in the continuing development of the LEM's propulsion systems.

Ibid., item C.

9 NASA and AC Spark Plug amended the company's contract for guidance and navigation equipment. The change embodied an incentive clause, based on a cost-schedule-performance scheme, and placed the estimated cost of the contract at \$235 000 000.

MSC, "Consolidated Activity Report for the Office of the Associate Administrator, Manned Space Flight, October 18-November 30, 1964," p. 39.

10 MSC's Structures and Mechanics Division and ASPO reviewed the LTA-10 test program to resolve the stop-work imposed upon Grumman. The review resulted in an agreement to have LTA-10 remain in the program with a modified configuration. LTA-10 would be used by North American at Tulsa, Oklahoma, for adapter/LEM modal and separation testing and would consist only of descent stage structure. Subsystems for LTA-10 which were eliminated were the ascent stage, landing gear, ascent propulsion and descent propulsion.

Memorandum, W. F. Rector III, MSC, to LEM Contracting Officer, "Contract NAS 9-1100, Deletion of Stop Work Order on LTA-10," November 10, 1964.

Joseph G. Thibodaux, Jr., MSC Propulsion and Power Division, reported at an Apollo Engineering and Development technical management meeting that the first J-2 firing of the service propulsion system engine was conducted at White Sands Missile Range (WSMR). Two fuel cell endurance tests of greater than 400 hours were completed at Pratt and Whitney. MSC would receive a single cell for testing during the month.

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10

MSC, "Minutes, Apollo/E and D Technical Management Meeting No. 9, November 10, 1964."

There appeared to be some confusion and/or disagreement concerning whether one or two successful Saturn V reentry tests were required to qualify the CM heatshield. A number of documents relating to instrumentation planning for the 501 and 502 flight indicated that two successful reentries would be required. The preliminary mission requirements document indicated that only a single successful reentry trajectory would be necessary. The decision would influence the measurement range capability of some heatshield transducers and the mission planning activity being conducted by the Apollo Trajectory Support Office. The Structures and Mechanics Division had been requested to provide Systems Engineering with its recommendation.

12-19

MSC, "ASPO Weekly Activity Report, November 12-19, 1964."

More careful examination of the boilerplate 28 aft heatshield indicated that the shear failures were in the face sheet splices which were not in the same locations as the core splices.

12-19

Ibid.

In its search for some method of reducing water impact pressures, North American was considering adding a 15- to 30.5-cm (6- to 12-in) "lump" to the CM's blunt face. The spacecraft manufacturer was also investigating such consequent factors as additional wind tunnel testing, the effect on heatshield design, and impact upon the overall Apollo program.

12-19

Ibid.

MSC reviewed a number of alternatives to the current design of the space suit helmet. Engineers selected a modified concept, one with the smallest feasible dimensions and began fabricating a thin fiber glass shell. The product would serve as the test article in a series of tests of an immobile, bubble-type helmet. The whole of this effort would support MSC's in-house program to find the best possible helmet design.

12-19

Ibid.

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12-19 MSC analyzed Grumman's report on their program to resize the LEM. On the basis of this information, ASPO recommended that the propellant tanks be resized for separation and lunar liftoff weights of 14 742 and 4908 kg (32 500 and 10 820 lbs), respectively. Studies should investigate the feasibility of an optical rendezvous device and the substitution of batteries for fuel cells. And finally, engineering managers from both Grumman and MSC should examine a selected list of weight reduction changes to determine whether they could immediately be implemented.

Ibid.; letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, LEM Weights Meeting," November 19, 1964; Bob Button, MSC, "Apollo Status," November 20, 1964.

12-19 Shorting had become a significant problem in the LEM fuel cells, and exemplified the continuing difficulties that plagued the system's development.

MSC, "ASPO Weekly Activity Report, November 5-12, 1964."

13 Robert E. Smylie, of the MSC Crew Systems Division, cited Hamilton Standard's reliability figures for the Apollo space suit assembly, including the suit per se and the portable life support system (PLSS):

<i>Item</i>	<i>Mission Success</i>	<i>Crew Safety</i>
Space suit	.9995	.99991
PLSS (Liquid cooled)	.9995	.99999
Complete assembly	.999	.9999

Memorandum, Robert E. Smylie, MSC, to Crew Integration Branch, Attn: C. Haines, "Space Suit Assembly Reliability Apportionment," November 13, 1964.

13 MSC defined the requirements for visual docking aids on both of the Apollo spacecraft:

- At a range of 305 m (1000 ft), the astronaut must be able to see the passive spacecraft and determine its gross attitude.
- From 61 m (200 ft) away, he must be able to judge the target's relative attitude and the alignment of his own vehicle.
- And from this latter distance—and still solely through visual means—the pilot must be able to calculate the distance between the two spacecraft and the closing rate.

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, November 13, 1964; MSC, "ASPO Weekly Activity Report, November 12-19, 1964."

16 NASA test pilot Joseph A. Walker flew the LLRV for the second time. The first attempted liftoff, into a 9.26-km (5-nm) breeze, was stopped because of excessive drift to the rear. The vehicle was then turned to head downwind and liftoff was accomplished. While airborne the LLRV drifted with the

wind and descent to touchdown was accomplished. Touchdown and resulting rollout (at that time the vehicle was on casters) took the LLRV over an iron-door-covered pit. One door blew off but did not strike the vehicle.

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Pilot Report, Joseph A. Walker, November 16, 1964.

Crew Systems Division (CSD) was proceeding with procurement of an in-flight metabolic simulator in response to a request by Systems Engineering Division. The simulator would be used to support the LEM mission for

16

NASA test pilot Joseph A. Walker walks away from the LLRV after a successful flight (note the casters on the vehicle).



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SA-206 and would be compatible for use in the CM. Responsibility for the project had been assigned to the Manager of the LEM Environmental Control System Office. It was projected that the Statement of Work would be completed by January 15, 1965; the proposals evaluated by April 1; the contract awarded by June 1, 1965; the prototype delivered by April 1, 1966, with two qualified simulator deliveries by July 1, 1966.

Letter, Richard S. Johnston, MSC, to Chief, Engineering Systems Division, "Inflight metabolic simulator," November 16, 1964.

16-December 15

After investigating the maximum radiation levels that were anticipated during Apollo earth orbit missions, North American confirmed the need for some type of nuclear particle detection system (NPDS). Except for periods of extremely high flux rates, the current design of the NPDS was considered adequate. During the same reporting period, North American awarded a contract to Philco to build the system.

NAA, "Apollo Monthly Progress Report," SID-62-300-32, January 1, 1965, p. 18.

17-18

The Emergency Detection System (EDS) Design Sub-Panel of the Apollo-Saturn Electrical Systems Integration Panel held its first meeting at North American's Systems and Information Division facility at Downey, Calif. A. Dennett of MSC and W. G. Shields of MSFC co-chaired the meeting.

Personnel from MSC, MSFC, KSC, OMSF, and North American attended the meeting. Included in the discussions were a review of the EDS design for both the launch vehicle and spacecraft along with related ground support equipment; a review of the differences of design and checkout concepts; and a review of EDS status lights in the spacecraft.

Proceedings, Emergency Detection System Design Sub-Panel of the Apollo-Saturn Electrical Systems Integration Panel, sgd. A. Dennett and W. G. Shields, December 2, 1964.

17-18

The Apollo Mission Planning Task Force met in Bethpage, New York, to define prelaunch handling procedures at the launch complex during lunar missions. At the meeting were representatives of those groups most intimately concerned with pad operations—ASPO and the MSC Flight Operations Directorate, Grumman, North American, GE, and the Kennedy launch center. The task force agreed on several fundamental items:

- The mobile arming tower (MAT) would be installed just once, and would be moved back only for the final launch preparations (at T minus seven hours).
- All operations that had to be performed with the MAT removed should be accomplished before that structure was mated to the launch umbilical tower.
- Checkout equipment would be removed for simulated flights and

would be reconnected only after data from the simulation had been evaluated.

- Total pad time was set at 12 days.

MSC, "ASPO Weekly Management Report, November 26–December 3, 1964."

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Ling-Temco-Vought received a contract from MSC, valued at \$365 000, for unmanned testing of Gemini and Apollo space suits in the firm's space environment simulator.

18

Space Business Daily, November 18, 1964, p. 84.

MSC's Assistant Director for Flight Crew Operations, Donald K. Slayton, told the Apollo Program Manager that the current display and keyboard (DSKY) for the Block II CSM and for the LEM were not compatible with existing display panel design of both vehicles from the standpoint of lighting, nomenclature presentation, and caution/warning philosophy. In his memorandum, Slayton pointed out mandatory operational requirements of the DSKY to ensure compatibility and consistency with the existing spacecraft display panel design.

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With reference to lighting, he said all numerics should be green, nomenclature and status lights white, and caution lights should be aviation yellow. All panel lighting should be dimmable throughout the entire range of brightness, including off.

In regard to nomenclature, Slayton pointed out that abbreviations on the DSKY should conform to the North American Interface Control Document (ICD). The referenced ICD was being reviewed by Grumman and North American and was scheduled to be signed December 1, 1964.

Referring to the caution and warning system, he pointed out that all caution lights on the DSKY should be gated into the primary navigation and guidance system (PNGS) caution light on the main instrument panel of both vehicles and into the PNGS caution light on the lower equipment bay panel of the CM.

Slayton requested that preliminary designs of the DSKY panel be submitted to the Subsystem Managers for Controls and Displays for review and approval.

Memorandum, Donald K. Slayton, MSC, to Apollo Program Manager, "Incompatibility of DSKY with LEM and CM Controls and Displays," November 19, 1964.

MSC was giving serious thought to using radioisotope generators to power the Apollo lunar surface experiments packages. If some method could be found to control waste heat, such a device would be the lightest source of power available. Accordingly, the Center asked Grumman to study the

19

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feasibility of incorporating it into the LEM's scientific payload. The company should analyze thermal and radiological problems, as well as methods of stowage, together with the possibility of using the generator for power and heat during the flight. To minimize the problem of integration, Grumman was allowed much flexibility in designing the unit. Basically, however, it would measure about .07 cu m (2.5 cu ft) and would weigh between 13 and 18 kg (30 and 40 lbs). Its energy source (plutonium 238) would produce about 50 watts of electricity (29 volts, direct current).

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Radioisotope power supply for lunar scientific experiments," November 19, 1964; MSC, "ASPO Weekly Management Report, November 19-26, 1964."

19-26

The MSC-Marshall Space Flight Center (MSFC) Guidance and Control Implementation Sub-Panel set forth several procedural rules for translunar injection (TLI):

- Once the S-IVB ignition sequence was started, the spacecraft would not be able to halt the maneuver. (This would occur about 427 sec before the stage's J-2 engine achieved 90 percent of its thrust capability.)
- Because the spacecraft would receive no signal from the instrument unit (IU), the exact time of sequence initiation must be relayed from the ground.
- The vehicle's roll attitude would be reset prior to injection.
- And when the spacecraft had control of the vehicle, the IU would not initiate the ignition sequence.

Memorandum, Secretaries, Guidance and Control Implementation Sub-Panel, MSFC and MSC, to Distr., "Action Items and Agreements from the Guidance and Control Implementation Sub-Panel Meeting" (November 17, 1964), November 19, 1964; with enclosures; MSC, "ASPO Weekly Management Report, November 19-26, 1964."

19-26

To solve the persisting problem of the integrity of the CM's aft heatshield during water impacts, MSC engineers were investigating several approaches: increasing the thickness of the face sheet (but with no change to the core itself); and replacing the stainless-steel honeycomb with a type of gridwork shell. Technicians felt that, of these two possibilities, the first seemed more efficient structurally.

MSC, "ASPO Weekly Management Report, November 19-26, 1964."

North American and Grumman agreed on the alignment of the two spacecraft during docking maneuvers: the LEM's overhead window would be aligned with right-hand docking window of the CM.

Ibid.

MSC determined that the lights on the fingertips of the space suits were adequate to supplement the CM's interior lighting. Thus North American's efforts to develop a portable light in the spacecraft were canceled. The exact requirements for those fingertip lights now had to be defined. The astronauts preferred red bulbs, which would necessitate a redesign of the existing Gemini system. [See October 29–November 5.]

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Ibid.; letter, C. L. Taylor, MSC, to NAA, Attn: J. C. Cozad, "Contract NAS 9-150, Crewman portable light," November 4, 1964.

The MSC Crew Systems Division reviewed the extravehicular mobility unit micrometeoroid protection garment. It was estimated a total weight of 13 to 18 kg (30 to 40 lbs) would be required for the two micrometeoroid protection garments which had a crew safety reliability goal of 0.9999 for the meteoroid hazard. Ground rules for their design were being defined.

19–26

MSC, "ASPO Weekly Management Report, November 19–26, 1964"; memorandum, Robert E. Smylie, MSC, to Paige B. Burbank, "Investigation of meteoroid protection for Apollo space suit," December 9, 1964.

MSC conducted studies to determine problems in donning and doffing the Apollo external thermal garment (ETG) and portable life support system (PLSS) by a subject in a full-pressure suit. The subject donned and doffed the ETG and PLSS unassisted with the suit in a vented condition and with assistance while the suit was pressurized to 25.5 kilonewtons per sq m (3.7 psig). Tests showed the necessity of redesigning the ETG in the neck and chest area to prevent a gathering of excess material which restricted downward visibility.

19–26

MSC, "ASPO Weekly Management Report, November 19–26, 1964"; memorandum, Francis J. DeVos, MSC, to Chief, Crew Systems Div., "Trip Report—Contract NAS 9-2820," November 19, 1964.

Officials from North American and MSC Crew Systems Division defined the container design and stowage of survival kits in the Block II CM. The equipment would be packed in fabric rucksacks and would be installed in the spacecraft's stowage compartment. [This method eliminated a removable hard container used in the Block I vehicle and would save weight.]

19–26

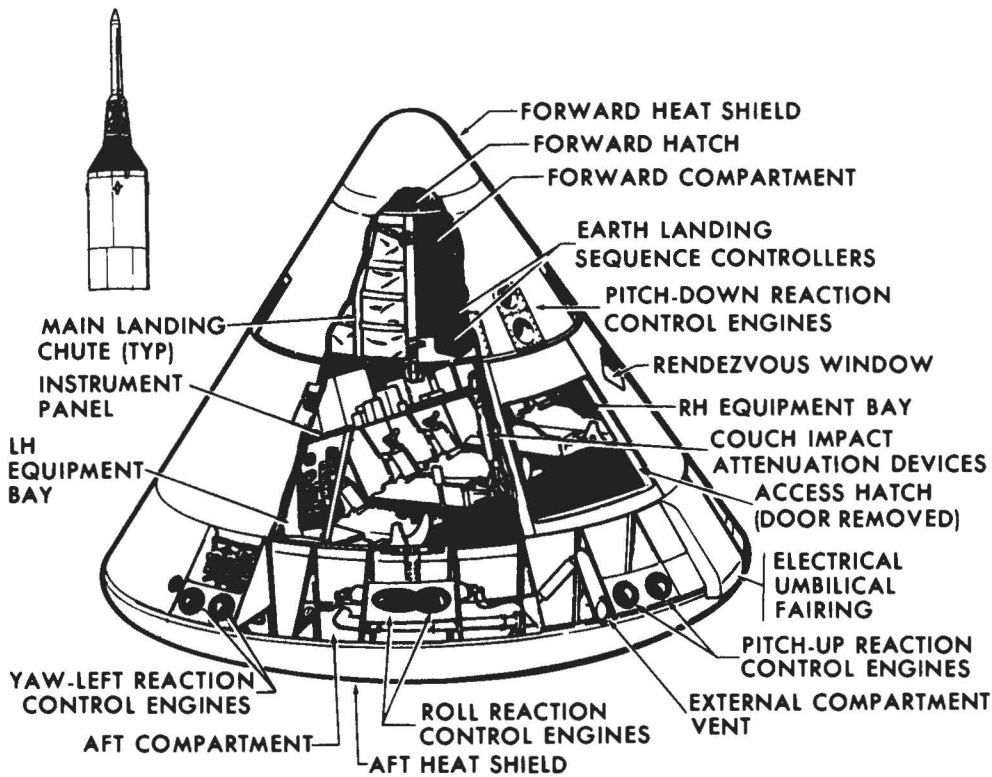
MSC, "ASPO Weekly Management Report, November 19–26, 1964"; letter, C. L. Taylor, MSC, to NAA, Attn: J. C. Cozad, "Contract NAS 9-150, Block II mockup—request for change disposition," December 1, 1964.

To ensure that the redesigned landing gear on the resized LEM would be consistent with earlier criteria, MSC sent to Grumman revisions to those design criteria:

19–26

- Maximum rate of descent—3.05 m (10 ft) per sec

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- Maximum horizontal velocity—1.22 m (4 ft) per sec
 - Maximum attitude rates (any axis)—3 degrees per sec
- MSC, “ASPO Weekly Management Report, November 19–26, 1964.”
- 19–26**
- In flights that simulated the moon’s gravity, MSC technicians evaluated the astronaut’s ability to remove scientific packages from the descent stage of the LEM. They affirmed the relative ease with which large containers (about .226 cu m [8 cu ft] and weighing 81.65 kg [180 lbs]) could be extracted and carried about.
- Ibid.*
- 19–26**
- The current thrust buildup time for the LEM ascent engine was .3 second. To avoid redesigning the engine valve—which was already the pacing item in the ascent engine’s development—MSC directed Grumman simply to change the specification value from .2 to .3 second.
- At the same time, engineers at the Center began studying ways to increase the engine’s thrust. Because of the LEM’s weight gains, the engine must either be uprated or it would have to burn longer. Preliminary studies showed that, by using a phase “B” chamber (designed for a chamber pressure of 689.5 kilonewtons per sq m (100 psia)), thus producing chamber pressure of about 792.9 kilonewtons (115 psia), the thrust could be increased from 1587 to 1814 kg (3500 to 4000 lbs). Moreover, this could be accomplished with the present pressurization and propellant feed systems.
- Ibid.*; TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, November 27, 1964.
- 19–26**
- MSC and Grumman representatives reviewed individual subsystem test logics for the LEM and agreed on test logic and associated hardware requirements for the entire subsystem development. Agreement was also reached on the vehicle ground test program which Grumman proposed to implement with their respective subcontractors during December. Cost and effort associated with the revised program would be jointly reviewed by MSC and Grumman during January and February 1965.
- Memorandum, W. F. Rector III, MSC, to LEM Subsystem Managers, “Subsystem Test Logic and Hardware Review at GAEC,” November 18, 1964; MSC, “ASPO Weekly Management Report, November 19–26, 1964”; memorandum, W. F. Rector III, MSC, to Chief, Program Control Div., “Staff Meeting Actions,” November 20, 1964, with enclosures.
- 19–26**
- MSC asked Grumman to design and fabricate a prototype for a lunar sample return container. This effort would explore handling procedures and compatibility with both spacecraft. Concurrently, the Center’s Advanced



Apollo Command Module, Block II.

Spacecraft Technology Division was studying structural and packaging requirements for such a container.

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MSC, "ASPO Weekly Management Report, November 19-26, 1964."

NASA concluded contract negotiations with AC Spark Plug for Apollo guidance and navigation equipment.

23

Ibid.

North American received NASA's formal go-ahead on manufacture of the Block II spacecraft.

23

Ibid.

The CSM Configuration Control Panel, at its first meeting, approved several engineering changes. Perhaps the most significant was the substitution of an elapsed time display for the clock on the main display console.

23

Ibid.

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23 A “pre-FRR” laid some preliminaries for the formal Flight Readiness Review (FRR) of boilerplate 23 (held at WSMR on December 4, 1964). Because the boost protective cover had not been designed to sustain the dynamic pressures that would follow deployment of the canards and vehicle “turn-around,” North American was asked to analyze the possibility of its failing.

Several other problems were aired—fluttering of the canards and the likelihood of damage to the parachute compartment during jettisoning of the launch escape tower and the boost cover. Joseph N. Kotanchik, chief of the Structures and Mechanics Division, confidently reported to ASPO that “these items will also be resolved prior to the FRR.”

MSC, “Minutes, Mission A-002 (BP 23/LJ II 12-51-1), Preliminary Flight Readiness Review, November 23, 1964”; MSC, “ASPO Weekly Management Report, November 26–December 3, 1964.”

23 Grumman and MSC representatives met at Bethpage, New York, to establish requirements for a new hardware delivery schedule for the LEM ground development test program. This program would involve changes in the workload at the subcontractors, WSMR, AEDC, and Grumman. New delivery schedules for flight engines were also finalized at the meeting.

MSC, “ASPO Weekly Management Report, November 26–December 3, 1964.”

23–25 MSC and Grumman reviewed the ground test program for the LEM guidance and navigation subsystem (including radar). All major milestones for hardware qualification would be met by the revised test logic, and both LEM and CSM radar were expected to be delivered on time. The major problem area was permissible deviations from fully qualified parts for pre-production equipment. Since this was apparently true for all LEM electronics equipment, it was recommended that an overall plan be approved by ASPO.

Ibid.

25 ASPO Manager Joseph F. Shea informed Apollo Program Director Samuel C. Phillips that it was his desire to review the progress of the two subcontractors (Space Technology Laboratory and Rocketdyne) prior to the final evaluation and selection of a subcontractor for the LEM descent engine.

Shea had asked MSC’s Maxime A. Faget to be chairman of a committee to accomplish the review, and would also ask the following individuals to serve: C. H. Lambert, W. F. Rector III, and J. G. Thibodaux, all of MSC; L. F. Belew, MSFC; M. Dandridge and J. A. Gavin, Grumman; I. A. Johnsen, Lewis Research Center; C. H. King, OMSF; Maj. W. R. Moe, Edwards

Rocket Research Laboratory; and A. O. Tischler, NASA Office of Advanced Research and Technology.

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The Committee should (1) establish review criteria during a planning meeting at MSC during the week of November 30, 1964; (2) visit the two subcontractors' facilities during the week of December 7, 1964, for review of technical status, manufacturing resources, and test facilities; and (3) prepare a written report and brief appropriate NASA personnel on their findings by December 18, 1964.

"Both GAEC and NASA will be parties to the final selection and it is not my intent to usurp GAEC's responsibility in this matter; but I do feel we should have the intelligence at our disposal to appreciate all ramifications of GAEC's final selection," Shea said.

Letter, Joseph F. Shea, MSC, to Maj. Gen. Samuel C. Phillips, November 25, 1964.

The Configuration Control Panel approved a deployment angle of 45° for the adapter panels on Block I flights. North American anticipated no schedule impact. MSC and North American were jointly evaluating the acceptability of this angle for Block II missions as well. A most important consideration was the necessity to communicate via the CM's high-gain antenna during the transposition and docking phase of the flight.

26-December 3

MSC, "ASPO Weekly Management Report, November 26-December 3, 1964."

MSC's Flight Operations Directorate accepted KSC's proposal for emergency nitrogen deluge into the SM and spacecraft/LEM adapter (SLA) in case of a hydrogen leak on the pad. The proposal was based upon no changes to the spacecraft and insertion to the SM/SLA area in about three minutes. However, errors in volume estimation and inlet conditions in the spacecraft required reevaluation of the proposal to assure that insertion could be accomplished in a reasonable length of time without changes in the spacecraft.

26-December 3

Ibid.

Because of heat from the service propulsion engine (especially during insertion into lunar orbit), a serious thermal problem existed for equipment in the rear of the SM. Reviewing the rendezvous radar's installation, the Guidance and Control Division felt that a heatshield might be needed to protect the equipment. Similar problems might also be encountered with the steerable antenna.

26-December 3

Ibid.

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26–December 3 MSC informed North American that the Center would furnish a VHF transmitter to serve as a telemetry dump for all manned Block I flights. This would permit wide flexibility in testing the CSM S-band's compatibility with the Manned Space Flight Network prior to Block II missions.
- Ibid.*
- 26–December 3** Crew Systems Division (CSD) engineers evaluated the radiator for the environmental control system in Block I CSM's. The division was certain that, because of that item's inadequacy, Block I missions would have to be shortened.
- During the same period, however, the Systems Engineering Division (SED) reported "progress" in solving the radiator problem. SED stated that some "disagreement" existed on the radiator's capability. North American predicted a five-day capability; CSD placed the mission's limit at about two days. SED ordered further testing on the equipment to reconcile this difference.
- Ibid.*
- 26–December 3** Crew Systems Division gave space suit manufacturers the responsibility of providing personal communications equipment in their products.
- Ibid.*
- 26–December 3** Bell Aerosystems Company tested a high-performance injector for the LEM ascent engine. The new design was similar to the current one, except that the mixture ratio of the barrier flow along the chamber wall had been changed from .85 to 1.05. Bell reported a performance increase of .8 percent (about 2.5 sec of specific impulse). Subsequent testing, however, produced excessive erosion in the ablative wall of the thrust chamber caused by the higher temperature. The MSC Propulsion and Power Division (PPD) felt this method of increasing the ascent engine's performance might not be practicable.
- At the same time, PPD reported that Bell had canceled its effort to find a lighter ablative material (part of the weight reduction program). A number of tests had been conducted on such materials; none was successful.
- Ibid.*; "ASPO Weekly Management Report" [December 10, 1964–January 7, 1965]; TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, November 27, 1964.
- 26–December 3** Grumman selected the Leach Corporation to supply data storage electronics assemblies for the LEM. Conclusion of contract negotiations was anticipated

about February 1, 1965. The resident Apollo office at Grumman gave its approval to the selection, with only two conditions: (1) because of its toxic characteristics, beryllium must not be used in the assemblies; and (2) Leach should demonstrate the feasibility of the proposed time-voice multiplexing scheme.

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MSC, "ASPO Weekly Management Report, November 26–December 3, 1964."

General Precision's Link Group received a \$7 million contract from NASA, through a subcontract with Grumman, for two LEM simulators, one at Houston and the other at Cape Kennedy. Along with comparable equipment for the CSM (also being developed by Link), the machines would serve as trainers for Apollo astronauts. The devices would duplicate the interior of the spacecraft; and visual displays would realistically simulate every phase of the mission.

27

Space Business Daily, November 27, 1964, p. 124.

North American tested the canard thrusters for the launch escape system, using both single and dual cartridges. These tests were to determine whether the pressure of residual gases was sufficient to maintain the canards in a fully deployed position. Investigators found that residual pressures remained fairly constant; further, the firing of a single cartridge produced ample pressure to keep the canards deployed.

30

"Apollo Monthly Progress Report," SID-64-300-32, pp. 1, 3, 31; "ASPO Weekly Management Report, November 26–December 3, 1964."

Acceptance testing was completed at Downey, California, on three principal systems trainers for the CSM (the environmental control, stabilization and control, and electrical power systems). The trainers were then shipped to Houston and installed at the site, arriving there December 8. They were constructed under the basic Apollo Spacecraft contract at a cost of \$953 024.

30

"Apollo Monthly Progress Report," SID-62-300-31, p. 24; "ASPO Weekly Management Report, December 3–10, 1964"; MSC News Release 64-191, December 8, 1964.

Six flights of the Lunar Landing Research Vehicle (LLRV) were made during the month, bringing the total number to seven. The project pilot, Joseph Walker, made all flights and demonstrated a rapid increase in the ease and skill with which he handled the craft as the flights progressed.

During
the
Month

Altitudes to between 18 and 21 m (60 and 70 ft) and flight duration up to three minutes were attained. With the jet engine remaining vertical, attitude angles in excess of 20° were demonstrated in both pitch and roll. Lift

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rockets were used on the last four flights. Six knots (6 n mi per hr) had been tentatively set as the maximum permissible wind velocity for flying.

November

Letter, Office of Director, Flight Research Center, to NASA Headquarters, "Lunar Landing Research Vehicle progress report No. 17 for period ending November 30, 1964," sgd. De E. Beeler for Paul F. Bikle, December 8, 1964.

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3-10

After studying increased thrust versus increased burn time, Grumman ordered Bell Aerosystems Company to redesign the LEM's ascent engine for a longer firing duration.

GAEC, "Monthly Progress Report No. 23," LPR-10-39, January 10, 1965, p. 12; MSC, "ASPO Weekly Management Report, December 3-10, 1964."

3-10

MSC approved plans put forth by North American for mockups of the Block II CSM. For the crew compartment mockup, the company proposed using the metal shell that had originally been planned as a simulator. Except for the transfer tunnel and lighting, it would be complete, including mockups of all crew equipment. Mockup 12, the Block I lighting tool, would be modified to conform to the interior of Block II spacecraft.

Systems Engineering Division reported the latest review schedule for the Block II mockups:

March 15, 1965—crew compartment

April 30, 1965—interior lighting

July 15, 1965—Design Engineering Inspection (DEI)

August 6, 1965—lighting DEI

"ASPO Weekly Management Report, December 3-10, 1964"; letter, C. L. Taylor, MSC, to NAA, Attn: J. C. Cozad, "Contract NAS 9-150, Delivery of Government furnished crew equipment for Block II mockup," December 22, 1964.

3-10

MSC froze the design of the drogue mortar for the launch escape system. Laboratory qualification was scheduled to begin about the middle of the month. Qualification of the mortars for the pilot parachute would then follow.

"ASPO Weekly Management Report, December 3-10, 1964."

3-10

Engineering and medical experts of the Crew Systems Division reviewed dumping helium from the CM's gas chromatograph into the cabin during reentry or in a pad abort. Reviewers decided that the resultant atmosphere (9.995 kilonewtons [1.45 psi] helium and 31.349 kilonewtons [4.55 psia] oxygen) posed no hazard for the crew. Systems Engineering Division recom-

mended, however, that dump time be reduced from 15 minutes to three, which could readily be done.

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MSC, "Consolidated Activity Report for Office of the Associate Administrator, Manned Space Flight, December 1964," p. 46.

At its Sacramento test site, Douglas Aircraft Company static-fired a "battleship" S-IVB second stage of the Saturn IB vehicle, for 10 sec. (A battleship rocket stage was roughly the vehicle's equivalent to a boilerplate spacecraft.) On January 4, 1965, after further testing of the stage's J-2 engine, the stage underwent its first full-duration firing, 480 sec.

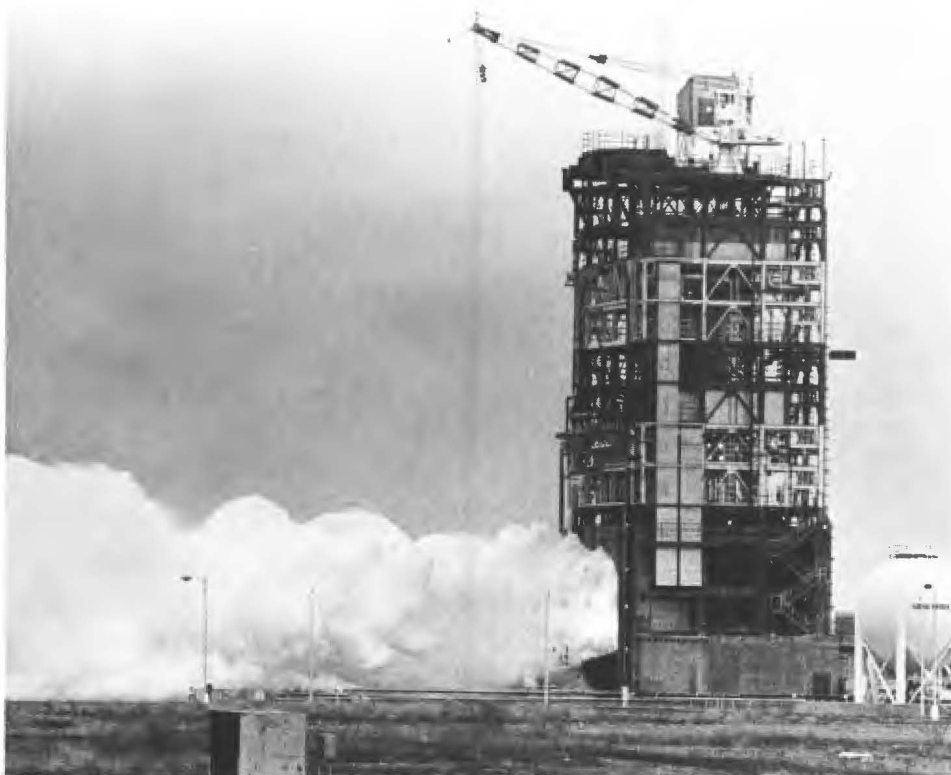
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Space Business Daily, December 4, 1964, p. 159.

Douglas Aircraft Company delivered the first S-IVB stage to Marshall Space Flight Center for extensive vibration, bending, and torsional testing. The

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FIRST FIRING MILESTONE—Flame and smoke spew from Saturn S-IVB upper stage in its first full-power "hot" firing at Douglas Sacramento Test Center, marking a major milestone in development of MSFC's Saturn launch vehicle. With thick, stainless-steel propellant tanks, instead of lightweight aluminum, the S-IVB "battleship" test stage was used by Douglas engineers in an extensive ground test program to prove out the design of the S-IVB.



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stage was not an actual flight stage and contained mockups of the engine and other components, but it duplicated the flight article in weight, mass, center of gravity, and stiffness.

Ibid., December 7, 1964, p. 167.

- 7 MSC ordered North American to fix the rotation angle of the adapter panels at 45 degrees. (This angle should give ample clearance during an SM abort.) Also, so that each panel would have two attenuators, North American should include such a device at each thruster location. (See June 16, 1965.)

On the same day, the Center directed North American to put a standard mechanical clock (displaying Greenwich Mean Time) in the lower equipment bay of the CM. [The spacecraft also had an elapsed time device on the main display console.]

Letter, H. P. Yschek, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 275," December 7, 1964; letter, H. P. Yschek, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 277," December 7, 1964.

- 7 MSC advised Grumman that, normally, the LEM would be the active vehicle during lunar rendezvous. This would conserve reaction control system propellants aboard the CSM.

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, December 7, 1964.

- 8 Boilerplate 23, Mission A-002, was successfully launched from WSMR by a Little Joe II launch vehicle. The test was to demonstrate satisfactory launch escape vehicle performance utilizing the canard subsystem and boost protective cover, and to verify the abort capability in the maximum dynamic pressure region with conditions approximating emergency detection subsystem limits. (See objectives in Appendix 5.)

"Apollo Monthly Progress Report," SID 62-300-32, p. 31; *Astronautics and Aeronautics*, 1964, p. 410.

- 8 A single main parachute was drop-tested at El Centro, Calif., to verify the ultimate strength. The parachute was designed for a disreef load of 11 703 kg (25 800 lbs) and a 1.35 safety factor. The test conditions were to achieve a disreef load of 15 876 kg (35 000 lbs). Preliminary information indicated the parachute deployed normally to the reefed shape (78 017 kg [17 200 lbs] force), disreefed after the programmed three seconds, and achieved an inflated load of 16 193 kg (35 700 lbs), after which the canopy failed. North American representatives would visit MSC during the week of December 14 to discuss this and other recent tests.

NAA, "Apollo Monthly Progress Report," SID 62-300-33, February 1, 1965, pp. 3-4; "ASPO Weekly Management Report, December 3-10, 1964."

Representatives of MSC's Information and Electronic Systems Division, Flight Operations Division, Flight Crew Operations Division, Guidance and Control Division, Astronaut Office, and ASPO, Goddard Space Flight Center, and Bellcomm, Inc., met to discuss communications during LEM and CSM rendezvous.

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8

Capability of the Manned Space Flight Network (MSFN) to provide data for rendezvous was studied. Aaron Cohen of ASPO stated sufficient data could be collected, processed, and transmitted via MSFN to the LEM to achieve rendezvous. Dr. F. O. Vonbun of Goddard showed that MSFN data did little to improve data already available in the LEM before launch. Although five tracking stations would communicate with the LEM during ascent and the first 10 minutes of orbit, there would be only a slight improvement in spacecraft position and motion data over the data already contained in the LEM computer. No decision was made concerning the MSFN's capability.

Alternate rendezvous methods were discussed.

Memorandum, Donald G. Wiseman, MSC, to Chief, Instrumentation and Electronic Systems Division, "Meeting on LEM/CSM rendezvous," December 9, 1964.

The Space Science Board of the National Academy of Sciences was asked to give NASA an independent evaluation of the need for a lunar sampling handling facility at Houston. NASA asked that the following questions be answered:

8

- What types of lunar sample analyses need to be done immediately upon return of the samples from the moon?
- What types of research can better be postponed until analyses can be handled at the best available research facility?
- What types of scientific research and handling facilities do you anticipate will be needed for such analyses?
- What do you anticipate in terms of manpower requirements for MSC to handle scientific activities in such a facility?

Letter, Homer E. Newell, NASA Associate Administrator for Space Science and Applications, to Dr. Harry H. Hess, Chairman, Space Science Board, December 8, 1964.

Grumman received from Houston criteria for firing times of the SM reaction control system (RCS). These served as a basis for the design of the LEM's steerable antenna. The thermal design proposed by Dalmo-Victor, the vendor, appeared feasible to watchdogs in MSC's Instrumentation and Electronic Systems Division. On the other hand, the unbalanced wind torque produced by the RCS engines was still a problem. RCA and Dalmo-Victor's estimates of the amount of torque varied considerably, and Grumman consequently undertook a study of this problem.

9

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December
- MSC, "ASPO Weekly Management Report, November 26–December 3, 1964"; TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, November 19, 1964; TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, December 9, 1964.
- 9 MSC revised the weight allocation for the LEM's R&D instrumentation to bring it in line with current mission planning. Limitations established were 295 kg (650 lbs) for 206A and 181 kg (400 lbs) for all other missions.
- Memorandum, W. F. Rector III, MSC, to Chief, Instrumentation and Electronic Systems Division, Attn: N. Farmer, "Lem 1, 2, and 3 measurement requirements," December 9, 1964; letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, LEM 1, 2, and 3 Measurement Requirements," December 14, 1964.
- 9 MSC approved the use of one 23.68-kg (50-lb) auxiliary battery for the LEM, as recommended by Grumman, and preparations began for negotiations with Yardney Electric Corp.
- TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, December 9, 1964; "Monthly Progress Report No. 23," LPR-10-39, p. 23.
- 9 Avco Corporation was under a 10-month contract (amounting to \$124 578) to MSC to study the effects of solar radiation and ultra-high vacuum on the materials and components of space suits. Testing would be performed in the Avco space environment chamber.
- Space Business Daily*, December 9, 1964, p. 185.
- 9-10 Grumman and LEM Project Office representatives met to discuss the split bus distribution system. They decided there would be two circuit breaker panels similar to those of Mockup 5. All power distribution system controls would be located on the system engineer's center side console with remote controls and valves on the commander's center side console.
- "Monthly Progress Report No. 23," LPR-10-39, p. 17.
- 10-January 7 Because of faults in both design and in testing procedures, the positive expulsion tanks for the CSM reaction control system failed their verification tests (begun during the preceding month).
- "ASPO Weekly Management Report" (December 10, 1964–January 7, 1965).
- 10-January 7 Crew Systems Division received from North American a mockup of the proposed design of the food stowage compartment in the Block II CSM. This article would be used for packaging studies in preparation for the lower equipment bay mockup review in February.
- Ibid.*

By improving filling and preparation procedures and by using nickel foil in the oxygen electrode, Pratt and Whitney eliminated both short- and long-term plugging in the LEM's fuel cell assembly. Since then, Pratt and Whitney had consistently operated single cells for over 400 hours and—as far as the company was concerned—felt this settled the matter.

1964

December

10-January 7

Ibid.

The resident Apollo office at North American discussed the company's tooling concepts for the Block II spacecraft with the chief of Marshall's Planning and Tool Engineering Division and the local Marshall representative. These reviewers agreed on the suitability of North American's basic approach. Though they recognized that the initial tooling cost would be high, they nonetheless felt that the total costs of manufacturing would not be appreciably affected. The substitution of mechanical for optical checking devices, it was agreed, would eliminate much of the "judgment factor" from the inspection process; mechanical checking also would assure uniformity of major components or subsystems.

10-January 7

Ibid.; "Apollo Monthly Progress Report," SID 62-300-33, p. 27.

MSC directed Grumman to provide a LEM abort guidance section (AGS) having

11

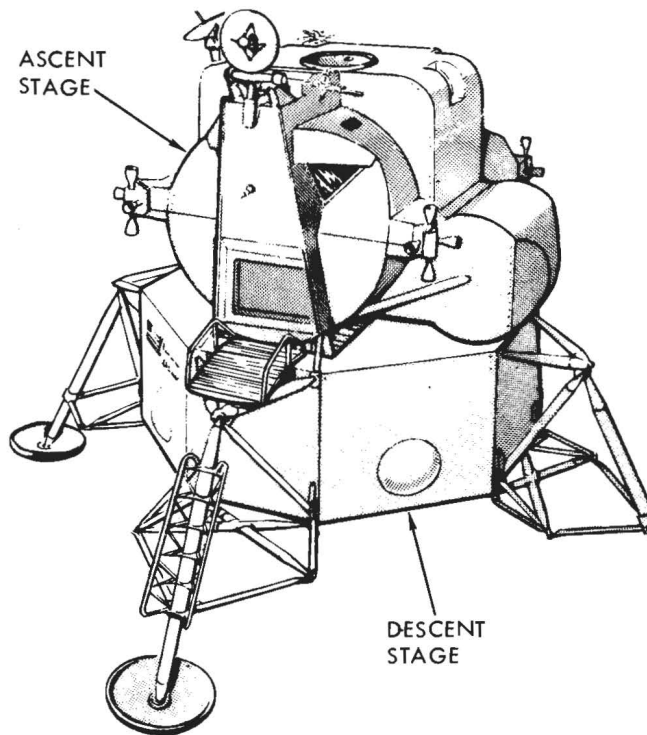
- a computer memory of 4096 words
- the provision for in-flight null bias gyro drift compensation
- a general purpose input/output device
- Bell 3B accelerometers
- input registers for rendezvous radar information such that a future interface could be mechanized if desired
- an interface between the primary navigation and guidance system (PNGS) and the AGS for position and velocity updating of the AGS from the PNGS.

Letter, Joseph F. Shea, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Abort Guidance Section Configuration," December 11, 1964.

From MSC, Grumman received updated criteria to be used in the design of the LEM's landing gear. (The gear must be designed to absorb completely the landing impact; it must also provide adequate stability for the vehicle under varying surface conditions, which were spelled out in precise detail.) Maximum conditions that MSC anticipated at touchdown were:

11

- vertical velocity — 3.05 m (10 ft) per sec
- horizontal velocity — 1.22 m (4 ft) per sec



The LEM.

1964
December

spacecraft attitude	
pitch	— 3 degrees
roll	— 3 degrees
yaw	— random
attitude rates	— 3 degrees per sec

At touchdown, all engines (descent and reaction control) would be off. “It must be recognized,” MSC emphasized, “that the vertical and horizontal velocity values . . . are also constraints on the flight control system.”

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, “Contract NAS 9-1100, Landing gear design criteria,” December 11, 1964.

- 14 ASPO’s Operations Planning Division directed Grumman to provide six recharges of the portable life support system (PLSS) and three PLSS batteries (rechargeable and replaceable).

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, “Contract NAS 9-1100, Resolution of M-5 mockup review chits 1-16 and 1-20,” December 14, 1964.

- 15 Associate Administrator for Manned Space Flight George E. Mueller informed MSC Director Robert R. Gilruth that the Integrated Mission Control

Center at MSC should be renamed Mission Control Center. He said, "By calling it the Mission Control Center, it has the advantage of retaining as much as possible of the original name which has become so well known to the press, the Congress and the public."

1964

December

Letter, Mueller to Gilruth, December 15, 1964.

Dalmo-Victor studied thermal-demanded weight increases for the LEM's steerable antenna. Investigators reported to Grumman and RCA that, in the plume of the CSM's reaction control engines, 1.18 kg (2.5 lbs) was necessary merely for the survival of the antenna; another 1.18 kg would be required for tracking during this impingement.

15-16

"Monthly Progress Report No. 23," LPR-10-39, p. 5; "ASPO Weekly Management Report" (December 10, 1964-January 7, 1965).

Aboard a KC-135 from Wright-Patterson AFB, the fecal canister and urine relief tube were first tested under zero-g conditions. Similar manned tests of a complete unit were scheduled for February 1965.

16

"Apollo Monthly Progress Report," SID 62-300-33, pp. 4-6.

A mission planning presentation was given to ASPO Manager Joseph F. Shea, Assistant Director for Flight Operations Christopher C. Kraft, Jr., and Assistant Director for Flight Crew Operations Donald K. Slayton covering missions AS-201, AS-202, and AS-203. Shea said he wanted either a natural decaying orbit of proper lifetime or reaction control system deorbit capability for the first manned missions. It was decided not to put a C-band beacon on the SM for the post CM/SM separation tracking. This decision came back to haunt the program much later.

16

Memorandum, Carl R. Huss, MSC, to JSC Historical Office, "Comments on Volume III of *The Apollo Spacecraft: A Chronology*," June 6, 1973.

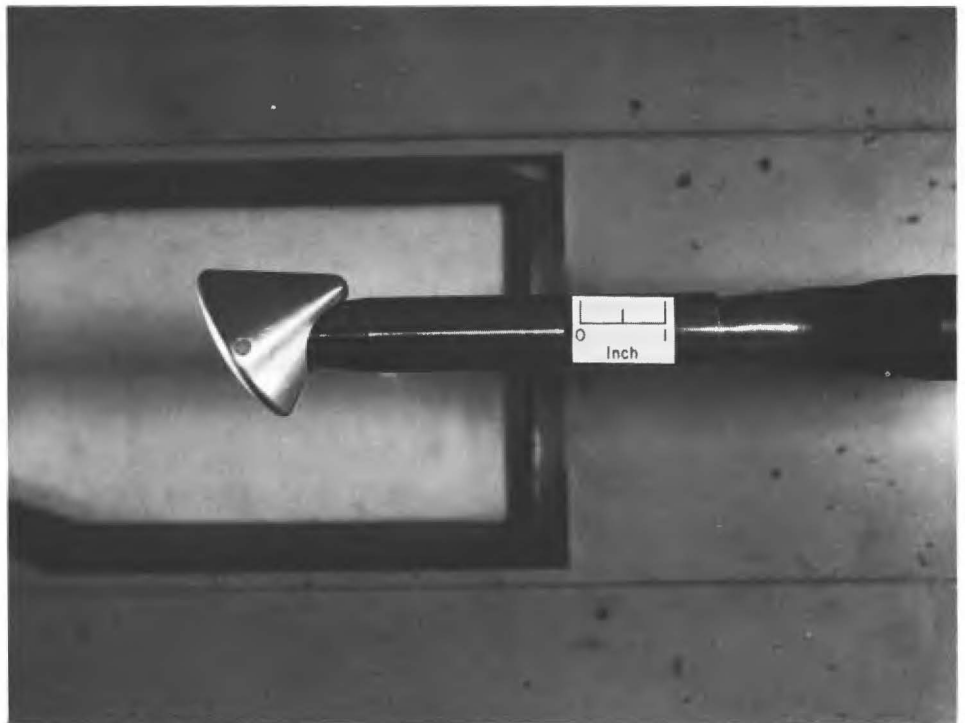
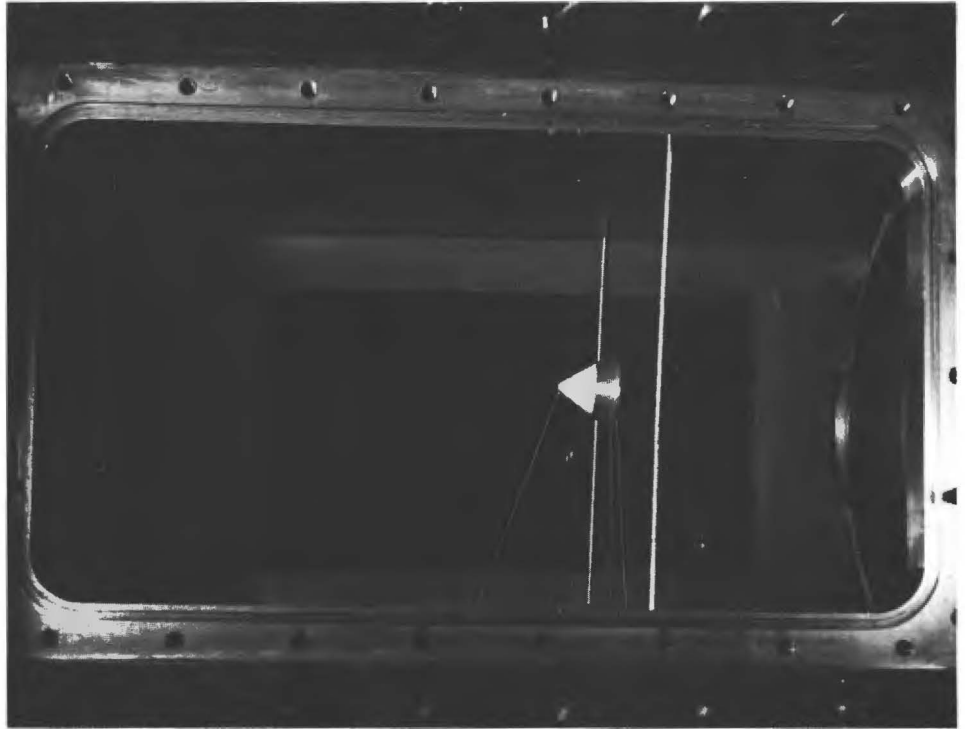
Phase II service propulsion system engine tests at Arnold Engineering Development Center were begun under simulated high altitude conditions with a successful first firing of 30 seconds. A total of nine firings were completed.

"Apollo Monthly Progress Report," SID 62-300-33, p. 13.

Ames researchers conducted 23 runs in the Center's wind tunnel to confirm the flight test instrumentation's compatibility with the aft heatshield of the CM. The instrumentation performed satisfactorily.

16-January 15

"Apollo Monthly Progress Report," SID 62-300-33, pp. 10-11.



At top is a profile view of an Apollo model in the 0.3-m (1-ft) shock tunnel at Ames Research Center. Bottom, an Apollo in the 4.27-m (14-ft) helium tunnel at Ames.

NASA announced the selection of two firms to supply electronics equipment for the Manned Space Flight Network:

1964

December

17

(1) Dynatronics, Inc., to design and manufacture pulse code modulation (PCM) telemetry systems. (The main function of the PCM system would be to decode, or as the NASA news release put it, "decommutate," telemetry signals from the spacecraft.) Dynatronics' contract would be worth an estimated \$3.5 million.

(2) Univac Division of Sperry Rand, to furnish data processors. (These machines, as their name indicates, would process those signals received by the PCM system. This information then would be transmitted to the Mission Control Center at Houston.) The value of Univac's contract was placed at \$4.5 million.

NASA News Release 64-318, "NASA Selects Apollo Data Contractor," December 17, 1964.

Crew Systems Division (CSD) engineers, in their continuing effort to improve the design of the space suit, recommended a number of modifications to the thermal garment (for example, a larger sleeve opening to facilitate inserting the second arm; and alterations to the neck and chest to increase the astronaut's downward view). By the middle of January, CSD's Robert E. Smylie could report several major design changes improved greatly the suit's don/doff characteristics and made it less bulky. (See January 19, 1965.)

18

Memorandum, Francis J. DeVos, MSC, to Chief, Apollo Support Office, "Improved External Thermal Garment fit and donning, doffing studies," December 18, 1964.

NASA Administrator James E. Webb thanked Secretary of Defense Robert S. McNamara for providing aircraft support for the Apollo program. Webb informed McNamara that NASA had transferred \$600 000 to the Electronic Systems Division of the Air Force, and "this should provide us the ability to initiate the definition phase of the C-135 Apollo support aircraft program." The aircraft would be used to supplement telemetry and communications coverage of the pre-injection phase of the flights.

18

Webb added that the Bureau of the Budget had the question of identifying four additional C-135's well on its way toward resolution; and that NASA would continue planning on the basis of 12 C-135 aircraft for the Apollo program.

McNamara had written Webb on November 27, 1964, that "The Air Force has completed a study of a number of alternative combinations of aircraft to meet Apollo requirements. They conclude that the optimum solution is to equip twelve C-135's to support Apollo . . ." Total cost of instrumenting 12 C-135's was estimated to cost \$27.7 million, including the \$600 000 for the definition phase.

Letters, Webb to McNamara, December 18, 1964; McNamara to Webb, November 27, 1964.

1964
December
18 North American delivered spacecraft 001's CM to White Sands. The SM was shipped several days later, and would be used for propulsion engine development. Aerojet-General shipped the service propulsion engine to the facility on January 6, 1965.

NAA, "Apollo Monthly Progress Report," SID 62-300-33, pp. 1, 12.

21 The Structures and Mechanics Division (SMD) summarized the thermal status of antennas for the Apollo spacecraft (both CSM and LEM). Generally, most troubles stemmed from plume impingement by the reaction control or radiation from the service propulsion engines. These problems, SMD reported, were being solved by increasing the weight of an antenna (either its structural weight or its insulation); by shielding it from the engines' exhaust; by isolating its more critical components; or by a combination of these methods.

Memorandum, R. G. Irvin, MSC, to J. W. Craig, MSC, "LEM thermal design mission," December 9, 1964; memorandum, Ralph S. Sawyer, MSC, to Chief, Propulsion and Power Division, "Reaction control system engine plume impingement on steerable high gain antenna earth tracker," December 21, 1964.

21-22 In response to MSC's new criteria for the landing gear of the LEM, Grumman representatives met with Center officials in Houston to revise the design. Grumman had formulated a concept for a 419-cm (165-in) radius, cantilever-type configuration. In analyzing its performance, Grumman and Structures and Mechanics Division (SMD) engineers, working separately, had reached the same conclusion: namely, that it did not provide sufficient stability nor did it absorb enough of the landing impact. Both parties to this meeting agreed that the gear's performance could be improved by redesigning the foot pads and beefing up the gear struts. Grumman was modifying other parts of the spacecraft's undercarriage accordingly.

At the same time, Grumman advised MSC that it considered impractical a contrivance to simulate lunar gravity in the drop program for test Mockup 5. Grumman put forth another idea: use a full-sized LEM, the company said, but one weighing only one-sixth as much as a flight-ready vehicle. SMD officials were evaluating this latest idea, while they were reviewing the entire TM-5 program.

"Project Apollo, Abstract of Procedures, LEM Structures and Landing Gear Systems Meeting, December 21-22, 1964"; "Monthly Progress Report No. 23," LPR-10-39, p. 15; MSC, "ASPO Weekly Management Report" [January 7-14, 1965].

23 NASA Technical Services constructed the molds that would be used to make the one-piece bubble helmets for the Apollo space suits. These forms would be delivered to General Electric and to Texstar, the two firms that

would actually fabricate the helmets, with the first shell expected about mid-January.

1964

December

At the same time, Crew Systems Division completed drop tests on the new helmet concept. The division's engineers also began designing and fabrication of support items (neck rings, feed ports, and skull caps), as well as exploring methods of maintaining the helmet's hygiene and habitability.

Letter, Richard S. Johnston, MSC, to Curtis Jones, GE, December 23, 1964; "ASPO Weekly Management Report" [December 10, 1964–January 7, 1965].

To strengthen the Agency's managerial organization, NASA announced a realignment within the Office of Manned Space Flight:

24

- The post of Deputy Associate Administrator for Manned Space Flight Operations was eliminated. (It had, in fact, been vacant since April 24, 1964, when Walter C. Williams had resigned.) In its stead, the position of Mission Operations Director was created and filled by E. E. Christensen.
- Two positions as mission directors were created under Christensen. Each director would have overall responsibility for a particular mission.
- A new organization to coordinate ground support efforts was created, the Operations Support Requirements Office, headed by B. Porter Brown.

Also included in this reorganization was a consolidation of activities at Cape Kennedy aimed at bringing assembly, checking, and launch responsibilities within the scope of a single organization. MSC's Florida Operations was absorbed; Kurt H. Debus assumed the title of Director of Launch Operations; and G. Merritt Preston, who had headed the local MSC group, became Debus' deputy.

NASA News Release 64-327, "NASA Realigns Manned Space Flight Unit in Gemini, Apollo Programs," December 24, 1964.

MSC directed North American to modify the CM so that the sight assembly could be used from either docking window.

28

Letter, James L. Neal, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 283," December 28, 1964; "Apollo Monthly Progress Report," SID 62-300-32, p. 11.

The Lunar Sample Receiving Laboratory, currently being planned for construction at MSC, would support—in addition to its vital role as a quarantine area—two important activities:

29

- (1) Research on the samples to support succeeding Apollo flights.
- (2) Sorting and distribution of lunar samples to the scientific community.

- 1964**
December Technical requirements for the facility were being defined by MSC's Space Environment Group, various Apollo science teams, and an ad hoc committee established by NASA Headquarters.
- Memorandum, John M. Eggleston, MSC, to Distr., "MSC Requirements for Apollo Operational Lunar Sample Measurements," December 29, 1964.
- 31** After conferring with the Space Medicine Branch and with the Gemini and Apollo support offices, Crew Systems Division officials opted for identical bioinstrumentation in both blocks of Apollo spacecraft. Hamilton Standard would also try to use identical harnesses.
- "ASPO Weekly Management Report" [December 10, 1964–January 7, 1965].
- During the Month** Grumman ordered its major subcontractors supplying electronic equipment for the LEM to implement revised test programs and hardware schedules (in line with the new design approach). A similar directive went to RCA to modify the attitude and translation and the descent engine control assemblies as required for the new concept of an integrated assembly for guidance, navigation, and control of the spacecraft.
- "Monthly Progress Report No. 23," LPR-10-39, p. 24.
- During the Quarter** Crew Systems Division approved the use of modified Gemini space suits in Block I Apollo spacecraft. MSC and David Clark Company amended their Gemini suit contract to cover design and fabrication of a prototype Block I suit.
- Memorandum, Robert E. Smylie, MSC, to Chief, Program Control Division, "Apollo Spacecraft Program Quarterly Status Report No. 10," January 19, 1965, and enclosures.
- During the Quarter** Ling-Temco-Vought began large-scale developmental testing of the radiator for the Block II CSM environmental control system. One problem immediately apparent was the radiator's performance under extreme conditions.
- Ibid.*
- During the Quarter** In September 1964, Hamilton Standard, manufacturer of the portable life support system (PLSS), had established a 108-watt-hour capacity for the system's batteries. And on the basis of that figure, Grumman had been authorized to proceed with the development of the LEM's battery charger (see November 5, 1964). (The size of the charger was determined by several factors, but primarily by the size of the battery and time limits for recharging.)
- During November, however, Hamilton Standard and Crew Systems Division (CSD) engineers advised the Instrumentation and Electronic Systems

Division (IESD) that the PLSS's power requirements had increased to about 200 watt-hours. (CSD had jurisdiction over the PLSS, including battery requirements; IESD was responsible for the charger.) Hamilton Standard placed most of the blame on the cooling pump motor, which proved far less efficient than anticipated, as well as on the addition of biosensor equipment. ASPO Manager Joseph F. Shea, reviewing the company's explanation, commented that "this says what happened . . . but is far from a justification—this is the type of thing we should understand well enough to anticipate." "How can this happen," he wondered, ". . . in an area which has been subjected to so much discussion and delay?"

Representatives from Grumman and Hamilton Standard, meeting at MSC on December 17, redefined PLSS battery and charging requirements, and Grumman was directed to proceed with the development of the battery charger. This episode was accompanied by some sense of urgency, since Grumman had to have firm requirements before the end of year to prevent a schedule slippage.

"ASPO Weekly Management Report" (December 10, 1964–January 7, 1965); TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, December 31, 1964.

MSC's Guidance and Control Division conducted a pilot simulation study to determine whether a pilot could take over manual control of the LEM between 4572 and 3048 m (15 000 and 10 000 ft) above the lunar surface and satisfactorily land the vehicle. The study also determined what flight information was required for pilot control.

The study investigated deceleration techniques, approach velocity, flare attitude, and the pilot information required for landings within a given footprint. If the site was deemed unsatisfactory for landing, after "eyeballing" it from 305 m (1000 ft), the pilot would, under normal circumstances, place the coordinates of a new landing site in the computer; then take over manually and fly while making selection of the landing site.

MSC, "MSC Internal Note No. 65-EG-3, Project Apollo, Simulation Study of Pilot Controlled Lunar Landings from the Transition Altitude," Thomas E. Moore and Clarke T. Hackler, January 5, 1965.

At the fourth meeting of the Reference Trajectory Sub-Panel, MSC and MSFC members agreed on a trajectory with a launch azimuth of 108°. Translunar injection would be performed over the Pacific Ocean during the first or second orbits. First-orbit injection would fix the minimum time required before the maneuver. Injection on the second pass would determine consequent penalties. The actions were initiated by Mission Planning and Analysis Division (MPAD) and were required to solidify and minimize analytical studies and operational planning.

Memorandum, Secretaries, Reference Trajectory Sub-Panel Meeting, to Distr., "Meetings of fourth Reference Trajectory Sub-Panel meeting held January 5, 1965," January 11,

1964

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nificant problems required the attention of Apollo managers at Houston and at North American:

- The effect of heavyweight LEM (up 1361 kg [3000 lbs]) on the spacecraft lunar adapter and on the CM's docking system. North American was studying this problem already.

- Wearing cycles and requirements for donning and stowage of the space suits must be resolved and incorporated into the CSM specifications. North American's interpretation of those specifications conflicted with the MSC Crew System Division's current plan that, during the first several missions, all three crewmen should be able to wear their suits without the helmets.

"Apollo CSM—Block II Preliminary Design Review (PDR), NASA-MS-ASPO, NAA-S&ID, 6-8 January 1965," pp. 4-40.

7

William A. Lee, chief of ASPO's Operations Planning Division, announced a revised Apollo launch schedule for 1966 and 1967. In 1968, a week-long earth orbital flight would be a dress rehearsal for the lunar mission. "Then the moon," Lee predicted. "We have a fighting chance to make it by 1970," he said, "and also stay within the \$20 billion price tag set . . . by former President Kennedy."

Astronautics and Aeronautics, 1965: Chronology on Science, Technology, and Policy (NASA SP-4006, 1966), p. 7.

7

MSC Deputy Director George M. Low issued a memorandum regarding differences in the Apollo schedule as made public in an Associated Press release with a Houston, Texas, dateline. Low cited the following statement by George E. Mueller, Associate Administrator for Manned Space Flight, and said it "represents our official and only position on Apollo schedules:

"• The Apollo schedule for accomplishment of major milestones leading to the first manned lunar landing has not changed.

- The first Saturn IB flight is scheduled in 1966.
- Apollo manned flights on Saturn IB are scheduled for 1967.
- Unmanned Saturn V flights are scheduled for 1967.
- Manned Apollo earth orbital flights are scheduled for 1968.

"We believe these major milestones will be met and our goal of a manned lunar landing in this decade can be accomplished."

AP Release, Houston, Texas, January 7, 1965; memorandum, Low to Distribution, "Apollo schedules," January 7, 1965; memorandum, Alfred P. Alibrando, NASA Headquarters, to Distribution, "Apollo Schedules," April 7, 1965.

7-14

Changing the CM back-face temperature requirement from 600° at touchdown to 600° at parachute deployment threatened to increase the cabin

air temperature. Physiologists at MSC had previously declared that the cabin temperature should not exceed 100°. The proposed change in the back-face requirement, North American reported, would raise the cabin's interior to 125°. MSC's Crew Systems Division reviewed these factors and decided the increased cabin temperature would not be acceptable.

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January

"ASPO Weekly Management Report" [January 7-14, 1965].

MSC was reviewing the control-display systems of the CSM and LEM to assess operational constraints. North American was requested to study all controls, displays, and systems functions for manned spacecraft to identify and eliminate single-point failures.

8

Letter, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, Control-display criteria for crew safety and mission success," January 8, 1965.

NASA announced that Kennedy Space Center's Launch Complex 16, a Titan missile facility, would be converted into static test stands for Apollo spacecraft. This decision eliminated the need for such a facility originally planned on Merritt Island and, it was predicted, would cost little more than a fourth of the \$7 million estimated for the new site.

11

Astronautics and Aeronautics, 1965, pp. 11-12.

North American selected Dalmo-Victor to supply S-band high-gain antennas for Apollo CSM's. (The deployable antenna would be used beyond 14 816 km [8000 nm] from the earth.) Dalmo-Victor would complete the antenna design and carry out the development work, and North American would procure production units under a supplemental contract.

11

"Apollo Monthly Progress Report," SID 62-300-33, p. 8.

Grumman and Hamilton Standard were exploring various designs for the extravehicular mobility unit. On the basis of some early conclusions, the MSC Crew Systems Division (CSD) recommended that meteoroid and thermal protection be provided by a single garment. Preliminary hypervelocity tests placed the garment's reliability at 0.999. Each would weigh about 7.7 kg (17 lbs), about 2.3 kg (5 lbs) less than the two-garment design. CSD further recommended that the unit be stored either in the LEM's descent stage or in a jettisonable container in the ascent portion. [See November 19-26, 1964.]

12

Memorandum, John F. Rayfield, MSC, to Record, "Status of Apollo Support Office concept of optimum Extravehicular Mobility Unit (EMU) meteoroid/thermal protection arrangement," January 12, 1965.

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12

MSC evaluated the VHF communications requirements and determined that there was no requirement for the LEM to communicate simultaneously over VHF with:

- (1) the CSM in lunar orbit
- (2) an extravehicular astronaut on the lunar surface.

There also was no requirement for the CSM to communicate simultaneously over VHF with:

- (1) an extravehicular astronaut
- (2) an astronaut in the LEM.

Grumman and North American were advised that voice communications during this mission phase would be maintained by the unified S-band equipment via the Manned Space Flight Network relay.

TWX, C. L. Taylor and W. F. Rector III, to NAA, Attn: J. C. Cozad, and GAEC, Attn: R. S. Mullaney, January 12, 1965.

12

Donald K. Slayton, MSC Assistant Director for Flight Crew Operations, pointed out to Managers of the ASPO and the Gemini Program Office that a number of units of spacecraft control and display equipment were needed to support the Spacecraft Control Office in the areas of spacecraft crew procedures development, crew station equipment development, flight crew familiarization, training, and spacecraft mission preparation. Such equipment was needed within MSC, at other NASA Centers, and at contractor facilities to support centrifuge programs, research vehicle programs, launch abort simulations, rendezvous and docking simulations, retrofire and reentry simulations, and other mission phase simulations. Slayton emphasized that uncoordinated requests for hardware procurement to support these programs were excessively costly in terms of equipment.

Slayton said that a "satisfactory method to reduce costs and increase equipment utilization and effectiveness is to assign responsibility as custodian to one technically cognizant organization which will ascertain the total requirement for equipment and be responsible for coordinating procurement and allocating and transferring hardware assignment required to meet program requirements." He recommended that the Crew Station Branch of Flight Crew Support Division be given the consolidated responsibilities.

Memorandum, Slayton to Manager, ASPO, and Manager, Gemini Program Office, "Proposed control and display utilization and cost reduction plan," January 12, 1965.

13

The first meeting of the Configuration Control Board was held at MSC with ASPO Manager Joseph F. Shea as chairman. Approval was given to delete 10 Apollo guidance and navigation systems; and W. F. Rector III was

directed to look into the use of computers and prototype units for electronic systems integration. In other actions, a decision on changes to CSM specifications to provide for the heavyweight LEM (a proposed increase from 12 705 to 14 515 kg [28 000 to 32 000 lbs]) was deferred until the next meeting; and Owen Maynard was directed to identify all Block II changes that must be implemented regardless of impact and have them ready for Board action by February 18, 1965.

1965

January

Minutes, Configuration Control Board Meeting No. 1, signed A. L. Brady, Secretary, CCB, January 13, 1965.

Development firings of the launch escape system's drogue and pilot parachute mortars were completed, and the units were slated for qualification trials the following month.

14-21

MSC, "ASPO Weekly Management Report, January 14-21, 1965."

OMSF asked MSC to provide NASA Headquarters with a statement of "the minimum definition of meteoroid environment in cislunar space" which would be necessary for confidence that Apollo could withstand the meteoroid flux. The "desirable degree of definition" was also requested. This material was to be used as inputs to the current cislunar Pegasus studies being conducted by OMSF.

14-21

Ibid.

Significant agreements from the Eleventh MSC-MSFC Flight Mechanics, Dynamics, Guidance and Control Panel meeting were:

14-21

- There was no requirement to inhibit the S-IVB attitude and attitude rate hold modes during the transposition and docking phase.
- The S-IVB auxiliary propulsion system had sufficient propellant to perform 21 roll maneuvers in earth orbit at 0.5 deg/sec for inertial measurement unit alignment and earth landmark sightings, one yaw maneuver at 0.3 deg/sec for sun avoidance before transposition and docking, and one pitch and/or yaw maneuver at 0.3 deg/sec before the final CSM/LEM separation maneuver from the S-IVB.

Ibid.

During testing, it was found that blast effects of the linear charge for the CM/SM umbilical cutter caused considerable damage to the heatshield. To circumvent this problem, North American designed a vastly improved pyrotechnic-driven, guillotine-type cutter. MSC readily approved the new device for both Block I and II spacecraft.

14

"Apollo Monthly Progress Report," SID 62-300-33, p. 4.

1965
January
14

North American completed acceptance tests for the CSM sequential and propulsion systems trainers. On January 15 the equipment was shipped to MSC, where it was installed the following week. This terminated the procurement program for the Apollo systems trainer.

Ibid., p. 20.

18

The Structures and Mechanics Division approved a low-burst factor for the gaseous helium tanks on the LEM (as recommended by Grumman). This change permitted a substantial lightening of the spacecraft's propulsion systems: descent 45 kg (99 lbs); ascent, 13 kg (29 lbs); reaction control, 2.3 kg (5 lbs).

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Reduction of burst safety factor for the gaseous helium bottles," January 18, 1965.

18

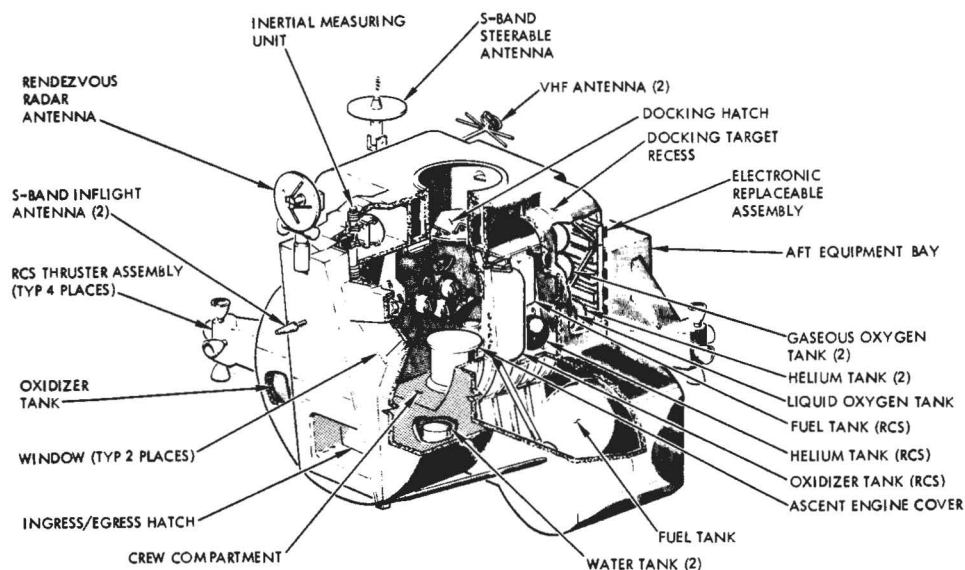
MSC White Sands Missile Operations was renamed MSC White Sands Operations to eliminate the similarity to the Army's White Sands Missile Range.

MSC Release 65-6, January 18, 1965.

18

After reviewing the requirement for extravehicular transfer (EVT) from the LEM to the CM, MSC reaffirmed its validity. The Center already had approved additional fuel for the CM, to lengthen its rendezvousing range, and modifications of the vehicle's hatch to permit exterior operation. The need for a greater protection for the astronaut during EVT would be de-

LEM ascent stage.



terminated largely by current thermal tests of the pressure suit being conducted by NASA and Hamilton Standard. While the emergency oxygen system was unnecessary during normal transfer from one vehicle to the other, it was essential during EVT or lunar surface activities.

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January

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, January 18, 1965.

General Motors' Allison Division completed qualification testing of the propellant tanks for the service propulsion system.

18

"Apollo Monthly Progress Report," SID-62-300-34, p. 8.

The MSC Mission Planning and Analysis Division made a presentation to Joseph F. Shea, Christopher C. Kraft, Jr., and Donald K. Slayton on Apollo Missions 201, 202, 204, 206, 207, 501, 503, and 504. It was stated that 204B was to be a repeat of 202; 204C was to be a repeat of 201; and 204D was to be the same as 204A but would be flown unmanned.

18

Memorandum, Carl R. Huss, JSC, to JSC Historical Office, "Comments on Volume III of *The Apollo Spacecraft: A Chronology*," June 6, 1973.

MSC was studying several approaches to the problems of automatic thermal control and automatic reacquisition of the earth by the S-band high-gain antenna while the CSM circled the moon. (The Block II spacecraft, MSC had stated, must have the ability to perform these functions wholly on its own. During an extended stay of the LEM on the lunar surface, when the CSM pilot needed uninterrupted sleep periods, antenna reacquisition was absolutely essential for telemetering data back to earth. And although the requirements for passive thermal control were not yet well defined, the spacecraft's attitude must likewise be automatically controlled.)

18

Robert C. Duncan, chief of the MSC Guidance and Control Division, presented his section's recommendations for solving these problems, which ultimately won ASPO's concurrence. Precise spacecraft body rates, Duncan said, should be maintained by the stabilization and control system. The position of the S-band antenna should be telemetered to the ground, where the angle required for reacquisition would be computed. The antenna would then be repositioned by commands sent through the updata link.

Memorandum, Robert C. Duncan, MSC, to Distr., "Block II Apollo High-gain antenna pointing in lunar orbit," January 18, 1965.

In simulated zero-g conditions aboard KC-135s, technicians evaluated a number of different devices for restraining the LEM crewmen. These trials demonstrated clearly the need for a hip restraint and for a downward force to hold the astronaut securely to the cabin floor. In mid-February a second

19-20

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series of flights tested the combination that seemed most promising: Velcro shoes that would be used together with Velcropile carpeting on the cabin floor of the spacecraft; a harness that enveloped the astronaut's chest and, through an intricate system of cables and pulleys, exerted a constant downward pressure; and a waist strap that secured the harness to the lighting panel immediately facing the crewman. These evaluations permitted Grumman to complete the design of the restraint system.

Memorandum, Donald K. Slayton, MSC, to Manager, ASPO, "LEM Zero Gravity Support and Restraint Evaluation," February 1, 1965.

20

The test altitude for mission A-004 was decreased from 22 860 to 19 507 m (75 000 to 64 000 ft) to ensure the attainment of limit loads on the CM during a tumbling power-on abort.

Memorandum, George E. Mueller, NASA Hq., to Administrator, "Apollo Spacecraft Intermediate Altitude Abort Test Mission A-004, Post Launch Report No. 1," January 26, 1966, with enclosure, "Post Launch Report No. 1."

20

The new membership of the MSC Manned Spacecraft Criteria and Standards Board, established September 4, 1963, was: F. John Bailey, Jr., Chairman; James W. Donnell, Secretary; James A. Chamberlin, Kenneth S. Kleinknecht, W. R. Durrett, William M. Bland, and Norman F. Smith.

MSC Circular No. 146 (Ref. 2-4-11), "MSC Manned Spacecraft Criteria and Standards Board," January 20, 1965.

21-28

The persistent problem of combustion instability in the LEM ascent engine, unyielding to several major injector redesigns, was still present during test firings at Bell Aerosystems. Following reviews by MSC and Grumman, the "mainstream effort" in the injector program was "reoriented" to a design that included baffles on the face of the injector. Largely because of this troublesome factor, it now appeared that the ascent engine's development cost, which only four months earlier Bell and Grumman had estimated at \$20 million, would probably approach \$34 million. Bell also forecast a 15.4-kg (34-lb) weight increase for the engine because of a longer burn design and a strengthened nozzle extension.

GAEC, "Monthly Progress Report No. 24," LPR-10-40, February 10, 1965, p. 20; MSC, "ASPO Weekly Management Report, January 21-28, 1965."

21

Northrop-Ventura verified the strength of the dual drogue parachutes in a drop test at El Centro, Calif. This was also the first airborne test of the new mortar by which the drogues were deployed and of the new pilot parachute risers, made of steel cables. All planned objectives were met. The deployment sequence was perfect, and there was no apparent kinking of the risers.

In the course of this drop, six of the 12 cutters, which sever the reefing lines on the main parachutes, failed. This failure, together with another cutter

malfunction during the previous month, signaled an intensive investigation at Ordco, the cutter manufacturer. Qualification of the severing device was thereby delayed.

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On January 22, Northrop, North American, and MSC conducted a design review for the drogue system and found no discrepancies.

“Apollo Monthly Progress Report,” SID-62-300-33, pp. 3-4; “ASPO Weekly Management Report, January 21-28, 1965.”

At the request of Maj. Gen. Samuel C. Phillips, Apollo Program Director, ASPO reexamined the performance requirements for spacecraft slated for launch with Saturn IBs. MSC currently assessed that the launch vehicle was able to put 16 102 kg (35 500 lbs) into a circular orbit 105 nm above the earth. Based on the spacecraft control weights, however, it appeared that the total injected weight of the modules would exceed this amount by some 395 kg (870 lbs).

21

A 454-kg (1000-lb) increase in the Saturn IB’s payload was the most desirable solution, ASPO Manager Joseph F. Shea wrote Phillips. However, by removing one set of propellant tanks and a helium tank from SM and slightly reducing the propellant supply, the spacecraft could still be kept within the launch vehicle’s capability without affecting mission objectives or crew safety. While several other alternative approaches appeared feasible, they would seriously impair spacecraft performance.

On February 23, Phillips informed Shea that he foresaw the requisite payload boost. While the control payload for the Saturn IB would remain unchanged, Phillips said, a new design goal of 16 556 kg (36 500 lbs) would be set. At the end of July it would be decided whether or not to make this last figure a new control capability.

Letter, Joseph F. Shea, MSC, to Maj. Gen. Samuel C. Phillips, January 21, 1965; memorandum, William A. Lee, MSC, to Distr., “Mission assignments for Block II CSM’s,” February 12, 1965; letter, Phillips, NASA, to Shea, February 23, 1965; memorandum, Lee, MSC, to Mission Planning and Analysis Division, Attn: J. P. Bryant, “Modified mission profile for CSM-LEM flight on Saturn I-B,” March 3, 1965.

Space Ordnance Systems was selected to develop the explosive bolts that held the LEM’s two stages together.

21-28

“ASPO Weekly Management Report, January 21-28, 1965.”

Two underwater firings verified the design concept of the main parachute disconnects.

21-28

ibid.

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Parallel development of the LEM descent engine was halted. Space Technology Laboratories was named the sole contractor; the Rocketdyne contract was canceled. Grumman estimated that the cost of Rocketdyne's program would be about \$25 million at termination.

Ibid.; "Monthly Progress Report No. 24," LPR-10-40, pp. 1, 30, 35.

22

The MSC-MSFC Mechanical Integration Panel discussed the possibility that, when deployed, the LEM adapter panels might interfere with radio communications via the S-band high-gain antenna. On earth-orbital missions, the panel found, the S-band antenna would be rendered useless. They recommended that MSC's Instrumentation and Electronic Systems Division investigate alternative modes for communications during the transposition and docking phase of the flight. During lunar missions, on the other hand, the panel found that, with panels deployed at a 45° angle, the high-gain antenna could be used as early as 15 minutes after translunar injection. Spacecraft-to-ground communications during transposition and docking could thus be available and manual tracking would not be needed. North American was informed that the high-gain antenna would be used during this maneuver, and was directed to fix the panel deployment angle for all Block II spacecraft at 45°.

Memorandum, Lyle M. Jenkins, MSC, to Distr., "Abstract of MSC meeting on solutions to the interference of the deployed SLA panels with communications," January 25, 1965; "ASPO Weekly Management Report, January 21-28, 1965."

22

Two construction companies, Blount Brothers Corporation, Montgomery, Ala., and Chicago Bridge and Iron Company, Oak Park, Ill., received a joint contract (worth \$5 178 000) for construction of a vacuum chamber at the Lewis Research Center's Plum Brook Station. The facility, which would be used for spacecraft and propulsion system testing, would be one of the largest such simulators in the world.

Astronautics and Aeronautics, 1965, p. 26.

22

Apollo Program Director Samuel C. Phillips forecast "heavy ground testing" for Apollo during 1965. The coming months, he said, should see the completion of testing on the first Apollo spacecraft intended for manned space flight, as well as flight qualification of the Saturn IB and initial testing of the Saturn V launch vehicles.

Ibid., p. 27.

23

ASPO approved the technique for LEM/S-IVB separation during manned missions, a method recommended jointly by North American and Grum-

man. After the CSM docked with the LEM, the necessary electrical circuit between the two spacecraft would be closed manually. Explosive charges would then free the LEM from the adapter on the S-IVB.

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Memorandum, Joseph F. Shea, MSC, to Distr., "Lunar Excursion Module (LEM)/Saturn S-IVB Stage Separation Technique," January 23, 1965.

Dalmo-Victor, vendor of the LEM S-band antenna, was given firm requirements for tracking and coverage, thus enabling the company to freeze the antenna design.

25

"MSC Weekly Management Report, January 28-February 4, 1965."

The optimism that permeated the Apollo program was reflected in statements by NASA's Associate Administrator, Robert C. Seamans, Jr., during budget briefings for the forthcoming year. He was "greatly encouraged" by recent design freezes and "very reassured" by testing of propulsion systems and launch vehicle stages. "We really feel," Seamans said, ". . . that we can get off the [lunar landing] flight on an earlier mission than I would have said a year ago." Certainly it was "conceivable" that the moon landing could come "in early 1970."

25

Astronautics and Aeronautics, 1965, pp. 29-30.

To determine flotation characteristics of the spacecraft, the Stevens Institute of Technology began a testing program using one-tenth scale models of the CM. Researchers found that the sequence in which the uprighting bags were deployed was equally critical in both a calm sea and in various wave conditions; improper deployment caused the vehicle to assume an apex-down position. These trials disproved predictions that wave action would upright the spacecraft from this attitude.

25

Further testing during the following month reinforced these findings. But because sequential deployment would degrade reliability of the system, North American held that the bags must upright the spacecraft irrespective of the order of their inflation. Stevens' investigators would continue their program, examining the CM's characteristics under a variety of weight and center of gravity conditions.

"Apollo Monthly Progress Report," SID 62-300-34, p. 7; "Apollo Monthly Progress Report," SID 62-300-35, April 1, 1965, pp. 7-8.

MSC negotiated a backup Block II space suit development program with David Clark Company, which paralleled the Hamilton Standard program, at a cost of \$176 000. Criteria for selecting the suit for ultimate development for Block II would be taken from the Extravehicular Mobility Unit Design and Performance Specification. A selection test program would be conducted

25

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at MSC using the CM mockup, the lunar simulation facility, and the LEM mockup.

Memorandum, Richard S. Johnston, MSC, to Joseph Shea, "Block II Apollo suit program," January 25, 1965.

- 25 ASPO established an operational requirement for propellant gauges in the LEM descent stage, the exact details to be worked out by Grumman. The gauges must be accurate to within one-half of one percent when less than one-fourth of the propellants remained.

Memorandum, William A. Lee, MSC, to Manager, ASPO, "Status of LEM descent ΔV budget," January 25, 1965; "ASPO Weekly Management Report, January 21-28, 1965."

- 26 Warren J. North, Chairman of the Lunar Landing Research Vehicle (LLRV) Coordination Panel, reported to MSC Director Robert R. Gilruth that the LLRV had been flown 10 times by Flight Research Center pilots—eight times by Joe Walker and twice by Don Mallick. Maximum altitude achieved was 91 m (300 ft) and maximum forward velocity was 12 m (40 ft) per sec. Subsequent to December 14, 1964, the vehicle had been undergoing detailed x-ray inspection, lunar simulation control system checkout, and minor changes prior to extending the flight envelope in February.

North said discussions with the pilots indicated that checkout prerequisites for future LLRV pilots should include helicopter proficiency plus at least two weeks of intensive simulator and vehicle test stand activity. Prototypes of the basic LEM controls and displays were being procured by MSC and would be phased into the LLRV simulator and flight vehicles during the spring and summer.

Memorandum, North to Gilruth, "Status of Lunar Landing Research Vehicle (LLRV) Program," January 26, 1965.

- 26 At a meeting held at Grumman, RCA presented its study on thermal effects for a fixed rendezvous radar antenna assembly which would be protected from the CSM service propulsion system by a thermal shield.

"Monthly Progress Report No. 24," LPR-10-40, p. 17; "ASPO Weekly Management Report, January 21-28, 1965."

- 27 MSC evaluated Grumman's proposal to stage components of the extra-vehicular mobility unit to achieve a substantial weight reduction.

"Minutes of the Lunar Excursion Module Crew Integration Systems Meeting No. 3, January 27, 1965," pp. 2-4.

The first major Saturn V flight component, a 10-m (33-ft) diameter, 27 215 kg (60 000 lb) corrugated tail section which would support the booster's 6672 kilonewtons (1.5-million-lb) thrust engines, arrived at MSFC from NASA's Michoud Operations near New Orleans. The section was one of five major structural units comprising Saturn V's first stage. 1965
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28

Astronautics and Aeronautics, 1965, p. 39.

After examining the CM's potable water system, engineers in the MSC Crew Systems Division found that the Gemini pistol-type water dispenser could not be used in the Apollo spacecraft without some changes in the dispenser design. 28

"ASPO Weekly Management Report, January 14-21, 1965" [see memorandum, G. Merritt Preston, MSC-Florida Operations, to Chief, Crew Systems Division, "Flight Water Program," January 28, 1965].

Initial development testing of LEM restraint systems was completed. Under zero-g conditions, investigators found, positive restraints for the crew were essential. While the system must be further refined, it consisted essentially of a harness that secured the astronaut's hips (thus providing a pivot point) and held him firmly on the cabin floor. 28-February 4

"ASPO Weekly Management Report, January 28-February 4, 1965."

MSC canceled plans (originally proposed by North American) for a device to detect failures in the reaction control system (RCS) for Block I CSMs. This was done partly because of impending weight, cost, and schedule penalties, but also because, given an RCS failure during earth orbit, the crew could detect it in time to return to earth safely even without the proposed device. This action in no way affected the effort to devise such a detection system for the Block II CSM or the LEM, however. 28-February 4

Ibid.

ASPO concurred with the requirement to provide an emergency defecation capability aboard the LEM as established by MSC's Center Medical Programs Office. The addition of a Gemini-type defecation glove appeared to present a satisfactory solution. Crew Systems Division was directed to proceed with their recommendation and add the Gemini gloves to the LEM crew provisions. 29

Memorandum, Owen E. Maynard, MSC, to Chief, Crew Systems Division, "Waste management provisions aboard the LEM," January 29, 1965.

Apollo boilerplate 28 underwent its second water impact test. Despite its strengthened aft structure, in this and a subsequent drop on February 9 29

- 1965**
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- the vehicle again suffered damage to the aft heatshield and bulkhead, though far less severe than that experienced in its initial test. The impact problem, it was obvious, was not yet solved.
- “Apollo Monthly Progress Report,” SID 62-300-33, pp. 1, 8, 16.
- During the Month**
- ASPO Manager Joseph F. Shea reiterated the space agency’s phasic view of the Apollo program. He was well pleased with the pace of the program and reported that ground testing of all CSM subsystems was “well along.” Reflecting on the year just past, Shea observed that it was one in which Apollo objectives were achieved “milestone by milestone.” He was equally optimistic about Apollo’s progress during the coming months, predicting that there would be “three Apollo spacecraft in continuous ground testing” by the end of the year.
- Astronautics and Aeronautics, 1965, p. 43.*
- During the Month**
- Dr. William H. Pickering, Director of Jet Propulsion Laboratory, commented on the importance of *Ranger VII* in locating possible lunar landing sites.
- Ibid.*, pp. 43-44.
- During the Month**
- Nine areas of scientific experiments for the first manned Apollo lunar landing mission had been summarized and experimenters were defining them for NASA. Space sciences project group expected to publish the complete report by March 1, to be followed by requests for proposals from industry on designing and producing instrument packages. A major effort was under way by a NASA task force making a time-motion study of how best to use the limited lunar stay-time of two hours’ minimum for the first flight.
- Ibid.*, p. 45.
- During the Month**
- To make it easier to get in and out of the spacecraft, Grumman modified the LEM’s forward hatch. During mobility tests on the company’s mockup, a hinged, trapezoidal-shaped door had proved superior to the original circular hatch, so the earlier design was dropped.
- “Monthly Progress Report No. 24,” LPR-10-40, p. 13.
- February**
1
- Pacific Crane and Rigging Company received a NASA contract, worth \$8.3 million, to install ground equipment at Kennedy Space Center’s Saturn V facility, Launch Complex 39. On the following day, the Army Corps of

Engineers awarded a \$2 179 000 contract to R. E. Carlson Corporation, St. Petersburg, Fla., to modify Launch Complex 34 to handle the Saturn IB.

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Astronautics and Aeronautics, 1965, pp. 48, 52.

The Apollo-Saturn Crew Safety Panel decided on a number of emergency detection system (EDS) and abort procedures for the early Apollo flights:

2-3

- If any of the three redundant automatic abort circuits so indicated, the launch vehicle would not be released.
- The EDS would be flight-tested on the SA-201 and SA-202 missions.
- Unmanned Apollo flights should be aborted from the ground only under the most severe conditions.
- Liftoff permitted automatic abort without manual backup.
- To ensure a successful abort, a redundant mode of EDS-commanded engine shutdown was mandatory.

After hearing the results of several supporting studies, the Panel further agreed that Saturn IB flights would be automatically aborted if the vehicle's roll rate reached 20° per second; if two engines should fail during the first 30 seconds of flight, the Saturn IB must be capable of aborting automatically, and the Saturn V must have the same capability for the first 60 seconds of flight; and, finally, the Panel stated that during the Saturn V's initial stages, automatic abort might be required if even one engine shut down.

"Summary of Proceedings, Apollo-Saturn Crew Safety Panel Meeting No. 11, 2-3 February, 1965," February 4, 1965.

ASPO established radiation reliability goals for Apollo. These figures would be used to coordinate the radiation program, to define the allowable dosages, and to determine the effect of radiation on mission success. The crew safety goal (defined as the probability of a crewman's not suffering permanent injury or worse, nor his being incapacitated and thus no longer able to perform his duties) was set at 0.99999. The major hazard of a radiation environment, it was felt, was not the chance of fatal doses. It was, rather, the possibility of acute radiation sickness during the mission. The second reliability goal, that for success of the mission (the probability that the mission would not be aborted because of radiation environment), was placed at 0.98.

3

These values, ASPO Manager Joseph F. Shea emphasized, were based on the 8.3-day reference mission and on emergency dose limits previously set forth. They were not to be included in overall reliability goals for the spacecraft, nor were they to be met by weight increases or equipment relocations.

Memorandum, Joseph F. Shea, MSC, to Assistant Director for E. and D., "Apollo Radiation Reliability Goals," February 3, 1965.

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4

A device to maintain the spacecraft in a constant attitude was added to the LEM's primary attitude control system (ACS). The feature brought with it some undesirable handling characteristics, however: it would cause the vehicle to land long. Although this overshoot could be corrected by the pilot, and therefore was not dangerous operationally, it would require closer attention during final approach. The attitude hold, therefore, hardly eased the pilot's control task, which was, after all, its primary function. Instead of moving the device to the backup ACS (the abort section), the Engineering Simulation Branch of MSC's Guidance and Control Division recommended that the system be modified so that, if desired, the pilot could disengage the hold mechanism.

Memorandum, Clarke T. Hackler, MSC, to Chief, Guidance and Control Division, "Evaluation of LEM modified (zero overshoot) rate command-attitude hold control mode," February 4, 1965.

4-11

After considering possible impacts, MSC directed North American to implement real-time commands to the up-data link equipment on command modules 012 and 014.

MSC, "ASPO Weekly Management Report, February 4-11, 1965."

4-11

MSC questioned the necessity of using highly purified (and expensive) fuel-cell-type oxygen to maintain the cabin atmosphere during manned ground testing of the spacecraft. The Center, therefore, undertook a study of the resultant impurities and effect on crew habitability of using a commercial grade of aviation oxygen.

Ibid.; memorandum, Robert E. Smylie, MSC, to Chief, Environmental Physiology Branch, "Breathing oxygen for Apollo Command Module ground testing in Airframe 008," March 15, 1965.

5

SM 001's service propulsion engine was static-fired for 10 sec at White Sands. The firing was the first in a program to verify the mission profiles for later flight tests of the module. (SM 001 was the first major piece of flight-weight Apollo hardware.)

MSC News Release 65-18, February 5, 1965; TWX, M. L. Raines, WSMR, to NASA Headquarters, MSC, MSFC, and ASPO Field Test Office, Cape Kennedy, Fla., "Airframe 001 First Firing," February 6, 1965.

8

MSC deleted the requirement for a rendezvous radar in the CSM.

MSC, "Minutes, Configuration Control Board Meeting No. 5," February 8, 1965.

8

MSC, North American, and Grumman reviewed the results of Langley Research Center's LEM-active docking simulation. While the overhead

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mode of docking had been found to be acceptable, two items still caused some concern: (1) propellant consumption could exceed supply; and (2) angular rates at contact had occasionally exceeded specifications. Phase B (Grumman's portion) of the docking simulations, scheduled to begin in about two weeks, would further investigate these problems. Langley researchers also had evaluated several sighting aids for the LEM and recommended a projected image collimated (parallel in lines of direction) reticle as most practicable. Accordingly, on March 9, MSC directed Grumman to incorporate this type of sighting device into the design of their spacecraft.

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Results of LEM active docking simulation at Langley Research Center," March 9, 1965.

Development tests recently completed by AiResearch on the water evaporator control system for the space suit heat exchanger disclosed its inadequacy because of its slow response time. To solve this problem, AiResearch and North American proposed an alternate control system approach similar to the glycol evaporator scheme used elsewhere in the environmental control system. This alternate design, which was tested and appeared a more desirable approach, would be incorporated on airframes 008 and 012 through Block II spacecraft. No schedule impact was anticipated.

8

"ASPO Weekly Management Report, February 4-11, 1965"; memorandum, Frank E. Samonski, Jr., MSC, to Chief, Test Division, "A14-033 requirements for Airframe 008 testing," February 8, 1965.

NASA invited 113 scientists and 23 national space organizations to a conference at MSC to brief them on the Gemini and Apollo missions. As a result of the conference, NASA hoped to receive proposals for biomedical experiments to be performed in Gemini and Apollo spacecraft.

8

MSC News Release 65-21, "Foreign Scientists Invited to Conference on Apollo Experiments," February 8, 1965.

North American completed the first ground test model of the S-II stage of the Saturn V.

9

Space Business Daily, February 9, 1965, p. 195.

ASPO and the MSC Instrumentation and Electronic Systems Division (IESD) formulated a program for electromagnetic compatibility testing of hardware aboard the CSM and LEM. The equipment would be mounted in spacecraft mockups, which would then be placed in the Center's anechoic chamber. In these tests, scheduled to begin about the first of September, IESD was to evaluate the compatibility of the spacecraft in docked and near-docked

10



A night roll-out of the S-II stage at North American's Downey, Calif., facility.

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configurations, and of Block I spacecraft with the launch vehicle. The division was also to recommend testing procedures for the launch complex.

Memorandum, R. S. Sawyer, MSC, to Chief, Systems Engineering Division, "Test Philosophy for CSM/LEM Electromagnetic Compatibility Test to be performed in the Anechoic Chamber Test Facility at MSC," February 10, 1965.

10

ASPO evaluated Grumman's proposal for an "all battery" system for the LEM descent stage. ASPO was aiming at a 35-hour lunar stay for the least weight; savings were realized by lessening battery capacities, by making the water tanks smaller, and by reducing some of the spacecraft's structural requirements.

Letter, Thomas J. Kelly, GAEC, to MSC, Attn: W. F. Rector III, "Submittal of Additional Information Relative to the Lem 'All-Battery' Study," February 10, 1965, with enclosures.

11

A drop test at El Centro, Calif., demonstrated the ability of the drogue parachutes to sustain the ultimate disreefed load that would be imposed upon them during reentry. (For the current CM weight, that maximum load would be 7711 kg [17 000 lbs] per parachute.) Preliminary data indicated that the two drogues had withstood loads of 8803 and 8165 kg (19 600 and

18 000 lbs). One of the drogues emerged unscathed; the other suffered only minor damage near the pocket of the reefing cutter.

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“Apollo Monthly Progress Report,” SID 62-300-35, pp. 3-4; MSC, “ASPO Weekly Management Report, February 11-18, 1965.”

MSC modified its bubble helmet design to fit on an International Latex “state-of-the-art” space suit. A mockup of the helmet was used in don/doff tests. Mean donning time was 4.2 sec; doff time averaged 1.47 sec. Further tests would be performed when a prototype helmet was completed (expected by February 26).

11-18

“ASPO Weekly Management Report, February 11-18, 1965.”

Hamilton Standard, the extravehicular mobility unit contractor, completed a two-week wearing test of the Apollo liquid-cooled undergarment. Investigators found that the garment could be worn for the entire lunar mission without any serious discomfort.

11-18

Ibid.

To make room for a rendezvous study, MSC was forced to end, prematurely, its simulations of employing the LEM as a backup for the service propulsion system. Nonetheless, the LEM was evaluated in both manual and automatic operation. Although some sizable attitude changes were required, investigators found no serious problems with either steering accuracy or dynamic stability.

11-18

Ibid.

North American selected the Ordnance Division of General Precision Link Group to supply the panel thrusters for the spacecraft lunar adapter.

11-18

Ibid.

Evaluations of the three-foot probes on the LEM landing gear showed that the task of shutting off the engine prior to actual touchdown was even more difficult than controlling the vehicle’s rate of descent. During simulated landings, about 70 percent of the time the spacecraft was less than 0.3 m (1 ft) high when shutdown came; on 20 percent of the runs, the engine was still burning at touchdown. Some change, either in switch location or in procedure, thus appeared necessary to shorten the delay between contact light and engine cutoff (an average of 0.7 sec).

11-18

Ibid.

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MSC relayed to NASA Headquarters North American's cost estimates for airlocks on the Apollo CM:

12	<i>Spacecraft</i>	<i>Development</i>	<i>Unit Cost</i>
	Block I	\$ 840 000	\$185 000
	Block II	960 000	112 000
	Blocks I & II	1 050 000	111 000

(The unit costs presumed two flight items for Block I and 12 for Block II spacecraft.)

During late February and early March, North American completed a conceptual design study of an airlock for the Block I CMs. Designers found that such a device could be incorporated into the side access hatch. A substitute cover for the inner hatch and a panel to replace the window on the outer hatch would have to be developed, but these modifications would not interfere with the basic design of the spacecraft.

TWX, Joseph F. Shea, MSC, to NASA Headquarters, Attn: Samuel C. Phillips, February 12, 1965; "Apollo Monthly Progress Report," SID 62-300-35, pp. 17-18.

12

MSC's Systems Engineering Division (SED) requested support from the Structures and Mechanics Division in determining the existence or extent of corrosion in the coolant loops of the SM electrical power subsystem (EPS) and the CM and LEM environmental control subsystems (ECS), resulting from the use of water/glycol as coolant fluid. Informal contact had been made with W. R. Downs of the Structures and Mechanics Division and he had been given copies of contractor reports and correspondence between MSC, North American, and MIT pertaining to the problem. The contractors had conflicting positions regarding the extent and seriousness of glycol corrosion.

SED requested that a study be initiated to: (1) determine the existence or extent of corrosion in the EPS and ECS coolant loops; and (2) make recommendations regarding alternate materials, inhibitors, or fluids, and other tests or remedial actions if it were determined that a problem existed.

Memorandum, Owen E. Maynard, MSC, to Chief, Structures and Mechanics Division, "Water/glycol Corrosion," signed Harry W. Byington, February 12, 1965.

15

A study by General Electric affirmed the necessity for the steerable S-band antenna for communications between the spacecraft and the ground at lunar distances. Communications margins were so small that, at those distances,

any degradation of equipment would seriously affect the spacecraft's contact with earth.

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Letter, E. J. Merrick, GE, to William A. Lee, "S-Band Communications Requirements Study," February 15, 1965, with enclosure: "CSM-LEM Directional Communications Antenna Relationship to Communications Margins and Mission Requirements."

Crew Systems Division (CSD) informed the Astronaut Office that the requirements submitted by Astronaut Michael Collins on February 5 had been included in the Block II suit program plans. Those requirements for astronaut training suits were:

16

<i>Suit Quantity</i>	<i>Type</i>	<i>Date Available</i>
1	A-5H	June 1965
6	A-5H	December 1965 (or sooner if possible)
6	A-6H1	March 1966
14	A-6H2	August 1966

CSD requested the Astronaut Office to provide the type and schedule of training programs in which suit use was anticipated, stating: "This information will be of value in assessing suit support requirements and the type of suit interface information to be gained from astronaut participation in these programs."

Memorandum, Richard S. Johnston, MSC, to Assistant Director for Flight Crew Operations, Attn: D. K. Slayton, "Apollo Block II training suits," signed E. L. Hays, February 16, 1965.

In the first of a series of manufacturing review meetings at Bethpage, N.Y., it was learned that Grumman's tooling program was behind schedule (caused primarily by engineering changes). Tool manufacturing might recoup much of the lost time, but this process was highly vulnerable to further design changes. Completion of tooling for the ascent stage of LTA-3 was now set for late April, a production delay of about two months.

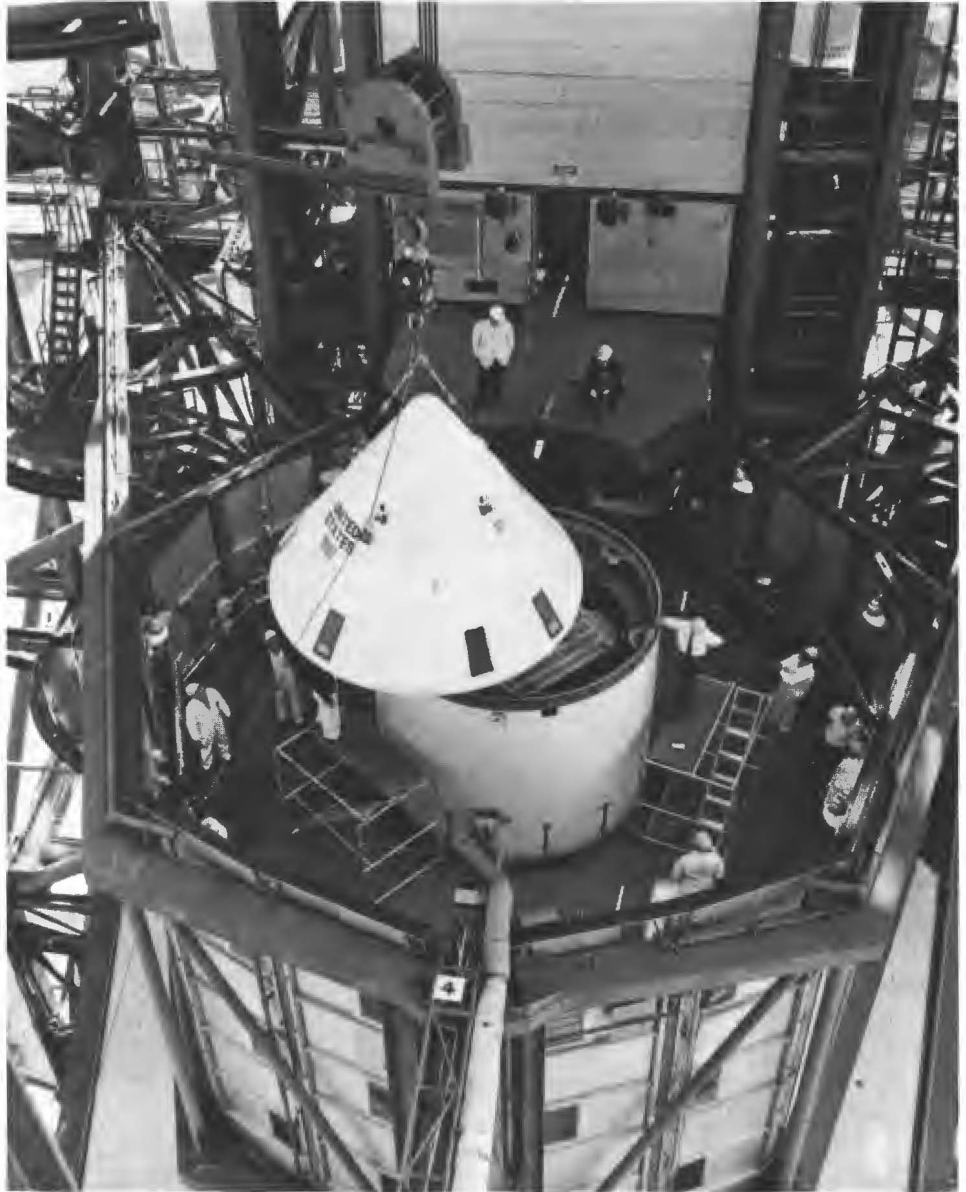
16

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "LEM Manufacture Review Meetings Minutes," March 3, 1965, with enclosure: "Minutes, LEM Manufacturing Review Meeting, February 16, 1965."

In a memorandum to ASPO, Samuel C. Phillips, Apollo Program Director, inquired about realigning the schedules of contractors to meet revised delivery and launch timetables for Apollo. Phillips tentatively set forth deliveries of six spacecraft (CSM/LEMs) during 1967 and eight during each succeeding year; he outlined eight manned launches per year also, starting in 1969.

16

Memorandum, Samuel C. Phillips, NASA, to MSFC, MSC, and KSC, Attn: Directors, "Apollo Delivery and Launch Schedules," February 16, 1965, with enclosures.



The CM is being mated to the SA-9 launch vehicle SM. The Pegasus satellite (part of an expanding meteoroid detection program directed by NASA's Office of Advanced Research and Technology) can be seen inside the SM.

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A Saturn I vehicle (SA-9) launched a multiple payload into a high 744 by 496 km (462 by 308 mi) earth orbit. The rocket carried a boilerplate (BP) CSM (BP-16) and, fitted inside the SM, the *Pegasus I* meteoroid detection satellite. This was the eighth successful Saturn flight in a row, and the first to carry an active payload. BP-16's launch escape tower was jettisoned following second-stage (S-IV) ignition. After attaining orbit, the spacecraft

were separated from the S-IV. Thereupon the *Pegasus I*'s panels were deployed and were ready to perform their task, i.e., registering meteoroid impact and relaying the information to the ground.

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NASA News Release 65-38, "Saturn I to Launch Pegasus Meteoroid," February 15, 1965; TWX, E. R. Mathews, KSC, to NASA Headquarters, MSFC, MSC, and MSFC Resident Manager, Sacramento, California, subject: "CLN SA-9 Apollo Flash Report No. 2," February 18, 1965; *Astronautics and Aeronautics*, 1965, pp. 71-72.

NASA awarded an \$8 879 832 fixed-price contract to the Univac Division of Sperry Rand Corporation for digital data processors for the Apollo project. Univac also would assist in modifying extant computer programs to meet Apollo requirements.

16

NASA News Release 65-50, "NASA Buys Univac Data Processing for Moon Project," February 16, 1965.

MSC announced a realignment of specialty areas for the 13 astronauts not assigned to forthcoming Gemini missions (GT 3 through 5) or to strictly administrative positions:

16

Operations and Training

- Edwin E. Aldrin, branch chief—mission planning
- Charles A. Bassett—operations handbooks, training, and simulators
- Alan L. Bean—recovery systems
- Michael Collins—pressure suits and extravehicular activity
- David R. Scott—mission planning and guidance and navigation
- Clifton C. Williams—range operations, deep space instrumentation, and crew safety.

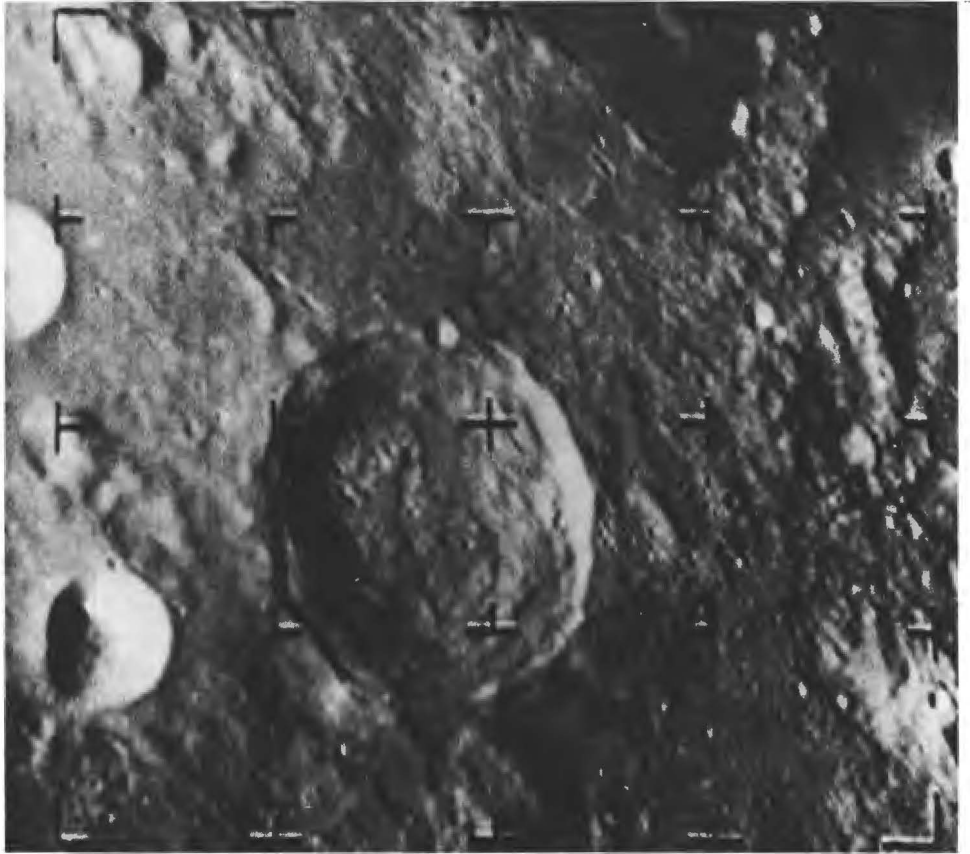
Project Apollo

- Richard F. Gordon, branch chief—overall astronaut activities in Apollo area and liaison for CSM development
- Donn F. Eisele—CSM and LEM
- William A. Anders—environmental control system and radiation and thermal systems
- Eugene A. Cernan—boosters, spacecraft propulsion, and the Agena stage
- Roger B. Chaffee—communications, flight controls, and docking
- R. Walter Cunningham—electrical and sequential systems and non-flight experiments
- Russell L. Schweickart—in-flight experiments and future programs.

MSC News Release 65-27, February 16, 1965.

The CM's waste management system demonstrated its feasibility under zero-g conditions during flights from Wright-Patterson Air Force Base. The

16-March 15



This is one of the 7000 television pictures transmitted to earth by *Ranger VIII*, about 7 min prior to its impact on the moon on February 20, 1965. The spacecraft altitude was approximately 756.4 km (470 mi) at the time this picture was taken. Delambre, 51.5 km (32 mi) in diameter, is featured in the lower center with its flat floor at left and highlands at right.

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system successfully contained both solid and liquid wastes and did not leak even when filled to capacity.

“Apollo Monthly Progress Report,” SID 62-300-35, p. 7.

17

The U.S. Navy Air Crew Equipment Laboratory began testing the Gemini/Block I Apollo space suit in a wide range of environmental temperatures to determine the comfort and physiological responses of the wearer. The program, delayed because of difficulties with humidity control, was to be completed in three to four weeks.

“ASPO Weekly Management Report, February 11-18, 1965.”

17

Ranger VIII, a lunar probe carrying six television cameras, was launched from Cape Kennedy by an Atlas-Agena B vehicle. The spacecraft’s trajectory

was nearly perfect; only minor midcourse corrections were required to place the craft squarely in the target area, in the Sea of Tranquility.

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Cameras in *Ranger VIII* were turned on 23 minutes before impact, and the spacecraft transmitted pictures back to earth until it struck the surface and was destroyed. The flight's product would be intensively studied by a panel of noted lunar scientists, among them Gerard P. Kuiper and Ewen A. Whitaker of the University of Arizona and Harold C. Urey of the University of California.

Astronautics and Aeronautics, 1965, pp. 73-74, 84-85.

MSC directed North American to delete the rendezvous radar from Block II CSMs. On those spacecraft North American instead would install LEM rendezvous radar transponders. Grumman, in turn, was ordered to halt its work on the CSM rendezvous radar (both in-house and at RCA) as well as all support efforts. At the same time, however, the company was directed to incorporate a tracking light on the LEM (compatible with the CSM telescope/sextant) and to modify the spacecraft's VHF equipment to permit range extraction in the CSM. (See February 8 and March 15.)

17

Letter, H. P. Yscek, MSC, to NAA, Space and Information Systems Div., "Contract NAS 9-150, CCA to Cover Removal of Rendezvous Radar Installation on CSM (MSN 150-508)," February 16, 1965; letter, Yscek, to NAA, S&ID, "Contract Change Authorization No. 303," February 17, 1965; letter, J. B. Alldredge, MSC, to NAA, S&ID, "Contract Change Authorization No. 303, Revision 1," March 11, 1965; letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Item 3, Contractor Responsibilities, Rendezvous Radar and Transponder," March 8, 1965, with enclosure.

North American proposed an idea for increasing the CM's land landing capability. This could be done, the company asserted, by raising the water impact limits (thus exceeding normal tolerances) and stiffening the shock struts. Presently, the spacecraft was incapable of a land landing within established requirements (i.e., in a 46-km [25-nm] wind). While even approximate figures were not available, the maximum wind velocity in which the CM could land—without exceeding crew tolerances—was probably between 19 and 28 km (10 and 15 nm) per hr. (No precise data on land and water landings would be available until after the drop tests of boilerplate 28 late in the year.)

17

Personnel of the ASPO Crew Integration Branch, however, were pessimistic about the North American scheme. They doubted that shock attenuation could be readily increased, nor did they see as likely any relaxation of crew tolerances. Further, the probability of a land landing introduced tighter constraints on wind conditions at the launch site. As they viewed it, the only

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- feasible way to improve the spacecraft's ground capability was through some mechanism that would further absorb the landing impact.
- Memorandum, Joseph P. Loftus, Jr., MSC, to Chief, Systems Engineering Division, "Command Module land impact capability," February 17, 1965.
- 17**
- ASPO Manager Joseph F. Shea clarified the manned/unmanned capabilities required of Block I CSM spacecraft to ensure that end-item specifications appropriately reflect those capabilities.
- CSMs 017 and 020 would fly unmanned entry tests on the Saturn V and need not be capable of manned missions. CSMs 012 and 014 were to be delivered to KSC for manned orbital missions on the Saturn IB but must be capable of being modified to fly unmanned missions.
- The planning for CSM 012 should be such that the mission type could be selected 5½ months prior to the scheduled launch of the 204 mission, yet not delay the launch.
- Memorandum, Shea, MSC, to Chief, Systems Engineering Division, "Block I CSM Mission Capabilities," February 17, 1965.
- 18**
- LEM Test Article 2 was shipped to Marshall Space Flight Center to undergo a series of Saturn booster vibration tests.
- "Monthly Progress Report No. 25," LPR-10-41, March 10, 1965, p. 1.
- 18**
- MSC's Crew Systems Division decreed that the extravehicular mobility unit (EMU) would employ a single garment for both thermal and meteoroid protection. By an earlier decision, the penetration probability requirement had been lowered from .9999 to .999. This change, along with the use of newer, more efficient materials, promised a substantial lightening of the garment (hopefully down to about 7.7 kg [17 lbs], excluding visors, gloves, and boots). The division also deleted the requirement for a separate meteoroid visor, because the thermal and glare visors provided ample protection against meteoroids as well. Tests by Ling-Temco-Vought confirmed the need for thermal protection over the pressure suit during extravehicular transfer by the LEM crewmen.
- Memorandum, Robert E. Smylie, MSC, to Chief, Systems Engineering Division, "Extravehicular Mobility Unit (EMU) thermal and meteoroid protection," February 18, 1965.
- 18-25**
- Because of the CM's recent weight growth, the launch escape system (LES) was incapable of lifting the spacecraft the "specification" distance away from the booster. The performance required of the LES was being studied fur-

ther; investigators were especially concerned with the heat and blast effects of an exploding booster, and possible deleterious effects upon the parachutes.

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MSC, "ASPO Weekly Management Report, February 18–25, 1965."

NASA selected Philco's Aeronutronic Division to design a penetrometer for possible use in the Apollo program. Impacting on the moon, the device would measure the firmness and bearing strength of the surface. Used in conjunction with an orbiting spacecraft, the system could provide scientific information about areas of the moon that were inaccessible by any other means. Langley Research Center would negotiate and manage the contract, estimated to be worth \$1 million.

19

NASA News Release 65-59, "NASA to Negotiate With Philco for Study of Moon Penetrometer," February 19, 1965; *Astronautics and Aeronautics*, 1965, p. 82.

To eliminate interference between the S-IVB stage and the instrument unit, MSC directed North American to modify the deployment angle of the adapter panels. Originally designed to rotate 170°, the panels should open but 45° (60° during abort), where they were to be secured while the CSM docked with and extracted the LEM.

19

But at this smaller angle, the panels now blocked the CM's four flush-mounted omnidirectional antennas, used during near-earth phases of the mission. While turning around and docking, the astronauts thus had to communicate with the ground via the steerable high gain antenna. For Block II spacecraft, therefore, MSC concurrently ordered North American to broaden the S-band equipment's capability to permit it to operate within 4630 km (2500 nm) of earth.

Letter, H. P. Yscek, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 304," February 19, 1965; letter, Yscek to NAA, S&ID, "Contract Change Authorization No. 305," February 19, 1965.

NASA awarded a fixed-price contract (worth \$1.5 million) to IBM to design a backup guidance and navigation computer for the Apollo CM.

23

MSC, "Quarterly Activity Report for the Office of the Associate Administrator, Manned Space Flight, for the Period Ending April 30, 1965," p. 24.

William F. Rector III, MSC's LEM Project Officer, reported at an ASPO Manager's Staff Meeting that the expected firing date for the heavyweight ascent (HA) rig #3 at WSTF had been slipped from March 18, 1965, until April 13. Grumman personnel at White Sands said the slip was necessary because (1) a propellant loading control assembly to be mounted on the rig could not be used in the planned location because it was not accessible for

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checkout and would require two weeks for refabrication of certain pipelines and further checkout; (2) checkout of various wiring between the HA-3 rig and the facilities did not occur on schedule and two weeks would be required to complete the task; and (3) adequate interfacing between the fluid and gaseous ground support equipment (GSE) and various facility pipes was not maintained with many pieces of GSE putting out higher pressure than the facility pipes design allowed.

Memorandum, Rector to Distr., "First Firing of HA-3," February 23, 1965.

23-26

MSC and North American conducted Part 2 of the mockup review of the CM's forward compartment and lower equipment bay. (Part 1 was accomplished January 14-15. This staged procedure was in line with the contractor's proposal for a progressive review program leading up to the Critical Design Review scheduled for July 19-23.) Except for minor changes, the design was acceptable.

"Apollo Monthly Progress Report," SID 62-300-33, p. 24; MSC, "ASPO Weekly Management Report, February 25-March 4, 1965."

24

NASA awarded a \$2 740 000 fixed-price contract to the Collins Radio Company for S-band telemetry equipment. Collins would install the equipment at three antenna facilities that supported Apollo lunar missions (at Goldstone, Calif.; Canberra, Australia; and Madrid, Spain).

NASA News Release 65-63, "Collins to Make S-Band Systems for Three 85-Foot Apollo Antennas," February 24, 1965; *Space Business Daily*, February 26, 1965, p. 286.

24

MSC's Procurement and Contracts Division notified ASPO that John B. Alldredge had been assigned as the Contracting Officer for Contract NAS 9-150 (the North American contract), replacing Henry P. Yschek.

Memorandum, C. L. Taylor, MSC, to Distr., "Notification of new Contracting Officer for C&SM Contract NAS 9-150," sgd. W. R. Kelly, February 24, 1965.

25

MSC and the David Clark Company reached an agreement on a contract for Apollo Block I space suits. The first suits, expected by July 1, would go to North American for testing.

Memorandum, Matthew I. Radnofsky, MSC, to Gemini and Flight Support Procurement, Attn: Arc F. Lee, "Contract NAS 9-3642, Apollo Block I Suit, David Clark Company," February 25, 1965.

25

KSC supplemented Chrysler Corporation's contract for support services for the Saturn I and IB launch programs. Effective through June 30, 1968, the agreement would cost NASA \$41 million plus an award fee.

Astronautics and Aeronautics, 1965, p. 94.

Using a mockup Apollo CM, MSC Crew Systems Division tested the time in which an astronaut could don and doff the Block I pressure garment assembly while at various stations inside the spacecraft. The two subjects' average donning times were nine min 33 sec and 10 min; mean doffing times were four min five sec and five min 23 sec.

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MSC, "ASPO Weekly Management Report, February 25–March 4, 1965."

To determine thermal and vacuum effects on the CM's parachutes, MSC Structures and Mechanics Division tested nylon samples in a vacuum under varying temperature conditions. After two weeks of exposure to this space-like environment, the samples exhibited only a 16 percent loss of strength (as against a design allowable of 25 percent).

25–March 4

Ibid.

DeHavilland completed deployment tests of the CM's pop-up recovery antenna.

25–March 4

Ibid.

On the basis of in-house tests, Grumman recommended a scheme for exterior lighting on the LEM. The design copied standard aeronautical practice (i.e., red, port; green, starboard; and amber, underside). White lights marked the spacecraft, both fore and aft; to distinguish between the two white lights, the aft one contained a flasher.

25–March 4

Ibid.; "Monthly Progress Report No. 25," LPR-10-41, p. 22.

ASPO Manager Joseph F. Shea named William A. Lee as an assistant program manager. Lee, who previously headed the Operations Planning Division (which had been absorbed into Owen E. Maynard's Systems Engineering Division), now assumed responsibility for Apollo Operations (both the flight-test program and the lunar mission). Lee thus joined Harry L. Reynolds, also an assistant manager, who was assigned to the LEM's development. Deputy Manager Robert O. Piland continued overseeing the CSM's development and, along with Shea, overall program management.

26

MSC News Release 65-34, February 26, 1965.

Louis Walter, Goddard Space Flight Center geochemist, reported that his research with tektites indicated the lunar surface may be sandlike. Walter had discovered the presence of coesite in tektites, believed to be particles of the moon sent into space when meteorites impact the lunar surface. Coesite, also found at known meteorite craters, is a form of silicon dioxide—a major constituent of sand—produced under high pressure. "If we accept the lunar

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February origin of tektites,” Walter said, “this would prove or indicate that the parent material on the moon is something like the welded tuft that we find in Yellowstone Park, Iceland, New Zealand, and elsewhere.” Welded tuft was said to have some of the qualities of beach sand.

Astronautics and Aeronautics, 1965, p. 96.

During the Month Because of a change in the size of the entry corridor, North American technicians sought to determine whether they might relax the requirements for pointing accuracy of the stabilization and control system at transearth injection. They could not. To ensure a ΔV reserve, the accuracy requirement must remain unchanged.

“Apollo Monthly Progress Report,” SID 62-300-35, p. 8.

During the Month Grumman reported three major problems with the LEM:

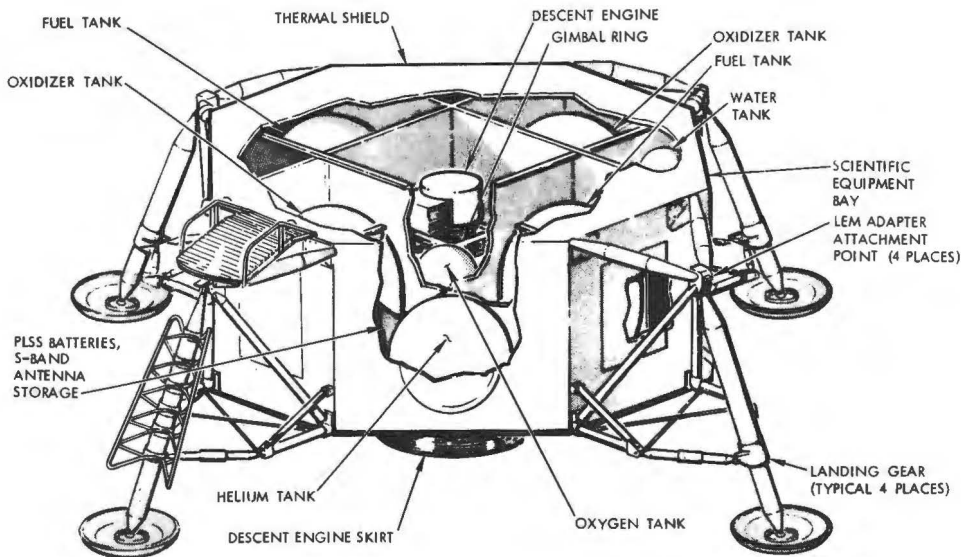
- (1) To enable the manufacturer to complete the design of the aft equipment bay, NASA must define the ground support equipment that would be supported by the LEM adapter platforms.
- (2) Space Technology Laboratories’ difficulties with the descent engine injector (the combustion instability in the variable-thrust engine).
- (3) The need for a lightweight thrust chamber for the descent engine, one that would still meet the new duty cycle.

“Monthly Progress Report No. 25,” LPR-10-41, p. 3.

March
1 ASPO organized a new management group, the Configuration Control Board, to oversee proposals for engineering changes. The board comprised groups representing management, the three Apollo modules, and critical Apollo systems (guidance and navigation, spacecraft checkout equipment, and the extravehicular mobility unit).

MSC, “Apollo Spacecraft Program Office Configuration Management Plan, March 1, 1965,” Revision A, March 19, 1965.

2 MSC decided in favor of an “all-battery” LEM (i.e., batteries rather than fuel cells in both stages of the vehicle) and notified Grumman accordingly. Pratt and Whitney’s subcontract for fuel cells would be terminated on April 1; also, Grumman would assume parenthood of GE’s contract (originally let by Pratt and Whitney) for the electrical control assembly. MSC ordered an immediate cessation of all other efforts involved in the fuel-celled configuration. During the next several weeks, Grumman issued study contracts to Yardney Electric and Eagle-Picher for cost proposals. On April 1, the spacecraft manufacturer presented its proposal for an all-battery LEM; MSC’s concurrence followed two weeks later.



LEM descent stage.

A portable life support system (PLSS) battery charger would no longer be required, but three additional nonrechargeable PLSSs would be carried to provide for extravehicular activities. This change would now require a total of six nonrechargeable batteries.

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On this same date, MSC ordered Grumman to end its work on a supercritical helium system for the LEM's ascent stage, and to incorporate an ambient mode for pressurization. All work on a supercritical system for the stage should be halted. However, Grumman should maintain the supercritical approach for the descent stage, while continuing parallel development on the ambient system. To permit the incorporation of either approach into the final design of the descent stage, components must be interchangeable.

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Implementation of Electrical Power Subsystem and Supercritical Helium Pressurization Configuration Changes," March 2, 1965; memorandum, Owen E. Maynard, MSC, to Chief, Instrumentation and Electronic Systems Division, "LEM Power generation system," March 15, 1965; GAEC, "Implementation of LEM All-Battery Configuration," April 1, 1965; letter, Rector to GAEC, Mullaney, "Contract NAS 9-1100, Implementation of All-Battery Configuration," April 15, 1965; "Monthly Progress Report No. 25," LPR-10-41, pp. 1, 20; GAEC, "Monthly Progress Report No. 26," LPR-10-42, April 10, 1965, pp. 1, 31; TWX, James L. Neal, MSC, to GAEC, Attn: R. S. Mullaney, March 11, 1965.

MSC Structures and Mechanics Division presented their findings on the possibility of qualifying the spacecraft's thermal protection in a single mission. While one flight was adequate to prove the ablator's performance,

3

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the division asserted, it would not satisfy the requirements as defined in the specification.

Memorandum, Joseph N. Kotanchik, MSC, to Chief, Systems Engineering Division, "Adequacy of the SA 501 Mission to Qualify the Apollo Thermal Protection System," March 3, 1965, with enclosures.

- 3 NASA and General Motors' AC Spark Plug Division signed the definitive contract (cost-plus-incentive-fee type) for primary guidance and navigation systems for the Apollo spacecraft (both CMs and LEMs). The agreement, extending through December 1969, covered manufacturing and testing of the systems.

NASA News Release 65-33, March 3, 1965.

- 3 To prevent radiator freezing—and consequent performance degradation—in the Block I environmental control system, MSC ordered North American to supplement the system's coolant. Forty-five kg (100 lbs) of water would be stored in the SMs of airframes 012 and 014.

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 309," March 3, 1965.

- 4 North American gave boilerplate 28 its third water drop test. Upon impact, the spacecraft again suffered some structural damage to the heatshield and the core, though much less than it had experienced on its initial drop. Conditions in this test were at least as severe as in previous ones, yet the vehicle remained watertight.

MSC, "ASPO Weekly Management Report, March 4-11, 1965."

- 5 Newton W. Cunningham, NASA's Ranger Program Manager, notified Apollo Program Manager Samuel C. Phillips that the Ranger investigators and Jet Propulsion Laboratory Ranger Project Office had submitted their unanimous choice of targets for the *Ranger IX* mission. The first two days of the launch windows were omitted from the plan; Day III: Crater Alphonsus; Day IV: Crater Copernicus; Day V: Crater Kepler; Day VI: Crater Aristarchus; Day VII: near Crater Grimaldi.

NASA's Office of Manned Space Flight agreed with Days IV-VII, but recommended a smooth highland area for Day I, a highland basin area for Day II, and the Flammarion highland basin for Day III.

Memorandum, Newton W. Cunningham, NASA, to Gen. Samuel C. Phillips, "Ranger 9 Target Selection," March 5, 1965; "Ranger D Target Selection," March 8, 1965.

- 5 Researchers at Ames Research Center began testing the stability of the Block II CM and escape tower (with canards) in the Center's wind tunnel.

Tests would be conducted on the CM itself and while mated with the tower.

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NAA, "Apollo Monthly Progress Report," SID 62-300-36, May 1, 1965, p. 3.

Preliminary investigation by Grumman indicated that, with an all-battery LEM, passive thermal control of the spacecraft was doubtful. (And this analysis did not include the scientific experiments package, which, with its radioisotope generator, only increased the problem.) Grumman and MSC Structures and Mechanics Division engineers were investigating alternate locations for the batteries and modifications to the surface coatings of the spacecraft as possible solutions.

8

Memorandum, Lee N. McMillion, MSC, to Owen E. Maynard, "Radioisotope power generator," March 5, 1965.

Northrop-Ventura began qualification testing of the CM's earth landing sequence controller.

8

MSC, "ASPO Weekly Management Report, March 4-11, 1965."

Missiles and Rockets reported a statement by Joseph F. Shea, ASPO manager, that MSC had no serious weight problems with the Apollo spacecraft. The current weight, he said, was 454 kg (1000 lbs) under the 40 823 kg (90 000 lb) goal. Moreover, the increased payload of the Saturn V to 43 091 kg (95 000 lbs) permitted further increases. Shea admitted, however, that the LEM was growing; recent decisions in favor of safety and redundancy could raise the module's weight from 13 381 kg to 14 575 kg (29 500 lbs to 32 000 lbs).

8

Astronautics and Aeronautics, 1965, p. 113.

Avco found that cracking of the ablator during cure was caused by incomplete filling, leaving small voids in the material. The company ordered several changes in the manufacturing process: a different shape for the tip of the "filling gun" to facilitate filling those cells that were slightly distorted; manual rather than automatic retraction of the gun; and x-raying of the ablator prior to curing. Using these new methods, Avco repaired the aft heatshield and toroidal corner of airframe 006, which was then re-cured. No cracking was visible. The crew compartment heatshield for airframe 009 came through its cure equally well. Voids in the ablator had been reduced to about two percent. "It appears," Structures and Mechanics Division reported, "that the problem of cracking . . . has been solved by better manufacturing."

9

MSC, "ASPO Weekly Management Report, March 4-11, 1965"; MSC, "ASPO Weekly Management Report, March 11-18, 1965"; memorandum, C. H. Perrine, MSC, to B. Erb and Leo Chauvin, "Attached draft of letter to NASA Headquarters on use of Block I

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Command Modules for Block II Heat Shield Qualification," March 9, 1965, with attachment.

March

9

Initial flights of the LLRV interested MSC's Guidance and Control Division because they represented first flight tests of a vehicle with control characteristics similar to the LEM. The Division recommended the following specific items for inclusion in the LLRV flight test program:

- The handling qualities of the LEM attitude control system should be verified using the control powers available to the pilot during the landing maneuver. The attitude controller used in these tests should be a three-axis LEM rotational controller.

- The ability of pilots to manually zero the horizontal velocities at altitudes of 30.48 m (100 ft) or less should be investigated. The view afforded the pilot during this procedure should be equivalent to the view available to the pilot in the actual LEM.

- The LEM descent engine throttle control should be investigated to determine proper relationship between control and thrust output for the landing maneuver.

- Data related to attitude and attitude rates encountered in landing approach maneuvers were desirable to verify LEM control system design limits.

- Adequacy of LEM flight instrument displays used for the landing maneuver should be determined.

Guidance and Control Division would provide information as to control system characteristics and desired trajectory characteristics. D. C. Cheatham, a member of the Lunar Lander Research Vehicle Coordination Panel, would coordinate such support.

Memorandum, Robert C. Duncan, MSC, to Chief, Flight Crew Support Division, "Recommended items for LLRV Flight Test Program," March 9, 1965.

10

NASA announced that it had awarded a \$3 713 400 contract to Raytheon Company for digital systems for the Apollo program. The equipment, which would be installed at control and tracking stations, would display information telemetered from the spacecraft, and thus would support mission decisions on the ground.

NASA News Release 65-79, "NASA Names Raytheon for Apollo Digital Display Equipment," March 10, 1965.

11

MSC directed North American to incorporate the capability for storing a kit-type mapping and survey system into the basic Block II configuration. The actual hardware, which would be installed in the equipment bay of certain SMs (designated by MSC), would weigh up to 680 kg (1500 lbs).

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 317," March 11, 1965.

MSC notified Grumman that a device to recharge the portable life support system's (PLSS) batteries was no longer required in the LEM. Instead, three additional batteries would be stored in the spacecraft (bringing the total number of PLSS batteries to six).

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TWX, James L. Neal, MSC, to GAEC, Attn: R. S. Mullaney, March 11, 1965.

MSC's Structures and Mechanics Division was conducting studies of lunar landing conditions. In one study, mathematical data concerning the lunar surface, LEM descent velocity, and physical properties of LEM landing gear and engine skirt were compiled. A computer was programmed with these data, producing images on a video screen, allowing engineers to review hypothetical landings in slow motion.

In another study, a one-sixth scale model of the LEM landing gear was dropped from several feet to a platform which could be adjusted to different slopes. Impact data, gross stability, acceleration, and stroke of the landing gear were recorded. Although the platform landing surface could not duplicate the lunar surface as well as the computer, the drop could verify data developed in the computer program. The results of these studies would aid in establishing ground rules for lunar landings.

MSC News Release 65-42, March 11, 1965.

MSC concurred in North American's recommendation that the $27\frac{1}{2}^\circ$ hang angle during parachute descent be retained. (Tests with one-tenth scale models of the CM indicated that, at the higher impact angles, excessive pressures would be exerted on the sidewalls of the vehicle.) Provisions for a "dual hang angle" were still in effect for Block I spacecraft up to airframe 017. Beginning with that number, the face sheets on the aft heat-shield would be modified to conform to the $27\frac{1}{2}^\circ$ impact angle.

11-18

"ASPO Weekly Management Report, March 11-18, 1965."

Crew Systems Division (CSD) engineers were studying several items that, though intended specifically for the Gemini program, were applicable to Apollo as well:

11-18

- During recent tests of the urine nozzle by McDonnell, microorganisms had been found in the sample. This indicated that explosive decompression into very low temperatures had failed to sterilize the urine. To determine possible shifts in the microbial pattern, CSD was examining samples both before and after dumping.

- Division researchers completed microbiological examinations of Gemini food bags. They found that, even though disinfectant tablets were not completely effective, storage of the containers for periods up to two

1965 weeks was nonetheless feasible. (These studies thus reinforced earlier findings of bacterial growth in the bags.)

March

CSD engineers also evaluated the Gemini-type water dispenser and found it suitable for the Apollo CM as well.

Ibid.

11-18 During the flight of boilerplate (BP) 23, the Little Joe II's control system had coupled with the first lateral bending mode of the vehicle. To ensure against any recurrence of this problem on the forthcoming flight of BP-22, MSC asked North American to submit their latest figures on the stiffness of the spacecraft and its escape tower. These data would be used to compute the first bending mode of BP-22 and its launch vehicle.

Ibid.

12 During a pad abort, propellants from the CM's reaction control system (RCS) would be dumped overboard. Structures and Mechanics Division (SMD) therefore established a test program to evaluate possible deleterious effects on the strength of the earth landing system's nylon components. SMD engineers would expose test specimens to RCS fuel (monomethyl hydrazine) and oxidizer (nitrogen tetroxide). This testing series would encompass a number of variables: the length of exposure; the time period between that exposure and the strength test; the concentration of propellant; and the rate and direction of the air flow. Testing was completed near the end of the month. SMD reported that "no significant degradation was produced by any of the test exposure conditions."

Memorandum, Robert B. West, MSC, to Paul E. Fitzgerald, "Preliminary report on minimum ELS requirements in the pad abort mode," March 12, 1965; "ASPO Weekly Management Report, March 11-18, 1965"; MSC, "ASPO Weekly Management Report, March 18-25, 1965."

15 MSC defined the functional and design requirements for the tracking light on the LEM:

- The light must be compatible for use with CSM scan telescope/sextant optics in visual mode during darkside lunar and earth operations.
- The light must provide range capability of 324.1 km (175 nm) for darkside lunar operations when viewed with the CSM sextant.
- The probability of detection within three-minute search time at maximum range when viewed with CSM sextant must exceed 99 percent for worst lunar background.
- The light must flash at the optimum rate for ease of detection and tracking (60 flashes per minute \pm 5 fpm).
- Brightness attenuation must be available for terminal phase operation and for minimizing spacecraft electrical energy drain.

- The light must be capable of inflight operation for continuous periods of one hour duration over four cycles.
- The light must have a total operating life of 30 hours at rated output with a shelf life of two years.
- The light was not required to be maintainable at the component level.
- The total system weight including cooling and electromagnetic interference shielding, if required, should not exceed 5.44 kg (12 lbs).

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Letter, Joseph F. Shea, MSC, to GAEC, Attn: R. S. Mullaney, "Functional and design requirements for LEM tracking light," March 15, 1965.

In November 1964, MSC asked Grumman to conduct a study on the feasibility of carrying a radioisotope power supply as part of the LEM's scientific equipment. The subsequent decision to use batteries in the LEM power system caused an additional heat load in the descent stage. Therefore, MSC requested the contractor to continue the study using the following ground rules: consider the radioisotope power supply a requirement for the purpose of preliminary design efforts on descent stage configuration; determine impact of the radioisotope power supply—in particular its effect on passive thermal control of the descent stage; and specify which characteristics would be acceptable if any existing characteristics of the radioisotope power supply had an adverse effect. The radioisotope power was used only to supply power for the descent stage.

15

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, subject: "Radioisotope Power Supply for Lunar Scientific Experiments," March 15, 1965.

An evaluation was made of the feasibility of utilizing a probe-actuated descent engine cutoff light during the LEM lunar touchdown maneuver. The purpose of the light, to be actuated by a probe extending 0.9 m (3 ft) beyond the landing gear pads, was to provide an engine cutoff signal for display to the pilot. Results of the study indicated at least 20 percent of the pilots failed to have the descent engine cut off at the time of lunar touchdown. The high percentage of engine-on landings was attributed to (1) poor location of the cutoff switch, (2) long reaction time (0.7 sec) of the pilot to a discrete stimulus (a light), and (3) the particular value of a descent rate selected for final letdown (4 ft per sec). It was concluded that a 0.9-m (3-ft) probe would be adequate to ensure pilot cutoff of the descent engine before touchdown provided the pilot reaction time could be reduced to 0.4 sec or less by improving the location of the cutoff switch.

15

Richard Reid, MSC, MSC-IN-65-EG-10, "Simulation and Evaluation of Landing Gear Probe for Sensing Engine Cutoff Altitude During Lunar Landing," March 15, 1965.

North American conducted acoustic tests on the spacecraft's interior, using boilerplate (BP) 14. Noise levels generated by the spacecraft's equipment exceeded specifications. Prime culprits appeared to be the suit compressor

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and the cabin fans. North American engineers asserted, however, that the test vehicle itself, because of its sheet metal construction, compounded the problem. These tests with BP-14, they affirmed, were not representative of conditions in flight hardware. Data on communications inside the spacecraft were inconclusive and required further analysis, but the warning alarm was sufficiently loud to be heard by the crewmen.

“ASPO Weekly Management Report, March 18–25, 1965.”

16

MSC estimated the number of navigational sightings that Apollo crewmen would have to make during a lunar landing mission:

- Translunar coast
 - (a) four maneuvers to align the inertial measurement unit (IMU)
 - (b) 20 navigational sightings requiring 10 maneuvers
- Transearth coast
 - (a) four maneuvers for IMU alignment
 - (b) 50 sightings, 25 maneuvers
- Lunar orbit
 - (a) 10 maneuvers for IMU alignment
 - (b) 24 sightings, 24 maneuvers.

[The Manned Space Flight Network was the primary source for navigational data during the coasting phases of the mission; and although the network could supply adequate data during the circumlunar phase as well, onboard capability must be maintained.]

Letter, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, “Contract NAS 9-150, Navigational Sightings Required for the Lunar Landing Mission,” March 16, 1965.

16

Because the adapter panels, when deployed to 45 degrees, would block the command link with the LEM, a command antenna system on the adapter was mandatory. MSC therefore directed North American to provide such a device on the adapters for spacecraft 014, 101, and 102. This would permit command acquisition of the LEM in the interval between panel deployment and the spacecraft’s clearing the adapter.

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, “Contract Change Authorization No. 322,” March 16, 1965.

16

MSC directed North American to include nine scientific experiments on SA 204/Airframe 012: cardiovascular reflex conditioning, bone demineralization, vestibular effects, exercise ergometer, inflight cardiac output, inflight



MSC test engineer Jack Slight is shown climbing out of a crater at the Center's Lunar Topographical Simulation Area. The six-degrees-of-freedom simulator in which he is strapped produces the effect of one-sixth earth gravity on his body. Slight is wearing an Apollo pressure suit and has a Jacob's staff in his hand.

vector cardiogram, measurement of metabolic rate during flight, inflight pulmonary functions, and synoptic terrain photography. On June 25, the last five experiments were deleted and a cytogenic blood studies experiment was added.

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Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division (S&ID), "Contract Change Authorization No. 323," March 16, 1965; letter, Alldredge to S&ID, "Contract Change Authorization No. 323, Revision 1," June 25, 1965.

MSC eliminated the requirement for relaying, via the LEM/CSM VHF link, transmissions from a moon-exploring astronaut to the earth. This change allowed the 279.0 megacycle (Mc) transmitters in both vehicles to be eliminated; cleared the way for a common VHF configuration; and permitted duplex voice communications between astronaut and spacecraft. For communicating with the LEM, MSC directed North American to provide a 259.7 Mc transmitter in the CSM.

16

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 320," March 16, 1965.

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- ASPO proposed deletion of a liftoff light in the Block II CM. The Block I design provided a redundant panel light which came ON at liftoff as a part of the emergency detection system (EDS). This light gave a cue to the pilot to verify enabling of the EDS automatic abort, for which manual backup was provided. The Block II CM would incorporate improved EDS circuitry without manual backup. Deletion of the liftoff light in the CM was proposed to save weight, power, space, and reliability, and to eliminate a crew distraction during the boost phase of flight.

Memorandum, Joseph F. Shea, MSC, to Assistant Directors for Flight Crew Operations and Flight Operations, "Deletion of Lift-off Light, Apollo Command Module," signed William A. Lee, March 16, 1965.

- 16–April 15**
- North American dropped boilerplate 1 twice to measure the maximum pressures the CM would generate during a high-angle water impact. These figures agreed quite well with those obtained from similar tests with a one-tenth scale model of the spacecraft, and supported data from the model on side wall and tunnel pressures.

"Apollo Monthly Progress Report," SID 62-300-36, p. 3.

- 17**
- After extensive analysis, Crew Systems Division recommended that the "shirtsleeve" environment be kept in the CM. Such a design was simpler and more reliable, and promised much greater personal comfort than wearing the space suit during the entire mission.

Memorandum, Maxime A. Faget, MSC, to Manager, ASPO, "Crew Systems Division recommendation on establishment of suit wear criterion," March 17, 1965.

- 18**
- Russia launched *Voskhod II* from the Baikonur Cosmodrome in Kazakhstan, piloted by Colonel Pavel Belyayev and Lt. Colonel Aleksey Leonov into an orbit 497 by 174 km (309 by 108 mi) high. During *Voskhod II*'s second orbit, Leonov stepped from the vehicle and performed mankind's first "walk in space." After 10 min of extravehicular activity, he returned safely to the spacecraft (apparently leaving and entering through an airlock). On the following day, the two cosmonauts landed near Perm, Russia, after 17 orbits and 26 hours of flight.

Astronautics and Aeronautics, 1965, pp. 131-132, 136, 157.

- 18**
- Because of continuing developmental problems, Hamilton Standard chose B. F. Goodrich to replace International Latex as subcontractor for the garment portion of the Apollo space suit.

Letter, Joseph F. Shea, MSC, to NASA Headquarters, Attn: George E. Mueller, "Extra-vehicular Mobility Unit subcontractor change," March 18, 1965.

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Grumman officials presented their findings on supercritical versus gaseous oxygen storage systems for the LEM [supercritical: state of homogeneous mixture at a certain pressure and temperature, being neither gas nor liquid]. After studying factors of weight, reliability, and thermal control, as well as cost and schedule impacts, they recommended gaseous tanks in the ascent stage and a supercritical tank in the descent stage. They stressed that this configuration would be about 35.66 kg (117 lbs) lighter than an all-gaseous one. Though these spokesmen denied any schedule impact, they estimated that this approach would cost about \$2 million more than the all-gaseous mode. MSC was reviewing Grumman's proposal.

During the latter part of the month, Crew Systems Division (CSD) engineers also looked into the several approaches. In contrast to Grumman, CSD calculated that, at most, an all-gaseous system would be but 4.08 kg (9 lbs) heavier than a supercritical one. CSD nonetheless recommended the former. It was felt that the heightened reliability, improved schedules, and "substantial" cost savings that accompanied the all-gaseous approach offset its slim weight disadvantage.

During late April, MSC ordered Grumman to adopt CSD's approach (gaseous systems in both stages of the vehicle). [Another factor involved in this decision was the lessened oxygen requirement that followed substitution of batteries for fuel cells in the LEM. See March 2.]

GAEC, "Monthly Progress Report No. 27," LPR-10-43, May 10, 1965, p. 17; MSC, "ASPO Weekly Management Report, March 18-25, 1965"; "ASPO Weekly Management Report, March 25-April 1, 1965"; "ASPO Weekly Management Report, April 22-29, 1965."

Lawrence B. Hall, Special Assistant for Planetary Quarantine, Bioscience Programs, Office of Space Science and Applications, NASA Headquarters, listed preliminary requirements for space in the Lunar Sample Receiving Station as recommended by the Communicable Disease Center of the Public Health Service. The estimates were based on CDC experience involving the design, construction, and operation of similar biological facilities and called for net space amounting to 7201 sq m (77 492 sq ft) for laboratories, scientific support service facilities, offices and other areas, and did not reflect requirements of the U.S. Department of Agriculture or experimenters who could justify their work being done under quarantine conditions. Hall noted that Dr. Randolph Lovelace and the Chief of CDC were in agreement that the facility should be isolated, certainly not in or near a metropolitan area, and that an island would be favored.

18

Memorandum for Record, Lawrence B. Hall, "Primary barrier for lunar quarantine," March 18, 1965.

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18-25 Structures and Mechanics Division engineers were studying several schemes for achieving the optimum weight of Block II CMs without compromising landing reliability: reducing velocity by retrorockets or “explosions” in the parachutes; controlling roll attitude to 0° at impact through a “rotatable pot” structure; changing landing medium (i.e., shape hole in water and/or aeration of the water).

MSC, “ASPO Weekly Management Report, March 18-25, 1965.”

18-25 Crew Systems Division (CSD) engineers, continuing their evaluation of liquid-cooled garments (LCG), tested Hamilton Standard’s newest version (the LCG-8). The manufacturer had modified placement of the tubes and had used a stretchable, more closely knit fabric. CSD found this style an improvement over its predecessor (the LCG-3): it was more efficient, more comfortable, and easier to don and doff. CSD officials accordingly froze the configuration of the garment around this latest model. Further design work would be minimal (chiefly interface modifications and improvements in fabrication techniques).

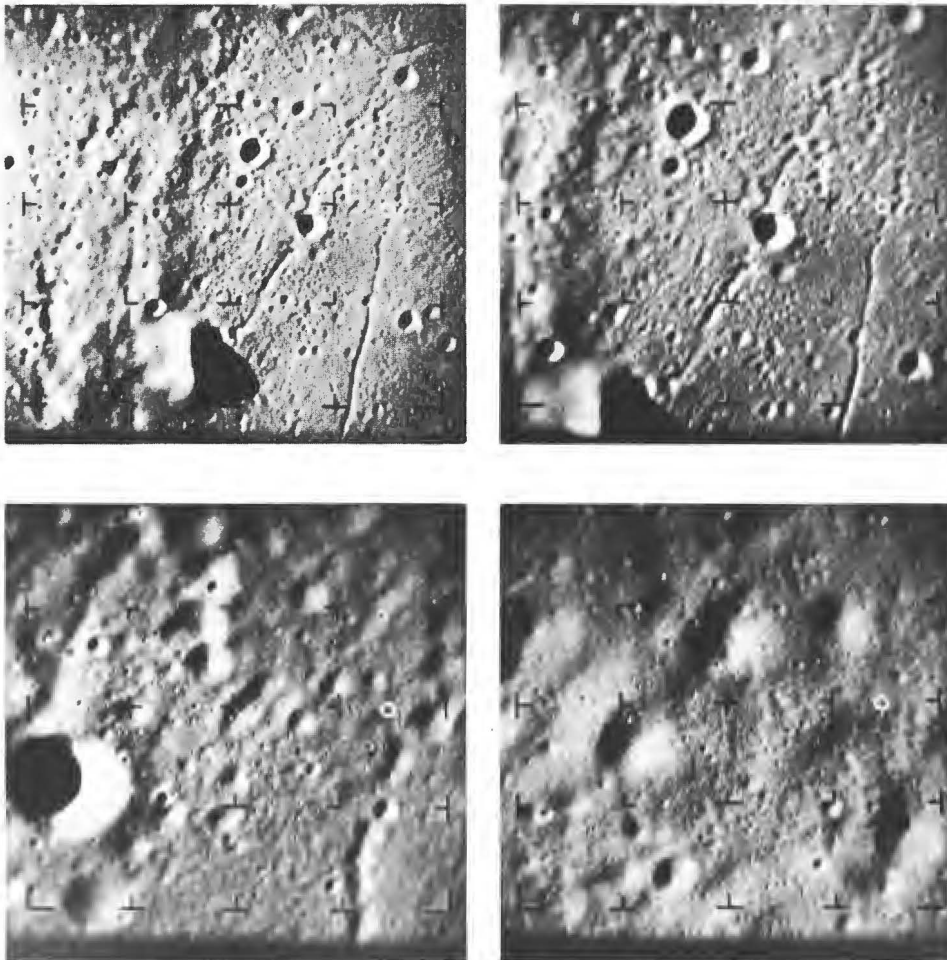
Ibid.

18-25 The Atomic Energy Commission evaluated proposals by Radio Corporation of America and General Electric (GE) for an isotope generator for the Surveyor lunar roving vehicle, and assigned follow-on work to the latter firm. GE’s concept, it was felt, was compatible with the possible requirement that the fuel source might have to be carried separately aboard the LEM. MSC’s Propulsion and Power Division reported that the generator’s “prospects . . . look[ed] very promising.”

Ibid.

19 Bell Aerosystems Company reported that a study had been made to determine if it were practical to significantly increase simulation time without major changes to the Lunar Landing Research Vehicle (LLRV). This study had been made after MSC personnel had expressed an interest in increased simulation time for a trainer version of the LLRV. The current LLRV was capable of about 10 minutes of flight time and two minutes of lunar simulation with the lift rockets providing one-sixth of the lift. It was concluded that lunar simulation time approaching seven minutes could be obtained by doubling the 272-kg (600-lb) peroxide load and employing the jet engine to simulate one-half of the rocket lift needed for simulation.

A major limiting factor, however, was the normal weather conditions at Houston, where such a training vehicle would be located. A study showed that in order to use a maximum peroxide load of 544 kg (1200 lbs), the temperature could not exceed 313 K (40°F); and at 332 K (59°F) the maxi-



The four pictures above are taken from *Ranger IX* during the last 33.7 sec prior to impact. The impact point is circled in all photos. Top left, altitude 81 km (50.3 mi) at 33.7 sec; top right, 56.3 km (35 mi) at 23.5 sec; bottom left, 19.6 km (12.2 mi) at 8.09 sec; and bottom right, 7.2 km (4.5 mi) at 2.97 sec. Area covered by the photos is 38.6 km (24 mi) across at top left; 26.97 km (16.75 mi) at top right; 9.3 km (5.8 mi) at bottom left; and 3.3 km (2.1 mi) at bottom right.

mum load must be limited to 465 kg (1025 lbs) of peroxide. On the basis of existing weather records it was determined there would be enough days on which flights could be made in Houston on the basis of 544 kg (1200 lbs) peroxide at 313 K (40°F), 465 kg (1025 lbs) at 332 K (59°F), and 354 kg (775 lbs) at 353 K (80°F) to make provisions for such loads.

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Letter, John Ryken, Bell Aerosystems Company, to Ronald Decrevel, "Preliminary Study of Methods of Increasing LLRV Lunar Simulation Time," March 19, 1965; letter, Ryken to Decrevel, "Effect of Houston Temperatures on Allowable LLRV Weight and Flight Time," March 23, 1965.

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NASA launched *Ranger IX*, last of the series, from Cape Kennedy aboard an Atlas-Agena vehicle. The target was Alphonsus, a large crater about 12° south of the lunar equator. The probe was timed to arrive when lighting conditions would be at their best. The initial trajectory was highly accurate; uncorrected, the craft would have landed only 400 miles north of Alphonsus. On March 23, a midcourse correction increased *Ranger IX*'s speed and placed it on a near-perfect trajectory: the spacecraft impacted the following day only four miles from the original aiming point.

From 2092 km (1300 mi) out until it was destroyed on impact, *Ranger IX*'s six television cameras took 5814 pictures of the lunar surface. These pictures were received at Jet Propulsion Laboratory's Goldstone, Calif., Tracking Laboratory, where they were recorded on tape and film for detailed analysis. They also were released to the nation's three major television networks in "real time," so millions of Americans followed the spacecraft's descent. The pictures showed the rim and floor of the crater in fine detail: in those just prior to impact, objects less than a foot in size were discernible.

A panel of scientists presented some preliminary conclusions from *Ranger IX* at a press conference that same afternoon. Crater rims and ridges inside the walls, they believed, were harder and smoother than the moon's dusty plains, and therefore were considered likely sites for future manned landings. Generally, the panel was dubious about landing on crater floors however. Apparently, the floors were solidified volcanic material incapable of supporting a spacecraft. Investigators believed several types of craters were seen that were of nonmeteoric origin. These findings reinforced arguments that the moon at one time had experienced volcanic activity.

Astronautics and Aeronautics, 1965, pp. 140, 142, 143, 146, 148-149; NASA News Release 65-25, "NASA Readies Two Ranger Spacecraft for Moon Missions," February 4, 1965; NASA News Release 65-96, "Ranger IX to Send World's First Live Moon Photos," March 23, 1965.

22

Glynn S. Lunney was named by MSC Director Robert R. Gilruth as Assistant Flight Director for Apollo missions 201 and 202. Lunney would continue to serve as Chief of the Flight Dynamics Branch, Flight Control Division, and as MSC Range Safety Coordinator with the U.S. Air Force Eastern Test Range.

MSC Announcement 65-33, "Appointment of Assistant Flight Director for Apollo 201 and 202 Missions," March 22, 1965.

22

The change from LEM fuel cells to batteries eliminated the need for a hard-line interstage umbilical for that system and the effort on a cryogenic

umbilical disconnect was canceled. The entire LEM pyrotechnic effort was redefined during the program review and levels of effort and purchased parts cost were agreed upon.

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MSC, "ASPO Weekly Management Report, March 18-25, 1965."

Jet Propulsion Laboratory scientists W. L. Sjogren and D. W. Trask reported that as a result of *Ranger VI* and *Ranger VII* tracking data, Deep Space Instrumentation Facility station locations could be determined to within 10 m (10.9 yds) in the radial direction normal to the earth's spin axis. Differences in the longitude between stations could be calculated to within 20 m (21.9 yds). The moon's radius had been found to be 3 km (1.86 mi) less than was thought, and knowledge of its mass had been improved by an order of magnitude.

22

Astronautics and Aeronautics, 1965, p. 160.

ASPO summarized their requirements for entry monitoring and backup reentry range control:

22

- The flight crew would monitor the entry to detect a skip or excessive "g" trajectory early enough to allow manual takeover and safe reentry.
- The entry corridor should be verified and indications of too steep or shallow an entry displayed to the crew.
- The spacecraft guidance and control systems should provide manual range control capability after failures in the primary guidance and navigation system (PGNS) prior to reentry, and after discrete or catastrophic failures in the PGNS during reentry.

Memorandum, Joseph F. Shea, MSC, to Chief, Guidance and Control Division, "Requirements for Command Module entry monitoring and backup reentry ranging capability," March 22, 1965.

MSC ordered Grumman to halt development of linear-shaped charge cutters for the LEM's interstage umbilical separation system, and to concentrate instead on redundant explosive-driven guillotines. By eliminating this parallel approach, and by capitalizing on technology already worked out by North American on the CSM umbilical cutter, this decision promised to simplify hardware development and testing. Further, it promised to effect significant schedule improvements and reductions in cost.

22

Memorandum, W. F. Rector III, MSC, to Contracting Officer, LEM, "Request for PCCP-MDF Driven Guillotine," March 22, 1965.

A two-stage Titan II rocket boosted *Gemini III* and its crew, astronauts Virgil I. Grissom and John W. Young, into an elliptical orbit about the

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This view of the *Gemini III* astronauts was taken through the window of the open hatch on Astronaut John W. Young's side of the spacecraft. Virgil I. "Gus" Grissom is on the right.

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earth. After three orbits, the pair manually landed their spacecraft in the Atlantic Ocean, thus performing the first controlled reentry. Unfortunately, they landed much farther from the landing zone than anticipated, about 97 km (60 miles) from the aircraft carrier U.S.S. *Intrepid*. But otherwise the mission was highly successful. *Gemini III*, America's first two-manned space

mission, also was the first manned vehicle that was maneuverable. Grissom used the vehicle's maneuvering rockets to effect orbital and plane changes.

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NASA News Release 65-81, "NASA Schedules First Manned Gemini Flight from Cape Kennedy," March 17, 1965; James M. Grimwood and Barton C. Hacker, with Peter J. Vorzimmer, *Project Gemini Technology and Operations: A Chronology* (NASA SP-4002, 1969), pp. 189-191; *Astronautics and Aeronautics, 1965*, pp. 145-46; "MSC Fact Sheet 29I-A, Gemini 3 Flight" [Ivan D. Ertel], April 1965.

Part I of the Critical Design Review of the crew compartment and the docking system in the Block II CM was held at North American. Systems Engineering (SED) and Structures and Mechanics (SMD) divisions, respectively, evaluated the two areas.

23-24

- Crew compartment:

(a) The restraint harness, acceptable in the Block I vehicle, interfered with attachments for the suit umbilicals. These attachments were critical for suit ventilation and mobility; the harness location was likewise critical for crew impact tolerances. Evaluation of alternate locations for the harness and umbilical fittings—or both—awaited the availability of a couch mockup. Manned sled tests might be needed to verify any harness changes.

(b) Restraints at the sleep station must be redesigned. At present, they did not allow sufficient room for a crewman in his pressure suit.

(c) To save weight, North American planned to strap crew equipment to shelves and bulkheads (rather than stowing such gear in compartments, as was done on the Block I vehicle).

(d) Most serious, in an earth landing, when the attenuator struts compressed, the couches would strike a portable life support system (PLSS). "No analysis has been made," SED reported, "to show that this is acceptable." For in such an occurrence, the crew could be injured or killed, the oxygen tank in the PLSS (under about 409 kg [900 lbs] of pressure) could explode, and the aft bulkhead might be ruptured. North American was scheduled to report on this problem on April 27.

- Docking system:

(a) SMD approved the probe and drogue concept, but recommended that fittings be standardized throughout (so that only one tool was needed).

(b) The division also approved North American's design for the outer side hatch (i.e., limiting its deployment to 90°), pending MSC's final word on deployment requirements.

(c) The division recommended that the forward hatch mechanism be simplified. (North American warned of schedule delays.)

MSC, "ASPO Weekly Management Report, March 18-25, 1965"; MSC, "ASPO Weekly Management Report, March 25-April 1, 1965"; letter, H. G. Osbon, NAA, to NASA MSC, Attn: C. L. Taylor, "Contract NAS 9-150, R&D for Apollo Spacecraft Minutes of Critical Design Review No. 2, Phase I conducted on 23-24 March, 1965," June 15, 1965.

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Grumman ordered Space Technology Laboratories to increase the lifetime of the thrust chamber in the LEM's descent engine. This required substantial redesigning and was expected to delay the engine's qualification date about seven months.

MSC, "ASPO Weekly Management Report, April 1-8, 1965."

24

ASPO requested the Structures and Mechanics Division (SMD) to study the problem of corrosion in the coolant loops of the CM's environmental control system, and to search for effective inhibitors. Current efforts at North American to lessen corrosion included improved hardware and operating procedures, but stopped short of extensive redesigning; and it would be some time before conclusive results could be expected. Early in May, Owen E. Maynard, chief of the Systems Engineering Division, directed SMD immediately to begin its search for inhibitors. If by July 1966 the corrosion problem remained unresolved, SMD could thus recommend stop-gap measures for the early spacecraft.

Memorandum, Joseph N. Kotanchik, MSC, to Chief, Systems Engineering Division, "Water/glycol corrosion," March 24, 1965, with enclosure: "Detailed Plan of Investigation on Corrosion Effects of Water/Glycol Mixtures on Spacecraft Radiators"; memorandum, Owen E. Maynard, MSC, to Chief, Structures and Mechanics Division, "Water/Glycol Corrosion," May 4, 1965.

24

MSC contacted Grumman with reference to the LEM ascent engine environmental tests at Arnold Engineering Development Center (AEDC), scheduled for cell occupancy there from May 1, 1965, until September 1, 1965. It was MSC's understanding that the tests might begin without a baffled injector. It was pointed out, however, that the first test was expected to begin July 1, and since the recent baffle injector design selection had been made, time remained for the fabrication of the injector, checkout of the unit, and shipment to AEDC for use in the first test.

Since the baffled injector represented the final hardware configuration, it was highly desirable to use the design for these tests. MSC requested that availability of the injector constrain the tests and that Grumman take necessary action to ensure compliance.

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, March 24, 1965.

24

ASPO Manager Joseph F. Shea said that the first major test of an Apollo spacecraft AFRM 009 tended to pace the CSM program and therefore had taken on a special program significance. Reflecting this significance, both MSC and North American had applied specific additional senior management and project engineering effort to that spacecraft. In the fall of 1965, Robert O. Piland, ASPO Deputy Manager, was assigned to give priority to

AFRM 009 to complement and support the normal ASPO project engineering activities. North American simultaneously gave a special assignment regarding 009 to Assistant Program Manager Charles Feltz.

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Recently North American had assigned a Chief Project Engineer to a full-time assignment on 009. ASPO's current management and project engineering plan for the spacecraft was: Piland would continue to give priority attention to 009, in addition to his normal duties, and would deal directly with Feltz. The ASPO Chief Project Engineer Rolf W. Lanzkron would be responsible for all ASPO project engineering activities for all spacecraft to be launched at KSC. He would give priority attention to all Block I spacecraft, ensuring schedules through adequate planning, timely decisions, and rapid referral of problems to the Deputy Manager where appropriate. Lanzkron would coordinate with North American's Chief Project Engineer, Ray Pyle, on matters pertaining to 009. Lanzkron would be supported in the Block I project engineering effort by a group headed by William Petynia.

Memorandum, Joseph F. Shea, MSC, to Distribution, "MSC Management and Project Engineering for AFRM 009," March 24, 1965.

After further design studies following the M-5 mockup review (October 5-8, 1964), Grumman reconfigured the boarding ladder on the forward gear leg of the LEM. The structure was flattened, to fit closer to the strut. Two stirrup-type steps were being added to ease stepping from the top rung to the platform or "porch" in front of the hatch.

25-April 1

"ASPO Weekly Management Report, March 25-April 1, 1965"; letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Line Item 4-Lunar Excursion Module, M-5 Review, Chits 1-4 and 1-13," April 30, 1965.

North American completed negotiations with Ling-Temco-Vought for design support on the environmental control radiators for Block II CSMs.

25-April 1

"Apollo Monthly Progress Report," SID 62-300-36, p. 8; "ASPO Weekly Management Report, March 25-April 1, 1965."

Crew Systems Division confirmed the feasibility of commonality of personal communications equipment for the entire Apollo program.

25-April 1

"ASPO Weekly Management Report, March 25-April 1, 1965"; memorandum, Richard S. Johnston, MSC, to Chief, Systems Engineering Division, Attn: R. Williams, "Apollo space suit communications program definition," April 5, 1965.

North American began a series of water impact tests with boilerplate 1 to obtain pressure data on the upper portions of the CM. Data on the side walls

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1965 and tunnel agreed fairly well with those obtained from 1/10 scale model drops; this was not the case with pressures on the top deck, however.

March "Apollo Monthly Progress Report," SID 62-300-36, p. 3.

27 Test Series I on spacecraft 001 was completed at WSTF Propulsion Systems Development Facility. Vehicle and facility updating in progress consisted of activating the gimbal subsystem and installing a baffled injector and pneumatic engine propellant valve. The individual test operations were conducted satisfactorily, and data indicated that all subsystems operated normally. Total engine firing time was 765 seconds.

"Apollo Monthly Progress Report," SID 62-300-36, pp. 13, 18; memorandum, Spacecraft 001 Project Engineer, to Distribution, "Review of S/C 001 and TF-2 Test Results," April 19, 1965.

29 MSC decided upon a grid-type landing point designator for the LEM. Grumman would cooperate in the final design and would manufacture the device; MIT would ensure that the spacecraft's guidance equipment could accept data from the designator and thus change the landing point.

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Item 3; LEM Landing Point Designator," March 29, 1965.

29 William F. Rector, the LEM Project Officer in ASPO, replied to Grumman's weight reduction study (submitted to MSC on December 15, 1964). Rector approved a number of the manufacturer's suggestions:

- Delete circuit redundancy in the pulse code modulation telemetry equipment
- Eliminate the VHF lunar stay antenna
- Delete one of two redundant buses in the electrical power system
- Move the batteries for the explosive devices (along with the relay and fuse box assembly) from the ascent to the descent stage
- Reduce "switchover" time (the length of time between switching from the oxygen and water systems in the descent stage to those in the ascent portion of the spacecraft and the actual liftoff from the moon's surface). Grumman had recommended that this span be reduced from 100 to 30 min; Rector urged Grumman to reduce it even further, if possible. He also ordered the firm to give "additional consideration" to the whole concept for the oxygen and water systems: (1) in light of the decisions for an all-battery LEM during translunar coast; and (2) possibility of transferring water from the CM to the LEM.

But ASPO vetoed other proposals to lighten the spacecraft:

- Delete the high intensity light. Because the rendezvous radar had

been eliminated from the CSM, Rector stated flatly that the item could "no longer be considered as part of the weight reduction effort."

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- Combine the redundant legs in the system that pressurized the reaction control propellants, to "modularize" the system. MSC held that the parallel concept must be maintained.
- Delete the RCS propellant manifold.
- Abridge the spacecraft's hover time. Though the Center was reviewing velocity budgets and control weights for the spacecraft, for the present ASPO could offer "no relief."

And lastly, Rector responded to Grumman's proposals for staging components of the extravehicular mobility unit (EMU). These proposals had been made on the basis of a LEM crew integration systems meeting on January 27, at which staging had been explored. Those discussions were no longer valid, however. MSC had since required a capability for extravehicular transfer to the LEM. In light of this complicating factor, MSC engineers had reevaluated the entire staging concept. Although staging still offered "attractive" weight reductions, they determined that, at present, it was impractical. Accordingly, Rector informed Robert S. Mullaney, the LEM Program Manager at Grumman, that his firm must revert to the pre-January 27 position—i.e., the EMU and other assorted gear must be stored in the ascent stage of the spacecraft.

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Weight Reduction Study Status," March 29, 1965.

Beech Aircraft Corporation stopped all end-item acceptance tests of hydrogen and oxygen tanks as a result of interim failure reports issued against three tanks undergoing tests. Failures ranged from exceeding specification tolerances and failure to meet heat leak requirements to weld failure on the H₂ tank. Beech would resume testing when corrective action was established and approved by North American.

29-April 4

NAA, "Project Apollo Spacecraft Test Program Weekly Activity Report (Period 29 March 1965 through 4 April 1965)," p. 4; "Apollo Monthly Progress Report," SID 62-300-36, p. 12.

MSC requested that Grumman incorporate in the command list for LEMs 1, 2, and 3 the capability for turning the LEM transponder off and on by real-time radio command from the Manned Space Flight Network. Necessity for capability of radio command for turning the LEM transponder on after LEM separation resulted from ASPO's decision that the LEM and Saturn instrument unit S-band transponders would use the same transmission and reception frequencies.

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TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, March 31, 1965.

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MSC directed Grumman to use supercritical helium only in the descent stage of the LEM; Grumman completed negotiations with AiResearch for the storage system.

**During
the
Month**

“Monthly Progress Report No. 26,” LPR-10-42, p. 1.

Bell Aerosystems Company received Grumman’s go-ahead to resume work on the thrust chamber of the LEM ascent engine. Bell conducted a dozen stability tests using an injector fitted with a 31.75 mm (1.25 in), Y-shaped baffle. Thus far, the design had recovered from every induced disturbance (including widely varied fuel-to-oxygen ratios). Also, to ease the thermal soakback problem, Bell planned to thicken the chamber wall.

“Monthly Progress Report No. 26,” LPR-10-42, pp. 8, 17.

**During
the
Month**

Grumman recommended to MSC that the stroking gear pad be used on the LEM and that design effort to refine crushing performance should continue.

Ibid., p. 1.

**During
the
Month**

Grumman reported the status of their development program on the LEM landing gear. The firm was:

- Continuing hardware design on the 424-cm (167-in) gear
- Testing honeycomb crushing characteristics at velocities up to 7.62 m per sec (25 fps)
 - Studying high-density honeycomb materials that would still be compatible with a lightweight secondary strut
 - Studying the possibility of strengthening the rim of the fixed (non-stroking) footpad
 - Designing a boilerplate footpad for use in drop tests
 - Planning drops of a 406-cm (160-in) gear
 - Continuing testing on primary and secondary struts

Ibid., pp. 13-14.

**During
the
Month**

Space Technology Laboratories’ major problems with the LEM descent engine, Grumman reported, were attaining high performance and good erosion characteristics over the entire throttling range.

Ibid., p. 19.

**During
the
Month**

Three flights were made with the Lunar Landing Research Vehicle (LLRV) for the purpose of checking the automatic systems that control the attitude of the jet engine and adjusting the throttle so the jet engine would support five-sixths of the vehicle weight.



A full-scale LEM mockup was located at MSC's Lunar Topographical Simulation Area.

On March 11 representatives of Flight Research Center (FRC) visited MSC to discuss future programs with Warren North and Dean Grimm of Flight Crew Support Division. A budget for operating the LLRV at FRC through fiscal year 1966 was presented. Consideration was being given to terminating the work at FRC on June 30, 1966, and moving the vehicles and equipment to MSC.

1965

**March
11**

1965

March

A contract was placed (on March 17) to erect a 12.19 x 12.19-m (40 x 40 ft) building at the south base area of FRC, where the LLRV was flown. Construction was expected to be complete in 60 days and the building should reduce LLRV interference with Air Force operations and enhance the preflight procedures.

Letter, Office of Director, FRC, to NASA Headquarters, "Lunar Landing Research Vehicle Progress Report No. 21 for period ending March 31, 1965," sgd. De E. Beeler for Paul F. Bikle, April 7, 1965.

April

1

Grumman presented to MSC its recommendations for an all-battery electrical power system for the LEM:

- Two batteries in the ascent stage
- Four batteries in the descent stage
- A new power distribution system
- Active cooling for the descent batteries and electrical control assemblies

Following a review of cost and resources proposals, MSC approved Grumman's configuration, and on April 15 gave the LEM manufacturer a go-ahead.

MSC requested that Grumman evaluate the possibility of furnishing power for the pre-separation checkout of the LEM wholly from that module's power supply. This procedure would obviate the CSM's supplying that power during the initial 60 min of the checkout. This would simplify the electrical connections between the two spacecraft and eliminate the possible requirement for an additional battery charger in the CSM. The Center advised North American, however, that such a charger might still be needed on Block II CSMs.

GAEC, "Implementation of LEM All-Battery Configuration," April 1, 1965; letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Implementation of All-Battery LEM Configuration," April 15, 1965.

1

The first stage of the Saturn IB booster (the S-IB-1) underwent its first static firing at Huntsville, Alabama. The stage's eight uprated H-1 engines produced about 71 168-kilonewtons (1.6 million lbs) thrust. On April 23, Marshall and Rocketdyne announced that the uprated H-1 had passed qualification testing and was ready for flight.

Astronautics and Aeronautics, 1965, p. 162; *Space Business Daily*, April 7, 1965, p. 209.

Apollo Program Director Samuel C. Phillips told ASPO Manager Joseph F. Shea that Bellcomm, Inc., was conducting a systems engineering study of lunar landing dynamics to determine "functional compatibility of the naviga-

tion, guidance, control, crew, and landing gear systems involved in Apollo lunar landing." Phillips asked that he be advised of any specific assignments in these areas which would prove useful in support of the ASPO operation.

1965

April

Shea replied, "We are currently evaluating the LEM lunar landing system with the Apollo contractors and the NASA Centers. We believe that the landing problem is being covered adequately by ourselves and these contractors." Shea added that a meeting would be held at Grumman April 21 and 22 to determine if there were any deficiencies in the program, and that he would be pleased to have Bellcomm attend the meeting and later make comments and recommendations.

Letter, Phillips to Shea, April 1, 1965; letter, Shea to Phillips, April 6, 1965.

H. I. Thompson Company's first combustion chamber with a tape-wrapped throat successfully withstood a series of four test firings. If further testing confirmed its performance, reported the resident Apollo office at Bethpage, N.Y., the design would be used in the LEM's ascent engine. (It would replace the current compression-molded throat, which suffered from excessive cracking.)

1-7

MSC, "Weekly Activity Report for Office of the Associate Administrator, Manned Space Flight, April 4-10, 1965," p. 2.

The thrust mount for the LEM ascent engine cracked during vibration testing. The mount would be strengthened.

1-8

During the same period, Bell tested the first one-piece ablative chamber for the ascent engine (designed to replace the molded-throat design, which developed cracks during testing). In firings that totaled over eight minutes, Bell engineers found that the unit suffered only negligible throat erosion and decay of chamber pressure.

"ASPO Weekly Management Report, April 1-8, 1965."

The cryoformed steel bottle for the portable life support system, manufactured by Arde-Portland, Inc., passed its first burst and cycling tests, which Crew Systems Division called a "major milestone" in its development.

1-8

Ibid.

MSC and Grumman reviewed the requirement for a backup mode of entering and leaving the LEM while on the moon. The new rectangular hatch was deemed "inherently highly reliable," and the only failure that was even "remotely possible" was one of the hatch mechanism. The proposal to use the top (or transfer) hatch was impractical, because it would cost 13.6 kg

1-8

- 1965** (30 lb) and would impose an undue hazard on both the crew and the spacecraft's thermal shield.
- April**
- Ibid.*
- 1-8** North American reviewed nondestructive techniques for testing honeycomb structures. The principal method involved ultrasonic testing, but this approach was highly dependent upon equipment and procedure. At best, ultrasonic testing could do no more than indicate faulty bond areas, and these could be confirmed only through destructive tests. A number of promising nondestructive methods were being investigated, but thus far none was satisfactory. The danger in this situation was that, if design allowables had to be lowered to meet the results of strength distribution tests, the weight advantage of honeycomb construction might be lost.
- "ASPO Weekly Management Report, April 1-8, 1965"; memorandum, D. D. Few, RASPO-Downey, to R. H. Ridnour, "Recent Bonding Problems at NAA," May 12, 1965, with enclosures.
- 2** North American presented final results of their modification to the electrical power system for spacecraft 011 to solve the power and energy problem. This consisted of the addition of three batteries which would be mounted on the center platform and used to supply instrumentation and mission control programmer loads during flight. These batteries would be paralleled with the entry and landing batteries at impact to provide power for post-landing recovery loads. MSC concurred with this approach.
- Memorandum, Owen E. Maynard, MSC, to Chief, Instrumentation and Electronic Systems Division, "S/C 011 circuit protection," April 8, 1965; TWX, C. L. Taylor, MSC, to NAA, Space and Information Systems Div., Attn: J. C. Cozad, April 13, 1965.
- 2** Following a presentation by North American on the status of the adapter, MSC spelled out specific and detailed design changes required.
- Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Div., Attn: J. C. Cozad, "Contract NAS 9-150, Spacecraft LEM Adapter (SLA) change status," April 2, 1965, with enclosure, "Technical Description of Proposed SLA Changes."
- 5-11** Rocketdyne completed qualification tests on two CM reaction control engines. These were successful. One of the nozzle extensions failed to seat, however, and was rejected. Its failure was being analyzed.
- NAA, "Project Apollo Spacecraft Test Program Weekly Activity Report (Period 5 April 1965 through 11 April 1965)," p. 3.
- 5-16** To evaluate the Block II CSM's manual thrust vector control, five pilots, among them two astronauts, flew the Apollo simulator at Honeywell. These mock flights demonstrated that the manual control was sufficiently accurate



This space simulator at Minneapolis-Honeywell, 3.96 m (13 ft) in diameter and weighing about 8.16 metric tons (9 tons), duplicated the CSM's flight characteristics in space. It was so delicately balanced it could be moved by a puff of air. (Honeywell Photo)

for transearth injection. Also, researchers determined that the optical alignment sight provided the crewmen with attitude references adequate for midcourse maneuvers.

1965

April

NAA, "Apollo Monthly Progress Report," SID 62-300-37, June 1, 1965, p. 6.

Quality verification vibration tests were completed on the command module of spacecraft 006.

6

Ibid., p. 1; memorandum, W. D. Graves, MSC, to Distr., "Quality Vibration Verification Testing (QVVT) Facility Validation," April 27, 1965.

1965

April

7

A LEM/CSM interface meeting uncovered a number of design problems and referred them to the Systems Engineering Division (SED) for evaluation: the requirement for ground verification of panel deployment prior to LEM withdrawal; the requirement for panel deployment in earth orbit during the SA-206 flight; the absence of a backup to the command sequencer for jettisoning the CSM (Flight Projects Division [FPD] urged such a backup signal); and Grumman's opposition to a communications link with the LEM during withdrawal of the spacecraft (FPD felt that such a link was needed through verification of reaction control system ignition). SED's recommendations on these issues were anticipated by April 22.

MSC, "ASPO Weekly Management Report, April 8-15, 1965"; memorandum, R. W. Lanzkron, MSC, to Chief, Systems Engineering Division, "LEM-1 CSM Interface Meeting," April 19, 1965; memorandum, Lanzkron to Chief, Systems Engineering Division, "LEM-1 CSM Interface Meeting," April 15, 1965.

8

Goddard Space Flight Center awarded a \$4.6 million contract to RCA for a deep space tracking and data acquisition system. The equipment, to be installed on Cooper's Island, Bermuda, would support a variety of NASA space missions, including Apollo flights.

Astronautics and Aeronautics, 1965, pp. 174-175; *Space Business Daily*, April 12, 1965, p. 231.

8-15

The MSC Crew Performance Section evaluated the ability of two pressure-suited astronauts to put on and take off their external thermal garments and portable life support systems (PLSS). The subjects had considerable difficulty positioning the PLSS; also, though these modified thermal garments were much easier to don and doff, the subjects still experienced some trouble inserting the second arm.

MSC, "ASPO Weekly Management Report, April 8-15, 1965."

8-15

Bell Aerosystems tested a pressure transducer for the LEM's ascent propulsion system (the first time such a device was ever used with hypergolic fuels). The transducer proved extremely accurate at sensing pressure differences between the propellant lines.

Ibid.; "Monthly Progress Report No. 27," LPR-10-43, p. 13.

9

George E. Mueller, Associate Administrator for Manned Space Flight, announced the transfer of control over manned space flights from Cape Kennedy, Fla., to Houston, Texas. MSC's Mission Control Center would direct the flights from end of liftoff through recovery.

NASA News Release 65-119, "Mission Control Center at Houston to Handle GT-4, Subsequent Manned Flights," April 9, 1965.

1965

April

9

Crew Systems Division (CSD) decided on a single garment for both thermal and micrometeoroid protection for Apollo astronauts. CSD's Richard S. Johnston summarized factors underlying this decision:

- The integrated garment would be easier to don and thus would simplify preparations for leaving the LEM; it would fit better and afford greater visibility, mobility, and access to suit controls.

- The dual-purpose garment would weigh about 2.3 kg (5 lbs) less than would two separate protective covers. And because it would consume less storage space, the ascent stage of the spacecraft could be lightened by about three pounds. Involved here, also, was the abort weight of the LEM. It was assumed that the most adverse conditions would be encountered during an "immediate abort," before the crew could depressurize the cabin or jettison now-superfluous equipment (such as the thermal/meteoroid garment).

- Conversely, separate protective garments—and the "staging" procedure they entailed—would require modifications to the spacecraft and would shorten the astronauts' stay outside the LEM. Moreover, and perhaps even more important, separate garments would limit rescue possibilities and would lessen crew safety.

Johnston emphasized that, if for any reason the integration scheme proved impracticable, the division could still return to the concept of separate thermal and micrometeoroid garments.

Memorandum, Richard S. Johnston, MSC, to Chief, Systems Engineering Division, "Extravehicular Mobility Unit (EMU) thermal and meteoroid protection," April 9, 1965.

Systems Engineering Division (SED) reviewed the Flight Operations Directorate's recommendation for an up-data system in the LEM during manned missions. (Currently the LEM's guidance computer received data either from the computer in the CSM or from MSC.) SED concluded that, because the equipment was not essential for mission success, an up-data system did not warrant the cost and weight penalties (\$750 000 and 4.54 kg [10 lbs]) that it would entail.

Memorandum, Owen E. Maynard, MSC, to Manager, ASPO, "LEM up-data system," April 9, 1965.

The Apollo Program Director, Samuel C. Phillips, informed the Associate Administrator for Manned Space Flight, George E. Mueller, that action was underway by Grumman to terminate all Pratt & Whitney LEM fuel cell activity by June 30, 1965. Pratt & Whitney would complete testing of LEM fuel cell hardware already produced and one complete LEM fuel cell module plus spare parts would be sent to MSC for in-house testing.

12

- 1965**
April North American's Space and Information Systems Division would continue development at Pratt & Whitney on the CSM fuel cell for 18 months at a cost not to exceed \$2.5 million, to ensure meeting the 400-hour lifetime requirement of the CSM system.

MSC would contract directly with Pratt & Whitney for CSM cell development followed by complete CSM module testing for a 1000-hour CSM module at a cost of approximately \$2.5 million. Grumman was scheduled to propose to ASPO their battery contractor selection on April 29, 1965.

Memorandum, Phillips to Mueller, "Plans for LEM Fuel Cell Termination and Related Effort," sgd. John H. Disher, April 12, 1965.

- 12** MSC awarded MIT a new \$15 529 000 contract to design guidance and navigation equipment for Apollo spacecraft.

MSC, "Quarterly Activity Report for Office of the Associate Administrator, Manned Space Flight, for Period Ending April 30, 1965," p. 25.

- 13** Marshall Space Flight Center finalized a \$2 697 546 addition to an existing contract with Douglas Aircraft Company to provide for environmental testing of a full-scale S-IVB forward stage simulator, a full-scale test instrument unit, and an Apollo thermal simulator. Testing would be conducted in Douglas' 11.89-m- (39-ft-) diameter space simulator at Huntington Beach, California, and would simulate a typical Saturn V flight from launch to earth orbit and injection into lunar path.

Astronautics and Aeronautics, 1965, p. 182; Space Business Daily, April 27, 1965, p. 317.

- 14** Construction workers emplaced the final beam in the structural skeleton of the Vertical Assembly Building at Merritt Island (KSC), Florida. Scheduled for completion in 1966, the cavernous structure (160 m [525 ft] tall and comprising 10 968 476 cu m [129 million cu ft]) would provide a controlled environment for assembling Saturn V launch vehicles and mating them to Apollo spacecraft.

Astronautics and Aeronautics, 1965, p. 184.

- 15** The first firing of the LEM ascent engine test rig (HA-3) was successfully conducted at White Sands Missile Range, New Mexico. A second firing on April 23 lasted 14.45 sec instead of 10 sec as planned. A third firing, lasting 30 sec, completed the test series. A helium pressurization system would be installed before additional testing could begin.

"Monthly Progress Report No. 27," LPR-10-43, pp. 1, 13; GAEC, "Monthly Progress Report No. 28," LPR-10-44, June 10, 1965, p. 1.



The space simulator at Douglas Aircraft Company, Huntington Beach, Calif.
(Douglas Photo)

ASPO informed North American that a meeting would be held at its Downey, California, plant April 20-23 to negotiate and have signed off all Block I and Block II suit interface control documents (ICDs) and the government furnished equipment ICDs. Hamilton Standard, Grumman, and David Clark were being instructed to have representation present to achieve

1965

April

15

- 1965** the signed ICDs. North American was instructed to have the ICDs in final form to be signed or negotiated.
- April**
- TWX, C. L. Taylor, MSC, to NAA, Attn: J. C. Cozad, April 15, 1965.
- Mid-month**
- Officials from North American and the three NASA centers most concerned (MSFC, KSC, and MSC) discussed the environmental umbilical arrangement for the CM. The current configuration hampered rapid crew egress and therefore did not meet emergency requirements. This group put forth several alternative designs, including lengthening the umbilical hood and relocating the door or hatch.
- Internal Letter, E. P. Smith, NAA, to Distr., "Trip Report—MSFC—Command Module Environmental Umbilical Interface," April 15, 1965.
- 15–22** Grumman reviewed the engineering simulation program. The total cost was anticipated at \$9 million.
- MSC, "ASPO Weekly Management Report, April 15–22, 1965."
- 15–22** At North American, ultrasonic inspection of the forward portion of airframe 007 disclosed only minor imperfections in the bonding, called "a dramatic demonstration of the improvement in the bonding process." (See April 1–8.)
- Ibid.*
- 15–22** MSC and Grumman reviewed the program for the LEM's reaction control system. The only issue outstanding was Grumman's in-house effort: MSC felt that that effort was "overestimated" and that the manufacturer alone should not handle support from subcontractors.
- Ibid.*; memorandum, W. F. Rector III, MSC, to Assistant Manager, ASPO, Attn: H. L. Reynolds, "LEM RCS Status," April 22, 1965.
- 15–22** North American began full-scale developmental testing on the CM's up-righting system.
- "ASPO Weekly Management Report, April 15–22, 1965"; "Apollo Monthly Progress Report," SID 62–300–37, p. 3.
- 16** MSFC conducted the first clustered firing of the Saturn V's first stage (the S–1C). The booster's five F–1 engines burned for about 6½ seconds and produced 33 360 kilonewtons (7.5 million lbs) thrust. George E. Mueller, Associate Administrator for Manned Space Flight, emphasized the significance of this test, calling it "one of the key milestones in the whole lunar landing program."

Eight days later, at its static facility in Santa Susana, California, North American first fired the S-II, intermediate stage of the Saturn V. The event was chronicled as the "second major Saturn V milestone" during April.

1965

April

Astronautics and Aeronautics, 1965, pp. 188, 198; *Space Business Daily*, April 20, 1965, p. 276; *Ibid.*, April 28, 1965, p. 322.

Owen E. Maynard, Chief of MSC's Systems Engineering Division, announced that the ordering of objectives into first, second, and third order had been discontinued and replaced with two classifications: primary and secondary objectives. Primary objectives were defined as those which were mandatory. Malfunctions of spacecraft or launch vehicle systems, ground equipment, or instrumentation which would result in failure to achieve these objectives would be cause to hold or cancel the mission until the malfunction had been eliminated. Secondary objectives were those considered desirable but not mandatory. Malfunctions resulting in failure to achieve these objectives would be cause to hold or cancel the mission as indicated in Mission Rules.

16

Memorandum, Owen E. Maynard, MSC, to Distr., "Changes to objective classification," April 16, 1965.

Two CSM fuel cells failed qualification testing, the first failing after 101.75 hrs of the vacuum endurance test. Pratt and Whitney Aircraft determined that the failure was caused by a cleaning fluid which contaminated and plugged the oxygen lines and contaminated the oxygen gas at the electrodes. The fuel cell would be rebuilt for qualification testing and test preparation procedures were to be revised.

16-May 15

An internal short circuit occurred in the second fuel cell 16 hrs before the end of the 400-hour qualification test. In spite of the failure the fuel cell met the current Block I mission specification and did not need to be redesigned.

"Apollo Monthly Progress Report," SID 62-300-37, p. 10.

North American completed qualification testing on the fuel tanks for the SM's reaction control system.

16-May 15

Ibid., p. 11; NAA, "Project Apollo Spacecraft Test Program Weekly Activity Report (12 April 1965 through 18 April 1965)," p. 3.

On the basis of current systems reliabilities and the design reference mission, North American estimated at one in a hundred the possibility that returning Apollo crewmen would land on solid ground rather than on water. The contractor used this estimate in formulating test programs for boilerplate 28 and spacecraft 002A and 007.

16-May 15

"Apollo Monthly Progress Report," SID 62-300-37, p. 12.

- 1965**
April
16–May 15
- North American halted testing on the hydrogen tanks for the CSM, produced by Beech, because of weld failures. Testing on a redesigned tank assembly began on May 8.
- Ibid.*, p. 9; "Project Apollo Spacecraft Test Program Weekly Activity Report (12 April through 18 April 1965)," p. 5.
- 19–26**
- North American, Hamilton Standard, Grumman, David Clark, and MSC representatives, meeting in Downey, California, resolved all interfaces between the space suit and the two blocks of spacecraft. As a result of these agreements, MSC directed North American and Grumman to make some minor changes (suggested by the Crew Systems Division) in the communications cables; to remove the portable life support systems from the CM; and to add a thermal-meteoroid garment—rather than one providing merely thermal protection—to the CM.
- "ASPO Weekly Management Report, April 22–29, 1965"; memorandum, Richard S. Johnston, MSC, to Chief, Systems Engineering Division, "Extravehicular Mobility Unit (EMU) thermal and meteoroid protection," April 9, 1965; memorandum, Johnston to Asst. Chief, Program Control Division, Attn: G. J. Stoops, "Implementation of RECP's pertaining to Extravehicular Mobility Unit (EMU) thermal and meteoroid protection," April 21, 1965.
- 20**
- NASA and Boeing negotiated a contract modification. For an additional \$3 135 977, Boeing would furnish instrumentation equipment and engineering support for Marshall Space Flight Center's program for dynamic testing of the Saturn V.
- Astronautics and Aeronautics*, 1965, p. 191; *Space Business Daily*, April 22, 1965, p. 291.
- 20**
- At the initial design engineering inspection (DEI) of Spacecraft 009, held at Downey, California, MSC and North American officials reviewed the compatibility of the vehicle with SA–201 mission requirements. The DEI Review Board approved 11 hardware changes and assigned 26 others for further study.
- Memorandum, Daniel A. Nebrig, MSC, to Distr., "Minutes of Houston Board Review for AFRM 009 DEI—Phase I," April 20, 1965; "Apollo Monthly Progress Report," SID 62–300–37, p. 3.
- 20**
- The ASPO CSM Project Officer, C. L. Taylor, said that immediate action must be taken to reduce the FY 1965 expenditures on the CSM program by \$5 million. Toward that end, he directed attention to a cost reduction program, "Project Squeeze," and said that a joint North American/NASA Project Squeeze had been in operation several months and had resulted in significant program reductions. However, the majority of items recommended for investigation were North American-oriented.

Taylor requested items for consideration be submitted no later than April 27, 1965, and pointed out some specifics which might be considered: (1) qualification programs, hardware quantities, tests, etc., (2) component testing, (3) analytical effort, (4) design to excess, (5) documentation, and (6) changes.

1965

April

Memorandum, C. L. Taylor, MSC, to Distr., "Project Squeeze," April 20, 1965.

MSC requested Grumman to make provisions for storage of two additional portable life support system (PLSS) batteries. This was an increase of two batteries over the previous requirement; requirement now was for two batteries in the PLSS and additional storage for six.

20

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, April 20, 1965.

MSC's Systems Engineering Division requested that Grumman be advised to terminate the RCA systems engineering subcontract as soon as possible. It had been determined that this contract was no longer useful. Based on data presented by Grumman during a program review, an immediate and complete termination would save about \$45 000.

20

Memorandum, Owen E. Maynard, MSC, to Chief, Contract Engineering Branch, "LEM Program Review Contract NAS 9-1100, RCA Systems Engineering Sub-Contract," April 20, 1965.

Grumman and MSC engineers discussed the effect of landing impacts on the structure of the LEM. Based on analyses of critical loading conditions, Grumman reported that the present configuration was inadequate. Several possible solutions were being studied jointly by Grumman and the Structures and Mechanics Division (SMD):

21-22

- Strengthening the spacecraft's structure (which would increase the weight of the ascent and descent stages by 19 and 32 kgs [42 and 70 lbs], respectively)
- Modifying the gear
- Reducing factors of safety and landing dynamics, including vertical velocity at touchdown

A decision was expected from SMD by June 1.

Also Grumman representatives summarized the company's study on the design of the footpads. They recommended that, rather than adopting a stroking-type design, the current rigid footpad should be modified. The modification, they said, would improve performance as much as would the stroking design, without entailing the latter's increased weight and complexity and lowered reliability. SMD was evaluating Grumman's recommendations.

MSC, "ASPO Weekly Management Report, April 22-29, 1965."

1965 MSC completed the program review on the electrical power system for the LEM and approved the cost through completion of the program (about \$23.2 million).
April

22

Ibid.

22 The MSC Systems Engineering Division published revisions to Apollo Mission 204A objectives and mission requirements. The principal difference between the revised version and the Initial Mission Directive for Mission 204 was the expansion of the secondary propulsion system performance objective, the radiation survey meter objective, which was deleted, and the don/doff of the Block I pressure garment and thermal blanket objectives which had also been deleted.

Memorandum, Owen E. Maynard, MSC, to Apollo Trajectory Support Office, "Revisions to Apollo Mission 204A objectives and mission requirements," sgd. C. H. Perrine, April 22, 1965.

22 The LEM Project Officer notified Grumman that the President's Scientific Advisory Committee (PSAC) had established sub-panels to work on specific technical areas, beyond the full PSAC briefings. One of the sub-panels was concerned with the environmental control subsystem, including space suits. This group desired representation from Hamilton Standard to discuss with regard to the LEM-ECS its interpretation of the reliability design requirements, its implementation through development and test phases, its demonstration of reliability, and its frank assessment of confidence in these measures. Briefing material should be available to the sub-panel by May 17, 1965, with a primary discussion meeting to be held at Hamilton Standard on May 24.

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, April 22, 1965; TWX, W. L. Conn, MSC, to Hamilton Standard, Attn: E. V. Marshall, April 22, 1965.

22 Grumman was requested to ship ground support equipment and associated equipment to field test sites as soon as it was available.

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, April 22, 1965.

22 Grumman was requested to attend a meeting at MSC and to present their reasons as to why the LEM reaction control system (RCS) propellant tanks could not be of common technology with the CSM RCS propellant tanks. Grumman was to also say why an additional development program was required for the LEM tanks.

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, April 22, 1965.

North American conducted the final zero-g trials (part of developmental testing on the CM's waste management system) and reported good results for both urine and feces apparatus. 1965
April

"Apollo Monthly Progress Report," SID 62-300-37, p. 4. 22-23

After reviewing the status of the LEM landing simulation program, the Guidance and Control Division reported that "significant data" from the Bell training vehicle were more than a year away. 22-29

"ASPO Weekly Management Report, April 22-29, 1965."

Allison Division of General Motors Corporation completed an analysis of failures in the LEM descent stage's propellant tanks. Investigators placed the blame on brittle forgings. MSC's Propulsion and Power Division reported that "efforts are continuing to insure [that] future forgings will be satisfactory." 22-29

Ibid.

Crews Systems Division reported that work on the suit visors was progressing well, and that operational mockups had been sent to North American for the upcoming critical design review. The visor could be attached and detached by a pressurized crewman; also, it afforded thermal protection and allowed a complete range of light attenuation. 22-29

Ibid.

North American updated the electrical power profile for spacecraft 011: 22-29

Requirement (watt-hours)

Prelaunch	159
Ascent	4457
Entry	1032
Postlanding	2288

During the flight, the entry and landing batteries would supplement the spacecraft's fuel cells; three auxiliary batteries would power the mission control programmer and the instrumentation. At touchdown, all batteries would supply energy for postlanding requirements.

Ibid.

MSC and Grumman conducted the design engineering inspection on LEM test article 10. Structures and Mechanics Division called it "significant" that 23

1965
April there were no requests for design changes. The vehicle was ready for shipment to Tulsa, Oklahoma, for static testing by North American, but, at the latter's request, delivery was delayed until May 28.

Ibid.; letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Minutes of the LTA-10 Development Engineering Inspection," April 29, 1965, with enclosure: "Minutes of LTA-10 Development Engineering Inspection, April 23, 1965."

26 North American received CM 009 forward and crew compartment heatshields from Avco Corporation. These heatshields were the first CM heatshields received by the contractor with complete ablative application.

"Apollo Monthly Progress Report," SID 62-300-37, p. 1.

26 Operating on a round-the-clock schedule, researchers at Langley Research Center began simulations of high-altitude aborts and CSM-active dockings. (See July 7-9.)

"ASPO Weekly Management Report, April 22-29, 1965."

26-May 2 Using boilerplate 14, North American simulated the mission for spacecraft 009. The test was conducted in two phases, with the vehicle on external and then internal power. All data showed satisfactory performance.

NAA, "Project Apollo Spacecraft Test Program Weekly Activity Report (Period 26 April 1965 through 2 May 1965)."

27 ASPO announced that a LEM Test Program Requirement Review would be held at Grumman during the first week in June. The purpose of the review would be to reach agreement with Grumman on an overall Test Program Plan and to consider planned allocation of hardware, test schedules, and test logic in relationship to flight missions.

The review would result in publication of a certification document which would define and catalog the program of testing, analysis, and rationalization which would form the basis for certification of flight spacecraft as capable of meeting requirements of flight missions. It would cover all formal qualification testing above the part level being done at subcontractors or vendors, component testing at Grumman, higher level of assembly testing conducted anywhere in support of a portion of test logic, and individual system test requirements to be conducted on integrated test vehicles such as LEM test article 1.

The format for the review would consist of individual subsystem test program reviews by the respective MSC and Grumman Subsystem Managers. MSC Subsystem Managers would be supported by RASPO, ASPO, and GE

personnel where appropriate. After their initial meeting, the MSC and Grumman Managers would summarize their findings to a MSC/Grumman review board, emphasizing deficiencies in the program (to include inadequate tests, hardware availability problems, and schedules which were inconsistent with flight support requirements).

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Memorandum, Owen E. Maynard, MSC, to Distribution, "LEM Test Program Requirements Review," April 27, 1965.

North American summarized its position on the design of the CM for earth impact in a letter to MSC. A number of meetings had taken place since the NASA/North American Technical Management Meeting February 25, 1964, at which the decision was made to reorient Apollo impact to water as the primary landing site.

27

The letter reviewed the history of boilerplate 28 drop tests and a series of MSC/North American meetings during the last two months of 1964 and the first two of 1965. On February 12, at a meeting at Downey, California, North American had recommended:

- Design for 0.99999 criteria.
- Retain the 27.5° hang angle to eliminate the requirement for re-design of upper crew compartment side wall. The dual hang angle configuration should be eliminated for spacecraft 017 and subsequently through Block II.
- Allow plastic deformation of the aft heatshield.
- Continue investigation of possible upper deck and tunnel problems.
- Fly spacecraft 009 with a probability of success at water impact of 0.999, and continue boilerplate 28 testing to give assurance of meeting this criterion.

In a follow-up meeting on March 2, NASA gave concurrence to these recommendations in the form of signed meeting minutes.

At the time of the April 27 letter, North American was implementing the design changes defined in the Apollo CM design changes for water impact. The changes were based on North American's best understanding of agreements between it and MSC regarding criteria, loads, definition of the ultimate land envelope, structural analysis, and the requirement that no-leakage integrity within the ultimate load level be demonstrated by test.

Letter, J. C. Cozad, North American, to NASA MSC, Attn: J. B. Alldredge, "Contract NAS 9-150, R&D for Project Apollo Spacecraft Design of Apollo Command Module for Earth Impact," April 27, 1965.

LEM Project Officer W. F. Rector III, in a letter to Grumman, established the minimum acceptable NASA requirements for accomplishing the inspec-

27

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tion, acceptance, and delivery operations at Bethpage, N.Y., on flight and major ground test vehicles.

Following manufacture, and prior to NASA acceptance, the spacecraft must undergo a thorough checkout by the contractor with MSC participating as an active member of a checkout team. Through experience in Projects Mercury and the CSM portion of Apollo, a team concept of operations had evolved for the aforementioned activities. The concept had proved highly successful in providing a balance of MSC and contractor personnel which assured that the evaluation of problems received proper attention and resulted in solutions acceptable to both NASA and the contractors. In addition, this "cross pollination" of skills provided a more complete evaluation of the spacecraft performance and systems anomalies.

Prior to starting acceptance testing, all systems should have completed a pre-installation acceptance check, been installed in the spacecraft, and the configuration verified. Acceptance checkout would begin following complete installation of all subsystems and hook-up to the Acceptance Checkout Equipment (ACE). After ACE was installed, individual subsystems tests were to be performed. The hook-up of ACE to the spacecraft would constitute the point at which the checkout team would assume responsibility for the vehicle. At that time a documentation system must provide a means for authorizing and permanently recording all work and testing to be performed on the spacecraft.

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, NASA Requirements for Inspection, Acceptance and Delivery Operations at Bethpage," April 27, 1965.

27-30

Part II of the Critical Design Review of the crew compartment and docking system for the Block II CM was held at Downey, California, using mockups 28 and 27A. (Part I had been held on March 23-24.)

- Systems Engineering Division reported 49 design changes were requested in the crew compartment, 45 of which were acted upon. The two most serious problems were: (1) stowage of the portable life support systems; (2) and the crewmen's knees striking the main display console at impact.

- Structures and Mechanics Division reported a number of minor changes to the docking system, primarily to simplify crew transfer and operation of the hatch mechanisms.

- Crew Systems Division (CSD) engineers evaluated the compatibility of the space suit and MSC's new in-house helmet with the Block II spacecraft. CSD reported that the suits were sufficiently mobile and afforded adequate visibility; problems with the shoulders, experienced in early versions of the suit, had been solved; and while the three crewmen still

quite literally rubbed elbows, this problem also had been alleviated and no longer hampered the crew's performance.

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MSC, "ASPO Weekly Management Report, April 29–May 6, 1965."

NASA Administrator James E. Webb, Deputy Administrator Hugh L. Dryden, and Associate Administrator Robert C. Seamans, Jr., decided that the announcement of any Apollo crew should be delayed as long as feasible without jeopardizing training schedules. They reasoned that as long as the entire astronaut group was undergoing generalized Apollo training, and until individual mission planning was complete, there should be no need to make even tentative crew selections.

28

Memorandum, Seamans to Associate Administrator for Manned Space Flight George E. Mueller, "Apollo Crew Selection," April 28, 1965.

Joseph F. Shea, ASPO Manager, approved Crew Systems Division's recommendation to retain the "shirtsleeve" environment for the CM. The design was simpler and promised greater overall mission reliability; also, it would be more comfortable for the crewmen. Wearing part of the space suit would compound problems with humidity and condensation inside the cabin. Accordingly, the crew would be clad only in their constant-wear garments or would be fully suited. (MSC and North American had explored the feasibility of putting a water separator in the cabin heat exchanger for airframe 012. It was hoped that, through partially suited operations, the crew could gain confidence in the spacecraft's pressurization system. North American advised, however, that considerable cost and schedule impacts could be expected. Moreover, such a device would be only partly successful—condensation would still be a major problem. Shea therefore vetoed the water separator and the idea of partially suited operations during the first manned Apollo flight.)

28

Memorandum, Joseph F. Shea, MSC, to Distr., "Wear of space suits in C/M," April 28, 1965.

Under NASA contract, proton irradiation of primates tests were conducted on the Oak Ridge cyclotron by a team from Brooks AFB and Crew Systems Division. During this period, 136 monkeys and 900 mice were irradiated.

28–May 3

MSC, "ASPO Weekly Management Report, May 6–13, 1965."

Portable life support systems (PLSS) stowed against the aft bulkhead in the CM would prevent the crew couch from stroking fully. This condition would be aggravated if, at impact, the bulkhead was forced inward. North American spokesmen maintained that, in a water landing, the bulkhead

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April would give only slightly and that the couch struts would not compress to their limits. They argued, therefore, that this condition would be of concern only in a land landing. On the contrary, said MSC. Center officials were adamant that any interference was absolutely unacceptable: it would lessen the attenuation capability of the couch (thereby jeopardizing crew safety); possibly, the bulkhead might even be ruptured (with obviously disastrous results). Because of this problem—and because the capability for extravehicular transfer from the CM to the LEM was required—MSC invited representatives from the three contractors involved to meet in Houston to deal with the question of PLSS stowage. (See May 12.)

“ASPO Weekly Management Report, April 29–May 6, 1965”; memorandum, Charles R. Haines, MSC, to Owen E. Maynard, “PLSS,” May 25, 1965.

29–May 6 Grumman recommended redundant pyrotechnic or solenoid valves in the propellant system of the LEM’s ascent stage. Thus the firm could meet NASA’s ground rule that no single failure would cause the mission to be aborted.

“ASPO Weekly Management Report, April 29–May 6, 1965.”

29–May 6 The Flight Projects Division (FPD) proposed a change in the checkout procedure at Merritt Island (KSC). The idea, drawn from Gemini, would eliminate checkout at the environmental control system (ECS) facility. Basically, FPD’s plan was to transport the mated CSM directly from the Operations and Checkout Building to the altitude chamber, where the ECS would be tested. Officials at North American approved the new procedure, and FPD requested the Checkout and Test Division to study its feasibility.

Ibid.

30 Grumman advised MSC that it had selected the Eagle-Picher Company as vendor for batteries in both stages of the LEM. At the same time, because a proposal by Yardney Electric Company promised a sizable weight saving, this latter firm would produce “pre-production” models for the ascent stage.

Ibid.

30 North American announced an Apollo Engineering Reorganization, designed to improve operational efficiency and to be consistent with existing requirements of the Apollo program. The reorganization would: (1) increase the number of managers, but reduce the individual manager’s scope and eliminate one level of management, making for clearer assignments and better communications; (2) incorporate certain checkout and ground support equipment systems engineering functions into Systems Engineering,

strengthening the integration capabilities and simplifying operational procedures; and (3) basic functions of analytical engineering within Apollo Engineering were being transferred to the Research and Engineering Division, increasing the effective use of technical and management personnel.

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NAA, Organization Announcement, Dale D. Myers, Apollo Program Manager, and H. G. Osbon, Chief Engineer, Apollo Engineering, to Apollo Engineering Supervision, "Apollo Engineering Reorganization," April 30, 1965.

A tentative agreement was reached between Grumman and MSC propulsion personnel concerning the Propulsion System Development Facility's test scheduling at White Sands operations in regard to stand occupancy times relating to the ascent and descent development rigs. The tentative schedule showed that the ascent LEM Test Article (LTA)-5 vehicle would not start testing until April 1967. The PA-1 rig (prototype ascent propulsion rig) would therefore be required to prove the final design and support early LEMs.

30

The PA-1 rig was designed and was being fabricated to accommodate small propellant tanks, and there were no plans to update it with larger ones. Therefore, advantages of flexibility, running tests of longer sustained durations, and with the final tank outlet configurations would not be realized. Grumman was requested to take immediate action to have the rig accommodate the larger tanks and install the smaller tanks by use of adapters or other methods.

TWX, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, April 30, 1965.

As a result of the decision for an all-battery LEM, MSC advised Grumman that power for the entire pre-separation checkout of the spacecraft would be drawn from that module's batteries (instead of only during the 30 minutes prior to separation). This change simplified the electrical mating between the two spacecraft and obviated an additional battery charger in the CSM. From docking until the start of the checkout, however, the CSM would still furnish power to the LEM.

30

TWX, James L. Neal, MSC, to GAEC, Attn: R. S. Mullaney, April 30, 1965.

Grumman reported two major problems with the LEM's descent engine:

During
the
Month

- (1) Space Technology Laboratories (STL) asked that the thrust chamber be lengthened by 13.9 cm (5.5 in). Weight penalty would be 11.3 kg (25 lbs).
- (2) STL concluded that, if used with Grumman's heatshield, the current nozzle extension would melt.

"Monthly Progress Report No. 27," LPR-10-43, pp. 3, 13.

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1

North American and NASA officials conducted an engineering inspection on boilerplate 23A at White Sands Missile Range, New Mexico. The board approved four requests on minor structural changes; a fifth request, involving tolerances on the boost protective cover, was slated for further study.

Memorandum, Joe W. Dodson, MSC, to Distr., "Results of DEI on BP-23A," May 4, 1965, with enclosures.

3

Systems Engineering Division did not concur in use of the chamber technician's suit by test subjects in AFRM 008 tests. AFRM 008 represented the only integrated spacecraft test under a simulated thermal-vacuum environment and was therefore considered a significant step in man-rating the overall system. For that reason use of the flight configuration Block I suit was a firm requirement for the AFRM 008 tests.

The same rationale would be applicable to the LEM and Block II vehicle chamber tests. Only flight configured spacecraft hardware and extravehicular mobility unit garments would be used by test subjects.

Memorandum, Owen E. Maynard, MSC, to Chief, Crew Systems Division, "Utilization of a Flight Configured Block I Space Suit with AFRM 008," sgd. Robert W. Williams, May 3, 1965.

3

R. Wayne Young was appointed Chief of the LEM Contract Engineering Branch, ASPO, to perform the functions of Project Officer for the LEM, effective May 3. At the same time M. E. Dell was appointed Chief of the G&N/ACE Contract Engineering Branch, ASPO, and would be responsible for all functions of Project Officer for the guidance and navigation, automatic checkout equipment-spacecraft, and Little Joe II systems for the Apollo spacecraft, and for technical management of the General Electric Support Contract.

Memorandum, J. Thomas Markley, MSC, to Distr., "Assignment of Chief, LEM Contract Engineering Branch and Chief, G&N/ACE Contract Engineering Branch, Apollo Spacecraft Program Office," May 4, 1965.

4

Technical personnel at MSC became concerned over an RCS oxidizer tank failure that occurred in February 1965, during propellant exposure and creep tests. The failure had previously been explained as stress corrosion caused from a fingerprint on the tank shell before heat treat. NASA requested that the test be repeated under tighter controlled procedures.

TWX, C. L. Taylor, MSC, to NAA, Space and Information Division, Attn: J. C. Cozad, May 4, 1965.

4

A Panel Review Board (PRB) meeting was held at Office of Manned Space Flight (OMSF) in Washington and the MSC and MSFC Chairmen of the Flight Mechanics Panel attended.

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Prior to the formal meeting, discussions with T. Thompson and B. Kaskey revealed that Bellcomm had recommended to Apollo Program Director Samuel C. Phillips that the contingency mission for AS 204 be an unmanned orbital flight and that no unmanned contingency mission be planned for 205. The reason for an unmanned contingency for 204 was to give MSFC an additional opportunity to obtain orbital data from the S-IVB stage.

PRB was informed that lack of specific requirements concerning contingency mission capability was hampering Flight Mechanics Panel in completion of interface control documents and associated mission development. Contingency capability was classified into two types: (1) contingency capability to provide for failures during the flight program or schedule adjustments of the hardware; and (2) in-flight contingencies due to malfunction of the launch vehicle.

Memorandum, C. H. Perrine, MSC, to Chief, Systems Engineering Division, "Trip Report on Panel Review Board Meeting at OMSF, May 4, 1965," May 7, 1965.

NASA Associate Administrator for Manned Space Flight George E. Mueller concurred with a plan of MSC Director Robert R. Gilruth to implement a three-station developmental Solar Particle Alert Network. Mueller said he understood that Gilruth would "review the necessity for the Guaymas station, and that you will examine having all data reduction related to this network carried out under contract," and adding that he felt the program would be enhanced if arrangement could be made to involve one or more academic institutions in the analysis of data.

Letter, Mueller to Gilruth, "Solar Particle Alert Network," May 4, 1965.

A preliminary flight readiness review was held in Houston on boilerplate (BP) 22. Several participants voiced serious doubts about the structural integrity of the boost protective cover, because of its sizable cutouts (required for pressure measurements) and its poor fit. Structures and Mechanics Division representatives argued that the article not be modified, however. They stressed that BP-23's cover, which also fit poorly, endured greater dynamic pressures than were anticipated for BP-22. Final inspection of the cover would be made at WSMR. (See May 19, 1965.)

"ASPO Weekly Management Report, May 6-13, 1965."

Although North American was including real-time digital command equipment in Block II CSMs (as NASA had directed), the firm recommended that such equipment not be placed on Block I vehicles. North American based their contention on two factors: (1) the anticipated cost and schedule impacts; and (2) command capability was not essential during earth orbital flights.

Letter, E. E. Sack, NAA, to NASA MSC, Attn: J. B. Alldredge, "Contract NAS 9-150, Contract Change Proposal SID-150-370, Revision 1, Preliminary; Real Time Radio Command Requirements on Block I and Block II CSM's," May 4, 1965, with enclosure.

1965

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4

MSC directed North American to provide spacecraft 012, 014, 017, and 020 with a system to monitor combustion instability in the service propulsion engine. (On April 8, officials of ASPO, Propulsion and Power Division, and the Flight Operations Directorate had agreed on the desirability of such a system.) Should vibrations become excessive, the device would automatically shut down the engine. Manual controls would enable the astronauts to lock out the automatic system and to restart the engine.

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 347," May 4, 1965; memorandum, Christopher C. Kraft, Jr., MSC, to Manager, ASPO, "Flight Combustion Stability Monitor (FCSM)," May 13, 1965.

5

In response to a query, Apollo Program Director Samuel C. Phillips told NASA Associate Administrator for Manned Space Flight George E. Mueller that plans to use VHF communications between the CSM, LEM, and extra-vehicular astronauts and to use X-band radar for the CSM/LEM tracking were reviewed. Bellcomm reexamined the merits of using the Unified S-Band (USB) type which would be installed in the CSM and LEM for communication with and tracking by the earth.

It was found that no appreciable weight saving or weight penalty would result from an all USB system in the Apollo spacecraft. Also, it was determined there would be no significant advantage or disadvantage in using the system. It was noted, however, that implementation of an all S-band system at that stage of development of the design of the CSM, LEM, and astronaut equipment would incur an obvious cost and schedule penalty.

Memorandum, Phillips to Mueller, "Use of Only Unified S-Band Communication Equipment in Apollo Spacecraft," May 5, 1965.

6

After lengthy investigations of cost and schedule impacts, MSC directed North American to incorporate airlocks on CMs 008 and 014, 101 through 112, and 2H-1 and 2TV-1. The device would enable astronauts to conduct experiments in space without having to leave their vehicle. Initially, the standard hatches and those with airlocks were to be interchangeable on Block II spacecraft. During October, however, this concept was changed: the standard outer hatch would be structured to permit incorporation of an airlock through the use of a conversion kit (included as part of the airlock assembly); and when an airlock was installed, an interchangeable inner hatch would replace the standard one.

TWX, Samuel C. Phillips, NASA, to MSC, Attn: J. F. Shea, January 4, 1965; letters, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division (S&ID), "Contract Change Authorization No. 348," May 6, 1965; Alldredge, MSC, to NAA, S&ID, "Contract Change Authorization No. 348, Revision 1," July 27, 1965; James Stroup, MSC, to NAA, S&ID, "Contract Change Authorization No. 348, Revision 2," August 4, 1965; Alldredge, MSC, to NAA, S&ID, "Contract Change Authorization No. 441," October 11, 1965.

ASPO overruled a recommendation by the Flight Operations Directorate for an up-data link in the LEM. Although an automated means of inserting data into the spacecraft's computer was deemed "highly desirable," there were prohibitive consequences:

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6

- Weight—7.25 kg (16 lbs) in the ascent stage
- Cost—\$1.7 million
- Schedule delay—five months

This last effect ASPO termed "flatly unacceptable."

Memorandum, William A. Lee, MSC, to Assistant Director for Flight Operations, "LEM Up-Data Link," May 6, 1965.

As a result of the Critical Design Review at North American during the previous month, Crew Systems Division (CSD) directed Hamilton Standard to fabricate an Apollo space suit with a pressure-sealing zipper. CSD would compare this concept with the current gusset design, which leaked excessively and hindered donning the suit.

6

TWX, Richard S. Johnston, MSC, to R. E. Breeding, Hamilton Standard Division, May 6, 1965; MSC, "ASPO Weekly Management Report, June 3-10, 1965."

The Apollo earth landing system (ELS) was tested in a drop of boilerplate (BP) 19 at El Centro, Calif. The drop removed constraints on the ELS for BP-22 (see May 19); also, it was a "prequalification" trial of the main parachutes before the start of the full qualification test program (see June 3).

6

"Apollo Monthly Progress Report," SID 62-300-37, p. 3.

Both General Electric and Radio Corporation of America studied the feasibility of using the spacecraft-LEM-adapter to dissipate heat from the radioisotope generator during initial phases of the mission. The generator would raise the temperature of the adapter about 30°; radiation back to the spacecraft was not considered serious.

6-13

MSC, "ASPO Weekly Management Report, May 6-13, 1965."

Structures and Mechanics Division engineers determined that the spacecraft-LEM-adapter would not survive a service propulsion system abort immediately after jettisoning of the launch escape tower. North American planned to strengthen the upper hinges and fasteners and to resize the shock attenuators on spacecraft 009.

6-13

Ibid.

1965 Launch escape system (LES) installation for CSM 009 was completed, marking the first LES completion.

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7

"Apollo Monthly Progress Report," SID 62-300-37, p. 1.

9

The U.S.S.R. launched a 1476-kg (3254-lb) scientific probe, called *Luna V*, on a trajectory to the moon. Western observers, among them England's Sir Bernard Lovell, speculated that the craft's mission was a soft landing. If that was indeed its goal, the attempt failed: *Luna V* crashed and all transmissions ceased. It was generally thought that the vehicle's retrorockets had malfunctioned.

Astronautics and Aeronautics, 1965, p. 222; *Space Business Daily*, May 11, 1965, pp. 49-50; M. K. Tikhonravov, B. V. Raushenbakh, G. A. Skuridin, and O. L. Vaysberg, *Ten Years of Space Research in the USSR*, NASA Technical Translation F-11, 500 of: "Desyat' let issledovaniya kosmosa v SSSR"; *Kosmicheskiye Issledovaniya*, Vol. 5, No. 5, pp. 643-679, 1967, p. 17.

10

ASPO reviewed Grumman's recommendation for a combination of supercritical and gaseous modes for storing oxygen in the LEM's environmental control system (ECS). MSC engineers determined that such an approach would save only about 14.96 kg (33 lbs) over a high-pressure, all-gaseous design. Mission objectives demanded only four repressurizations of the LEM's cabin. On the basis of this criterion, the weight differential was placed at less than nine pounds.

As a result of this analysis, MSC directed Grumman to design the LEM ECS with an all-gaseous oxygen storage system. (See June 11.)

Letter, W. F. Rector III, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Lunar Excursion Module—ECS Oxygen Storage Configuration," May 10, 1965, with enclosures.

10

Public Health Service (PHS) officials revealed that the Surgeon General had discussed the PHS/NASA relationships on back-contamination problems with the NASA Administrator. During this discussion, the Surgeon General proposed: (1) expansion of the space biology and contamination contract program in the PHS; (2) assignment by the PHS of a liaison officer to NASA; and (3) development by NASA of an interagency advisory committee on both outbound and inbound contamination problems with PHS participation.

The Administrator and Surgeon General were reported to have agreed that negotiations at staff level were appropriate. As a result, NASA was drafting a proposal to go from the Administrator to the Surgeon General embodying

not only the three items listed but also proposing a NASA organizational structure capable of implementing the objectives of the two agencies.

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Memorandum, O. E. Reynolds, Director Bioscience Programs, NASA Headquarters, to Associate Administrator for Space Science and Applications, "Status of the Public Health Service—National Aeronautics and Space Administration negotiations on back contamination," May 10, 1965.

ASPO Assistant Manager William A. Lee heard a proposal to modify the LEM radar programs to reduce FY 1966 costs by \$7 million. It was his understanding that the proposal would be presented to the Configuration Control Board. Lee said he at first thought the change would be "tolerable," but later felt it was a poor idea.

10

The major points of the proposal were:

- Delete landing radars from LEMs 1 and 2: the landing radar was not essential to earth-orbital missions of these two vehicles. In fact, ASPO had planned to drop it on LEM-2 (AS-207) to save weight. Nevertheless the proposal was a violation of the "all-up" concept, and, if adopted, would set a precedent for further deletions.

- Delete the rendezvous radar on LEM 1.
- Use "qualifiable" but not qualified rendezvous radars on LEMs 2 and 3.
- Install the rendezvous radars for LEMs 2, 3, and 4 at KSC rather than at Grumman.

Lee opined that the violations of program ground rules inherent in these changes would establish a dangerous precedent and cut back existing margins too early in the program. It would also, he said, "open the door to a series of 'one-of-a-type' LEMs tailored to their specific development missions. . . . It is too early in the LEM program to consider compromising these requirements, and to do so for budgetary reasons almost certainly will prove to be false economy."

Memorandum, William A. Lee, MSC, to Manager, ASPO, "Proposed reduction in LEM radar expenditures," May 11, 1965.

Crew Systems Division let a contract to the Zaret Foundation to study effects of radiation on the lens of the human eye. The foundation would develop instruments that, by examining changes in the organ, would determine the precise dose that it had absorbed. Radiation could produce cataracts. Up to this time, however, the amount of radiation that could be absorbed safely was not known, nor could the initial damage be detected. It was generally thought that this damage was cumulative and that it was irreparable. For the crew's safety, the amount of radiation that the eye could

11

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sustain had to be known. And, of course, some technique for measuring dosages was essential. (See July 2.)

May

“ASPO Weekly Management Report, June 3–10, 1965.”

11

MSC instructed Grumman to negotiate award of a contract to supply batteries for the ascent and descent stages of the LEM with Eagle-Picher Company. Grumman had solicited and received proposals from Eagle-Picher and Yardney Electric Corporation. The bids, including fees, were: Eagle-Picher, \$1 945 222; and Yardney, \$1 101 673. Grumman evaluated the bids; made presentations to MSC personnel; and proposed on May 6 that they negotiate with Eagle-Picher for ascent and descent batteries; and with Yardney for development of a lighter ascent battery at a cost of approximately \$600 000. MSC instructed Grumman not to place the proposed development contract with Yardney, stating that such work could be more appropriately done by MSC work with Yardney or other battery vendors.

Memorandum of Conference, Apollo Program Management Office, “LEM Battery Procurement, MSC Comments on GAEC Recommendation for Contractor Selection,” sgd. J. B. Trout, May 11, 1965.

12

Developmental testing began on a new landing device for the CM, one using rockets (mounted on the heatshield) that would be ignited immediately before impact. The current method for ensuring the integrity of the spacecraft during a landing in rough water involved strengthening of the aft structure. The new concept, should it prove practicable, would offer a twofold advantage: first, it would lighten the CM considerably; second, it would provide an improved emergency landing capability.

MSC, *Space News Roundup*, May 28, 1965, p. 8.

12

MSFC informed MSC that the thrust of the H-1 engine was being uprated to 1000 kilonewtons (205 000 lbs), thus increasing the Saturn IB’s payload capability.

Letter, Frederick E. Vreuls, MSFC, to O. E. Maynard, MSC, “Uprating the H-1 Engine in the Saturn IB Vehicle,” May 12, 1965.

12–June 24

Representatives from North American, Grumman, Hamilton Standard, and MSC discussed the problem of stowing the portable life support systems (PLSS).

Current specifications called for two PLSSs under the crew couch in the CM at launch, one of which would be brought back to earth. This location presented some serious problems, however. (See April 29–May 6.)

MSC officials laid down several ground rules for the discussions:

- The capability for extravehicular transfer must be maintained.



The space suit for the lunar landing mission was the only operational equipment designed to go all the way to the lunar surface and return to earth. Above is a photo of a subject in that suit as designed at that time, with the portable life support system strapped on.

- During translunar flight, the capability must exist for general extravehicular activity from the CM.
- And upon landing, the PLSS must not interfere with the sweep of the crew couch.

The participants explored a number of stowage options (and the complications involved), even exploring the possibilities of staging and of using a

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Gemini Extravehicular Life Support System. As a result of these talks, Hamilton Standard began studying the feasibility of repackaging the PLSS to fit underneath the side hatch of the CM and to determine whether the reshaped system would be compatible with both spacecraft.

During the next few weeks, MSC concluded that, at earth launch, one PLSS would be stowed in each spacecraft. With the help of Hamilton Standard engineers, North American and Grumman designers worked out a stowage volume acceptable to all concerned. Hamilton Standard agreed to repackage the PLSS accordingly. MSC ordered North American to provide for stowage of one PLSS beneath the side hatch of the CM, again stressing that the system must not interfere with the crew couch during landing impact; also, the Center directed Grumman to plan for PLSS stowage in the LEM and to study ingress and egress with the reshaped backpack. (Studies by the Crew Systems Division had already indicated that, from the standpoints of compatibility and mobility, the new shape probably would be acceptable.)

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, May 17, 1965; memorandum, Charles R. Haines, MSC, to Owen E. Maynard, "PLSS," May 25, 1965; memorandum, Haines, to Record, "PLSS stowage study," May 25, 1965; "ASPO Weekly Management Report, May 27-June 3, 1965"; MSC, "ASPO Weekly Management Report, June 10-17, 1965"; memorandum, R. Wayne Young, MSC, to James L. Neal, "PLSS stowage in the LEM," June 21, 1965; letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, Portable Life Support System (PLSS) Stowage in the Command Module," June 24, 1965.

13

Samuel C. Phillips, Apollo Program Director, issued the mission directive for Apollo-Saturn 201. The mission would flight-test the Saturn IB and the Apollo CSM.

NASA OMSF, "Apollo Program Flight Mission Directive for Apollo-Saturn 201 Mission," Program Directive M-D MA 2240.061, May 13, 1965.

13

AC Spark Plug officials presented to MSC their evaluation of bidders to design an optical rendezvous sensor for the LEM. Because three different approaches were planned, AC gained Guidance and Control Division's approval to let three subcontracts. The firms chosen were Perkin-Elmer, Hughes Aircraft, and the Itek Corporation.

MSC, "ASPO Weekly Management Report, May 20-27, 1965."

13-20

Crew Systems Division (CSD) representatives contracted with Northrop Space Laboratories to study physiological effects of tailward g forces. (CSD believed these forces might be "very hazardous." Consequently, the lowest impact limits for Apollo missions were in that direction.) Northrop would study bradycardia (slow heart rate) in animals induced by such acceleration,

and would apply these findings to humans. CSD hoped thereby to determine whether current limits were "ultraconservative."

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MSC, "ASPO Weekly Management Report, June 3-10, 1965."

To broaden communications capabilities during near-earth phases of a mission, the S-band omnidirectional antennas on all Block II CMs were moved to the toroidal (doughnut-shaped) section of the forward heatshield.

13-20

MSC, "ASPO Weekly Management Report, May 27-June 3, 1965."

North American released a preliminary report, "Apollo Reliability Modeling Documentation," in response to an action item assigned to MSC by the President's Scientific Advisory Committee (PSAC) Space Technology Panel at an Apollo program reliability briefing for the panel in January. The expected crew safety reliability was assessed at 0.973 with a confidence level of 60 percent. Functional logic diagrams indicated the amount of redundancy in each CSM function. North American noted that a direct comparison should not be made between mission AS-506 lunar orbit rendezvous (LOR) crew safety reliability and the preliminary crew safety number 0.976 for spacecraft 012. The LOR assessment, while preliminary, was developed in greater depth than the assessment for the PSAC briefing. However, a real increase in reliability was indicated from spacecraft 012 to the LOR mission because the reliability values were about equal, and the complexity and number of required functions in the LOR were far greater.

16-June 15

NAA, "Apollo Monthly Progress Report," SID 62-300-38, July 1, 1965, p. 13.

North American conducted the third in a series of water impact tests on boilerplate 1 to measure pressures on forward portions of the spacecraft. Data from the series supported those from tests with one-tenth scale models of the CM. The manufacturer reported, therefore, that it planned no further full-scale testing.

16-June 15

Ibid., p. 3.

MSC informed Grumman it believed it would be beneficial to the LEM development program for MSC to participate in the manned environmental control system tests to be conducted in Grumman's Internal Environment Simulator. The following individuals were suggested to participate: Astronaut William A. Anders or an alternate to act as a test crewman for one or more manned runs; D. Owen Coons or an alternate to act as a medical monitor for the aforementioned astronaut; and John W. O'Neill or an

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1965 alternate to monitor voice communications during the test and record astronaut comments.

May

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, MSC participation in Grumman manned environmental control system (ECS) tests," May 17, 1965.

18-20 Representatives from Motorola, RCA, Grumman, and MSC held the first design review on the S-band transponder for the LEM. Several areas were pointed out in which the equipment was deficient. Motorola was incorporating improved circuitry to ensure that the transponder met specifications.

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Rendezvous Radar Transponder Assembly Design," May 28, 1965; TWX, Young to Mullaney, "Communication Subsystem Input Voltage Levels," June 1, 1965; TWX, Young to Mullaney, "LEM S-Band Transponder," June 1, 1965.

19 Apollo mission A-003, a planned high-altitude abort test, was flown at WSMR. About 25 seconds after launch, and at an altitude of about three miles, the Little Joe II booster disintegrated as a result of violent—and unprogrammed—roll. The launch escape system (LES) functioned perfectly, however, and lifted the spacecraft (boilerplate 22) clear of the vehicle. ASPO Manager Joseph F. Shea, while acknowledging that A-003's "prime objectives . . . were not met," rightly observed that the LES nonetheless "proved its mettle in an actual emergency." (See mission objectives in Appendix 5.)

NASA News Release 54-145, "NASA to Test Apollo Escape System at High Altitude," May 9, 1965; memorandum, George E. Mueller, NASA, to Administrator, "Apollo Spacecraft Flight Abort Test, Mission A-003, Post Launch Report No. 1," May 24, 1965, with enclosure; MSC, *Space News Roundup*, May 28, 1965; TWX, NASA, MSC/WSO, to addressees, "Apollo Mission A-003 one hour report," sgd. J. F. Shea, May 19, 1965; General Dynamics, Convair Division, *Little Joe II Test Launch Vehicle, NASA Project Apollo: Final Report*, GDC-66-042 (May 1966), Vol. I, p. 1-18.

20-27 Engineers from General Electric and MSC's Crew Systems and Systems Engineering Divisions determined that transferring water from the CSM to the LEM involved a 5.4-kg (12-lb) increase in the latter's separation weight. Grumman had placed the penalty at only 1.8 kg (4 lbs). Because the LEM's weight was so critical, the water transfer scheme was canceled.

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, June 3, 1965.

20-27 To determine lunar touchdown velocity uncertainties, MIT studied radar-aided powered descent. From MIT's findings, Guidance and Control Division concluded that one or two sensors should provide velocity updates to the guidance system throughout the descent maneuver.

MSC, "ASPO Weekly Management Report, June 10-17, 1965."



This spectacular series of photos shows the breakup of the A-003 Little Joe II at top left. The photos at top right, bottom left, and bottom right show the launch escape system lifting the boilerplate spacecraft safely away from the disintegrating booster.

Marquardt Corporation completed preliminary flight rating tests on the reaction control engine for the SM.

"Apollo Monthly Progress Report," SID 62-300-38, p. 10.

NASA launched another reentry heating experiment, Project Fire II, from Cape Kennedy, Fla. An Atlas D booster propelled the instrumented probe,

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called a “flying thermometer,” into a ballistic trajectory over 805 km (500 mi) high. After 26 minutes of flight, when the spacecraft began its descent, a solid-fueled Antares rocket accelerated its fall.

The probe entered the atmosphere at a speed of 40 877 km (25 400 mph) and generated temperatures of about 11 206 K (20 000°F). Data on heating were transmitted to ground stations throughout the descent. Thirty-two minutes after the launch—and but six minutes after the Antares was fired—the device impacted in the Atlantic about 8256 km (5130 mi) southeast of the Cape.

NASA News Release 65-131, “NASA Schedules Project Fire Launch in May,” April 28, 1965; NASA News Release 65-179, “NASA Reports Project Fire Performed Well,” May 27, 1965.

23

The Life Sciences Committee of the National Academy of Sciences’ Space Science Board recommended to NASA that American astronauts returning from the moon and planets be kept in quarantine for at least three weeks to prevent possible contamination of the earth by extraterrestrial organisms, Howard Simons reported in the *Washington Post*. A report entitled “Potential Hazards of Back Contamination from the Planets” presented quarantine and other recommendations: the need to avoid decontamination of returning equipment until it had been subjected to biological study; the possible need for the astronauts to shed their outer garments on the moon and Mars before returning home; the need to conduct immediate research on any samples of extraterrestrial life brought to earth; and trial runs to acquaint astronauts with methods for minimizing chance of contamination.

Astronautics and Aeronautics, 1965, p. 246.

21-24

The Resident ASPO at Grumman approved three vendor selections by the LEM manufacturer:

(1) Mechanical Products, Inc.—circuit breakers. (MSC concurred in the use of hermetically sealed breakers.)

(2) Hartman Electric Co.—relays (also hermetically sealed).

(3) Electronic Products Division of Hughes Aircraft Co.—rectangular connectors.

MSC, “ASPO Weekly Management Report, May 20-27, 1965”; memorandum, Ralph S. Sawyer, MSC, to Chief, Systems Engineering Division, “Common usage of Circuit Breakers,” May 18, 1965.

24

MSC concurred in Grumman’s selection of the RF tracking mode for the LEM’s steerable antenna.

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, “Contract NAS 9-1100, LEM high gain steerable antenna RF tracker,” May 24, 1965.

At Wright-Patterson AFB, North American engineers conducted zero-g tests of crew transfer using mockup 27A. The two subjects, astronauts Donn F. Eisele and Richard F. Gordon, had difficulty manipulating the forward hatches and the drogue assembly. North American reported that handles might be required on those pieces of hardware.

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"Apollo Monthly Progress Report," SID 62-300-38, p. 5; memorandum, Donald K. Slayton, MSC, to Manager, ASPO, "CM/LEM Tunnel Hatches and Docking Hardware Zero Gravity Removal and Installation Test," June 18, 1965.

Donald K. Slayton, Assistant Director for Flight Crew Operations, described a potential hazard involved in crew procedures inside the LEM. Two sets of umbilicals linked the Block II space suit to the environmental control system (ECS) and to the portable life support system (PLSS). Though slight, the possibility existed that when a hose was disconnected, the valve inside the suit might not seat. In that event, gas would escape from the suit. Should this occur while the LEM was depressurized, the astronaut's life would be in jeopardy. Consequently, Slayton cautioned, it would be unwise to disconnect umbilicals while in a vacuum. This in turn imposed several mission constraints:

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- PLSSs could not be recharged while the LEM was unpressurized.
- If the astronauts were planning to leave the spacecraft, they had to switch to the PLSSs and disconnect the ECS hoses *before* depressurizing their vehicle.
- Because the cooling circuit in the PLSS operated only in a vacuum, the crew must depressurize the LEM shortly after switching to their PLSSs.

Memorandum, Slayton, MSC, to Chief, Systems Engineering Division, "Apollo suit procedures inside the LEM," May 24, 1965.

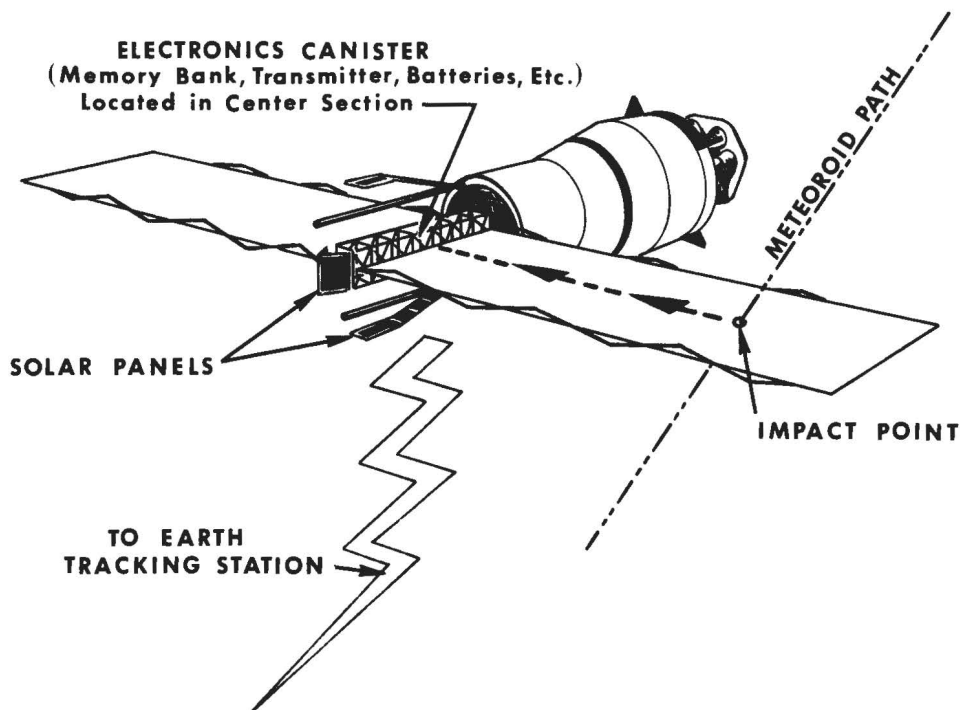
NASA launched *Pegasus II*, a meteoroid detection satellite, from Cape Kennedy. (See February 16, 1965.) The Saturn I launch vehicle (SA-8) placed the spacecraft, protected by a boilerplate CSM (BP-26), into a 740-by-509-km (460-by-316-mi) orbit. Once in orbit, the dummy CSM was jettisoned. *Pegasus II*, still attached to the second stage of the launch vehicle, then deployed its 29-m (96-ft) winglike panels. Within several hours, the device began registering meteoroid hits.

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NASA News Release 65-151, "NASA to Launch Second Pegasus Meteoroid Satellite," May 17, 1965; NAA, "Project Apollo Spacecraft Test Program Weekly Activity Report (Period 24 May 1965 through 30 May 1965)," pp. 1-2; MSFC Historical Office, *History of the George C. Marshall Space Flight Center from January 1 through December 31, 1965* (MHM-11), Vol. I, p. 53.

MSC directed North American to install Block II-type, flush-mounted omnidirectional S-band antennas on CMs 017 and 020. These antennas would survive reentry and thus would afford telemetry transmissions throughout

25



Pegasus "finds" a meteoroid.

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the flight. On June 25, the Center ordered that they be installed in the toroidal (doughnut shaped) section of the aft heatshield.

Letters, James Stroup, MSC, to NAA, Space and Information Systems Division (S&ID), "Contract Change Authorization No. 357," May 25, 1965; J. B. Alldredge, MSC, to NAA, S&ID, "Contract Change Authorization No. 357, Revision 1," June 25, 1965.

25

ASPO pointed out to the Systems Engineering Division that planning of the manned Apollo missions had been constrained to maximize the Manned Space Flight Network support available for guidance and navigation (G&N) functions. While this was a desirable technique to maximize mission success probabilities, it led to a tendency to neglect onboard G&N capabilities.

"It is ASPO policy that, wherever feasible, both onboard and ground systems will be exercised fully during manned developmental missions. Spacecraft maneuvers should be computed both on the ground and in the flight vehicle, and the results of these computations recorded and compared. . . . It is requested that Apollo mission planning conform to this policy and that any tendency to omit full exercise of the onboard G&N capability be corrected."

Memorandum, William A. Lee, MSC, to Chief, Systems Engineering Division, "Utilization of onboard G&N capability during Apollo Manned Development Missions," May 25, 1965.

MSC completed contract negotiations with Westinghouse Electric Company on gear for the LEM's television camera (cables and connectors, stowage containers, and camera mockups). Because of technical requirements, the idea of using the same cable in both spacecraft was abandoned.

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MSC, "ASPO Weekly Management Report, May 27-June 3, 1965."

To aid reacquisition and tracking of the high-gain antenna, MSC directed North American to study the feasibility of an inertial reference system on Block II spacecraft, one that would use rate signals from the CSM's stabilization and control system. Without this system, the astronauts would have to perform anywhere from 250 to 500 antenna reacquisitions during a single lunar mission. And during sleeping periods, when the CM pilot was alone in the vehicle, it was mandatory that the antenna automatically reacquire the earth.

26

Letters, James Stroup, MSC, to NAA, Space and Information Systems Division (S&ID), "Contract Change Authorization No. 358," May 26, 1965; J. B. Alldredge, MSC, to NAA, S&ID, "Contract Change Authorization No. 358, Revision 1," July 23, 1965.

ASPO requested the Apollo Program Director to revise the LEM control weight at translunar injection as follows:

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- Ascent stage 2193 kg (4835 lbs)
- Descent stage 2166 kg (4775 lbs)
- Total LEM (fueled) 14 515 kg (32 000 lbs)

The increase would be made possible by reductions of service propulsion system propellant requirements associated with the revised ΔV budget. ASPO pointed out that existing CSM and adapter control weight propellant requirements allowed a maximum LEM injected weight of 14 877 kg (32 800 lbs) with no increase in the launch vehicle payload requirement.

Letter, Joseph F. Shea, MSC, to NASA Headquarters, Attn: Director Apollo Program, "Revised LEM Control Weights," May 26, 1965.

William A. Lee, ASPO Assistant Manager, asked Systems Engineering Division to study the feasibility of an abbreviated mission, especially during the initial Apollo flights. Because of the uncertainties involved in landing, Lee emphasized, the first LEMs should have the greatest possible reserves. This could be accomplished, he suggested, by shortening stay time; removing surplus batteries and consumables; and reducing the scientific equipment. Theoretically, this would enable the LEM pilot to hover over the landing site for an additional minute; also, it would increase the velocity budgets

26

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May

both of the LEM's ascent stage and of the CSM. He asked that the spacecraft's specifications be changed to fly a shorter mission:

- Stay time—10 hours
- Exploration time—six man-hours
- Scientific payload—32 kg (70 lbs)
- Lunar samples returned—36 kg (80 lbs)

Lee said that this modification would produce a spacecraft that could be adapted to short and long missions.

Memorandum, William A. Lee, MSC, to Chief, Systems Engineering Division, "Spacecraft capability for short-duration lunar landing missions," May 26, 1965.

27

Because correspondence from Grumman and the Resident ASPO there hinted at deleting some equipment from the first LEM, MSC reaffirmed that LEM-1 would be an "all-up" spacecraft, as specified in the SA-206A mission requirements.

MSC Internal Note No. 65-PL-1 (Revision A), "Project Apollo Mission Requirements for Apollo Spacecraft Development Mission 206A (LEM 1)," May 11, 1965; TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Mission Requirements for Apollo Spacecraft Development Mission 206A (LEM 1) MSC Internal Note No. 65-PL-1 (Rev. A) dated May 11, 1965," June 2, 1965.

27-June 3

MSC's Crew Systems Division (CSD) received from Hamilton Standard Division a liquid cooling garment which had been modified to include a comfort liner. Preliminary tests by the contractor showed a substantial increase in comfort with only a small decrement to cooling capacity. CSD scheduled tests to validate the performance.

MSC, "ASPO Weekly Management Report, May 27-June 3, 1965."

28

ASPO approved the use of common communications equipment in Block I and II space suits. The hardware would be procured from North American (under their contract with Pacific Plantronics), then furnished to the suit contractors (David Clark and Hamilton Standard).

TWX, James Stroup, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, June 7, 1965.

30-June 5

ASPO Manager Joseph F. Shea reported the accomplishment of a number of important items:

- Boilerplate 23A command module and launch escape system were moved to the launch pad at WSMR and stacked; integrated ground support equipment checkout was in progress.

- North American was directed to stop all work on systems installation on CSM 006. Test objectives would be reassigned to boilerplate 14 and CSM 008.

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May

- The first deliverable LEM attitude and translation control assembly had passed acceptance test at RCA and was delivered to Grumman.

- The Design Engineering Inspection on LEM descent propulsion test rig PD-1 was completed and the rig shipped to WSMR/PSDF. The LEM ascent propulsion rig HA-4 was shipped to AEDC for ascent engine environmental tests.

- The LEM Technical Specification and the LEM Master End Item Specification were incorporated into the Grumman contract on June 1, 1965.

"Weekly Activity Report, May 30-June 5," sgd. Joseph F. Shea.

Thiokol Chemical Company completed qualification testing on the tower jettison motor. An ignition delay on February 22 had necessitated a redesign of the igniter cartridge. Subsequently, Thiokol developed a modified pyrogen seal, which the firm tested during late August and early September.

During
the
Month

"Apollo Monthly Progress Report," SID 62-300-38, pp. 2, 8, 11.

Using one-third scale models, Grumman tested the LEM's antenna field at the extremes of the frequency range. Data evaluation showed that the range was adequate; errors were well within expected values.

During
the
Month

"Monthly Progress Report No. 28," LPR-10-44, p. 16.

Using improved restraint hardware, Grumman resumed tests simulating the shock of landing on the moon. Investigators reported better lateral stability—and they no longer bounced off the floor. Astronaut Donn F. Eisele, who took part, judged the system superior to those used in earlier trials.

During
the
Month

Ibid., p. 14.

Bell Aerosystems Company successfully cycled a LEM ascent engine propellant valve 500 times (double the specification requirement). Also, the company conducted a full-duration altitude firing with an ablative nozzle extension to verify heating characteristics.

During
the
Month

Ibid., p. 1.

MSC postponed the formal LEM program review (wherein spacecraft requirements would be redefined and Grumman's contract converted to an incentive type). The Center directed the company to submit firm proposals

During
the
Month

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for all contract change authorizations (CCA), which were promised by July 11. Grumman was preparing a revised estimate of total program cost. In the meantime, both parties were negotiating on all outstanding CCAs.

Also, Grumman described its continuing cost reduction effort. To keep expenditures within limits "suggested" by MSC, the firm was preparing detailed budgets both for itself and its subcontractors. The company had made a number of changes to strengthen its administrative structure and, with Houston's support, was reviewing possible schedule changes with an eye toward eliminating some test vehicles.

Ibid., p. 1.

**During
the
Month**

Three flights were made with the lunar landing research vehicle (LLRV) by FRC pilot Don Mallick for the purpose of checking the initial weighing, the thrust-to-weight, and the automatic throttle systems.

General Electric would update the LLRV CF-700 jet engines at their Edwards AFB facility rather than at Lynn, Mass. The change in work location would mean an earlier delivery date and a significant cost reduction. The updating would make the engines comparable to the production engines and would add an additional 890 newtons (200 lbs) of thrust.

Letter, Paul F. Bikle, FRC, to NASA Headquarters, "Lunar Landing Research Vehicle progress report No. 23 for the period ending May 31, 1965."

June

1

ASPO Manager Joseph F. Shea replied to a recommendation by the Assistant Director for Flight Operations to incorporate warning lights in Block I and II CMs to indicate failure of the gimbal actuator secondary drive motors. ASPO decided that no failure indication would be provided for the redundant drive motors in Block I spacecraft because: (1) in-flight checkout procedures would provide for exercising the gimbal actuators by the primary and secondary drive motors prior to service propulsion system burns; and (2) all manned Block I missions would be conducted in earth orbit and reaction control system deorbit capability was stipulated.

The warning lights would be incorporated in Block II spacecraft, and the in-flight checkout procedures would also apply to Block II lunar missions.

Memorandum, Joseph F. Shea, MSC, to Assistant Director for Flight Operations, "Service Propulsion System (SPS) Secondary Gimbal Motor Fail Indication," June 1, 1965.

2

In an attempt to reduce the overall preflight time in connection with lunar landing research vehicle (LLRV) activities, a meeting was held at Flight Research Center. Principal participants were Ray White, Leroy Frost, Leonard Ferrier, Joe Walker, Don Mallick, Cal Jarvis, Jim Adkins, Zeon Zwiuk, Wayne Ottinger, and Gene Matranga.

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June

The session commenced with an estimate of time required to perform each of the functions on the preflight checklist. Review indicated that preflight might be shortened in several ways: (1) since the radar altimeter and doppler radar units did not affect safety of flights, it was suggested that radar checks on flight mornings be reduced to a minimum or be performed without inspection coverage; (2) addition of ac and dc voltmeters in the cockpit would eliminate need for power checks during the avionics preflight; (3) when the weight and drag computer had been properly checked in flight, the weight and drag preflight check could be streamlined down from the 30 minutes currently required; and (4) investigate the need to refill H₂O₂ after prime.

In general, though several operations were performed simultaneously during most of preflight, it appeared other operations could be performed in parallel and thereby reduce overall preflight time.

Memorandum for Files, "LLRV Preflight Procedures," Gene J. Matranga, June 2, 1965.

ASPO advised North American that, at present, no unmanned flights were planned for the Block II CM. After the company concluded its own analysis of Apollo requirements, MSC would determine whether the heatshield must be verified prior to manned missions. But because of the long "lead time" involved, North American should continue securing the requisite instrumentation pending a final decision.

2

TWX, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, subject: "Requirements for Mission Programmers and Heat Shield Measurements in Block II CSM," June 2, 1965.

Northrop-Ventura began qualification testing of the earth landing system for Apollo with a drop of boilerplate 19 at El Centro, Calif. The entire landing sequence took place as planned; all parachutes performed well.

3

"Apollo Monthly Progress Report," SID 62-300-38, pp. 2-3.

NASA launched *Gemini IV*, America's second multi-manned space mission, piloted by astronauts James A. McDivitt and Edward H. White II, from Cape Kennedy. *Gemini IV*'s primary objective was to evaluate the performance of man and machine during prolonged space flight. Also during this flight, White opened the hatch on his spacecraft and performed America's first "space walk." On June 7, after four days in space, McDivitt and White landed their vehicle in the Atlantic Ocean some 724 km (450 mi) east of the Cape.

6

James M. Grimwood and Barton C. Hacker with Peter J. Vorzimmer, *Project Gemini Technology and Operations: A Chronology* (NASA SP-4002, 1969), pp. 200-202.



Astronaut Edward H. White II is shown during the third orbit of the *Gemini IV* flight as he floated in space, attached to the spacecraft by a 7.6-m (25-ft) umbilical line. His right hand gripped a hand-held self-manuevering unit which he used to propel himself during the 21-min "space walk."

1965

June

3-10

MSC approved North American's recommendation that a programmer timer approach be used for earth reacquisition by the CSM's S-band high-gain antenna.

"ASPO Weekly Management Report, June 3-10, 1965."

5

ASPO Manager Joseph F. Shea concluded, after reviewing the boilerplate 22 mission, that all the test objectives would be met satisfactorily either in the flight of spacecraft 002 or in the ground qualification program. For that reason the boilerplate 22 flight would not be repeated.

Memorandum, Shea to Distr., "Test Objectives," June 5, 1965.

ASPO reported a number of significant activities in its Weekly Activity Report.

1965

June

6-12

- The CSM design engineering inspection was satisfactorily conducted at North American June 8-10.
- Qualification of the Apollo standard initiator was successfully completed by Space Ordnance Systems, Inc.
- The first full systems firing of the LEM ascent engine was accomplished at Bell Aerosystems using the heavyweight ascent (HA)-2 propulsion test rig.
- The LEM development program was revised and LEM test article (LTA)-4, LTA-5 ascent stage, flight test article (FTA)-1, and FTA-2 were eliminated.

"Weekly Activity Report, June 6-12, 1965," sgd. Joseph F. Shea.

George E. Mueller, Associate Administrator for Manned Space Flight, approved procurement of the lunar surface experiments package (LSEP). The package, to be deployed on the moon by each LEM crew that landed there, would transmit geophysical and other scientific data back to earth. NASA's Office of Space Science and Applications would make the final selection of experiments. Mueller emphasized that the LSEP must be ready in time for the first lunar landing mission. Management responsibility for the project was assigned to MSC's Experiments Program Office.

7

Memorandum, George E. Mueller, NASA, to MSC, Attn: Dave Lang, "Request for Approval of Procurement Plan for Lunar Surface Experiments Package," June 7, 1965; NASA OMSF, Apollo Program Directive No. 3, "Management Assignment for the Lunar Surface Experiments Package (LSEP) Project," June 15, 1965.

Apollo Program Director Samuel C. Phillips approved MSC's request for revised velocity budgets for the two spacecraft. It was understood that these new values would: (1) still meet the free return trajectory constraint; and (2) increase (to at least two degrees) the LEM's out-of-plane launch capability. MPAD/FOD provided the analysis and recommendations leading to this decision.

7

Letter, Samuel C. Phillips, NASA, to MSC, Attn: Director, ASPO, "Revised Apollo Spacecraft Delta V Budget (U), per letter dated May 18, 1965, Reference PS8/L-82/65," June 7, 1965; Memorandum, Carl R. Huss, JSC, to JSC Historical Office, "Comments on Volume III of *The Apollo Spacecraft: A Chronology*," June 6, 1973.

MSC directed NAA to make a "predesign" study of a rocket landing system for the Block II CM. (The Center had already studied the system's feasibility and had conducted full-scale drop tests.)

7

Letter, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, CM Rocket Landing System Study Meeting, 15 June 1965," June 22, 1965, with enclosure, "Minutes of Rocket Landing System Study Meet-

- 1965** ing," June 15, 1965; TWX, J. C. Ellis, NAA, to NASA Headquarters, Attn: Director, Procurement and Supply Division, July 15, 1965.
- June**
- 7-13** North American's Rocketdyne Division began qualification testing on the CM's reaction control system engines.
- NAA, "Project Apollo Spacecraft Test Program Weekly Activity Report (Period 7 June 1965 through 13 June 1965)," p. 3.
- 8** Russia launched *Luna VI*, an instrumented moon probe. Tass reported that all onboard equipment was functioning normally. Two days into the flight, however, the spacecraft's engine failed to shut down following a mid-course correction. This failure caused *Luna VI* to miss its target by more than 160 000 km (99 419 mi).
- Space Business Daily*, June 11, 1965, p. 216; Tikhonravov, *et al.*, *Ten Years of Space Research in the USSR*, p. 17.
- 8-10** MSC reviewed a lighting mockup of the crew compartment in the Block II CM. The design concept, though needing further refinement, was deemed acceptable. Engineers from Crew Systems Division found that lights on the fingertips of the suit gloves worked quite well; optimum positioning was as yet undetermined, however. At the same time, MSC reviewed the design of the Block I side hatch (i.e., not modified to meet Block II extravehicular requirements). Reviewers found North American's major problems were warpage and crew ingress from space. Further, the design of both side hatches needed "additional coordination" with that of the umbilical access arm of the launch tower to ensure compatibility.
- "ASPO Weekly Management Report, June 3-10, 1965"; "ASPO Weekly Management Report, June 10-17, 1965."
- 9** Crew Systems Division reported that MSC had ordered Hamilton Standard to integrate seven layers of thermal protection into the A5H pressure suit.
- Memorandum, Francis J. DeVos and William C. Kincaide, MSC, to Record, "Meeting on June 9, 1965, to discuss thermal and meteoroid protection for the Apollo Extravehicular Mobility Unit," June 22, 1965.
- 10-17** Crew Systems Division reported that, as currently designed, the environmental control system (ECS) in the LEM would not afford adequate thermal control for an all-battery spacecraft. Grumman was investigating several methods for improving the ECS's thermal capability, and was to recommend a modified configuration for the coolant loop.
- Memorandum, Owen E. Maynard, MSC, to Distr., "LEM battery thermal control problem," June 17, 1965.

NASA hired the U.S. Navy's Air Crew Equipment Laboratory (ACEL) to study several physiological aspects of pure-oxygen environments. Primarily, ACEL's study would try to determine: (1) whether known effects (such as lung collapse) could somehow be reversed; and (2) whether such environments enhanced respiratory infections.

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June
10-17

"ASPO Weekly Management Report, June 10-17, 1965."

A list of materials that North American reported using in the CM's habitable area omitted more than 70 items that had appeared in earlier such reports. MSC ordered the company to determine why. This item could affect the course of backup toxicity testing. Materials listed as "used but not tested" were given highest priority in toxicity testing.

10-17

Ibid.

MSC ordered Grumman to propose a gaseous oxygen storage configuration for the LEM's environmental control system (ECS), including all oxygen requirements and system weights. Because no decision was yet made on simultaneous surface excursions by the crew, Grumman should design the LEM's ECS for either one- or two-man operations. And the Center further defined requirements for cabin repressurizations and replenishment of the portable life support systems. Oxygen quantities and pressures would be worked out on the basis of these ground rules. (See July 1-8.)

11

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, June 11, 1965.

The question of whether a data tape recorder would be installed on LEM-1 had been discussed at several Apollo 206 Mission Operations Plan meetings and there was a strong possibility it would not be installed.

11

In a memorandum to ASPO Manager Joseph F. Shea, Assistant Director for Flight Operations Christopher C. Kraft, Jr., pointed out that his Directorate had responsibility to ASPO of insuring "that all possible test objectives are accomplished. This is done not only by real-time conduct of the mission, but also through considerable premission planning which integrates the desired profile with the Manned Space Flight Network. The underlying purpose of all these operations activities is the accumulation of data, which for unmanned, nonrecoverable spacecraft such as LEM-1 can only be provided through the use of RF telemetry. The FOD (Flight Operations Directorate) does not believe the Apollo 206A Mission Objectives can be assured of being accomplished without the addition of a data tape recorder and associated playback transmitter. . . ."

Kraft said the tradeoff of weight and cost of a data recorder and dump transmitter versus possible loss of data for primary mission objectives, consider-

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June

ing the cost of a Saturn IB launch vehicle, a fully functional LEM spacecraft, and the ground support required, seemed inequitable. He recommended that a data tape recorder and associated playback transmitter be installed on LEM-1 (and 2) to ensure that test objectives were achieved.

Memorandum, Kraft to Shea, "LEM-1/Mission 206A Data Tape Recorder," June 11, 1965.

- 11 ASPO Manager Joseph F. Shea, in a memorandum to Robert Williams, said that, confirming their discussion with Christopher C. Kraft, Jr., and Donald K. Slayton, both had agreed that HF orbital communications in the Block II Apollo spacecraft were not needed. Shea asked Williams to look into the implications of removing the requirement.

Memorandum, Shea to Williams, "Block II communication system," June 12, 1965.

- 11 MSC and North American discussed the brittleness of the boost protective cover and the possibility that, during tower jettison or abort, the cover might break up and cause damage to the spacecraft. Having investigated a number of various materials and construction techniques, North American recommended adding a nylon fabric to strengthen the structure. Company engineers believed that, thus reinforced, the cover would be less likely to tear apart in flight. Even though this would increase the weight of the cover by about 27 kg (60 lbs), MSC concurred. The change applied to both Block I and Block II CMs, and was effective for spacecraft 002, 009, and all subsequent vehicles.

Letter, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, Implementation of Actions Recommended at the NASA/NAA Boost Protective Cover Problem Area Review at MSC June 11, 1965," June 21, 1965, with enclosure: "Abstract of Proceedings, NASA/NAA Boost Protective Cover Problem Area Review, MSC, June 11, 1965," June 14, 1965; memorandum, Owen E. Maynard, MSC, to Chief, Structures and Mechanics Division, "Action Items resulting from Boost Protective Cover Problem Area Review at MSC, June 11, 1965," June 15, 1965; memorandum, Maynard, to Chief, C&SM Contract Engineering Branch, "CCA to NAA on backing material for Boost Protective Cover," June 24, 1965.

- 12 Apollo Program Director Samuel C. Phillips listed the RF communications systems envisioned by NASA Headquarters on the first three R&D LEMs and requested ASPO Manager Joseph F. Shea's comments.

The first three LEMs (LEM-1, LEM-2, and LEM-3) would be equipped with communications equipment in addition to that required in the LEM for lunar missions to provide: (1) transmission of required engineering (R&D) data; (2) redundant operational telemetry; (3) updating of spacecraft equipment via an up-data command link; and (4) redundant tracking capability.

The LEM R&D communications system was essentially independent from the operational communications systems. It would be housed primarily in the equipment bay (which on operational flights would house the scientific payload equipment).

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Letter, Phillips to Shea, "R&D Communications and Tracking systems in LEMs 1, 2, 3," June 12, 1965.

Samuel C. Phillips, Apollo Program Director, noted MSC request for support from Goddard Space Flight Center on LEM battery development as well as Goddard's agreement to furnish limited support.

12

Phillips suggested to ASPO Manager Joseph F. Shea that since MSFC had much experience in the design, development, and operational aspects of battery systems, it was important to use their experience and recommended MSFC be contacted if such action had not already occurred.

Memorandum, Phillips to Shea, "LEM Battery Development," June 12, 1965.

MSC Director Robert R. Gilruth appointed a Technical Working Committee, headed by Edwin Samfield, to oversee the design of a Lunar Sample Receiving Laboratory at the Center.

14

Memorandum, Robert R. Gilruth, MSC, to Chief, Engineering Division, "Formation of a Technical Working Committee for the design of a Lunar Sample Receiving Laboratory and designation of consultants to assist in the selection of an architect-engineer firm," June 14, 1965.

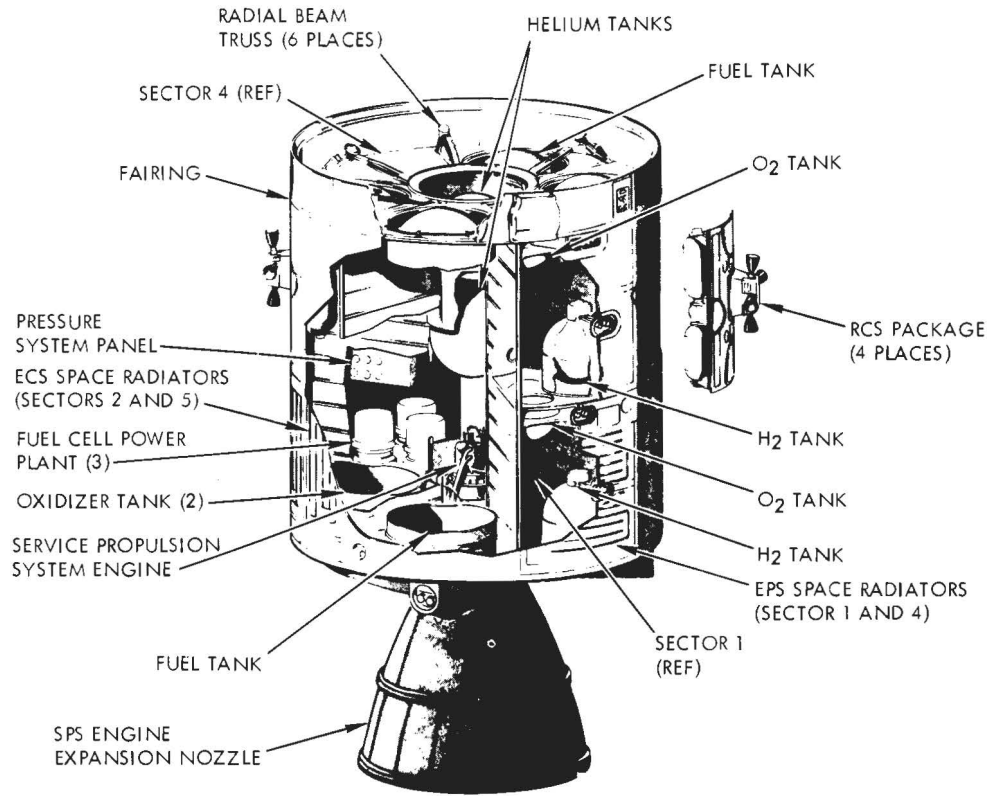
Using a LEM mockup at Grumman, and with the assistance of astronauts Roger B. Chaffee and Donn F. Eisele, engineers from Hamilton Standard performed mobility tests of the reconfigured portable life support system (PLSS). Crew Systems Division (CSD) reported that the reshaped back pack did not hinder entering or leaving the spacecraft; and while some interference problems were inescapable when the PLSSs were worn inside the spacecraft for any period of time, CSD believed that damage could be prevented through training and by limiting movement by the crew. Grumman, however, contended that the newer PLSSs had "serious implications" for mobility inside the LEM.

14-15

GAEC, "Monthly Progress Report No. 29," LPR-10-45, July 10, 1965, p. 3; "ASPO Weekly Management Report, June 10-17, 1965"; MSC, "ASPO Weekly Management Report, June 17-24, 1965."

Independent studies were made at MSC and North American to determine effects and impact of off-loading certain Block II service propulsion system components for Saturn IB missions. The contractor was requested to determine the weight change involved and schedule and cost impact of removing

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The service module.

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one oxidizer tank, one fuel tank, one helium tank and all associated hardware (fuel and oxidizer transfer lines, propellant quantity sensors and certain gaging wire harnesses) from CSM 101 and CSM 103. The MSC study was oriented toward determining technical problems associated with such a change and the effects on spacecraft operational requirements.

The North American study indicated that removing the equipment would save about \$690 000, along with a weight reduction of approximately 454 kg (1000 lbs). Their report also indicated there would be no schedule impact provided go-ahead was given for CSM 101 prior to June 1, 1965, and for CSM 103 prior to November 1, 1965.

The MSC study indicated a maximum burn limitation of 280 seconds, due to excessive drop in helium temperature; and also pointed out that the change to the gaging system might not be as simple as North American stated because of the arrangement of the secondary sensing system. However, those problems did not appear insurmountable.

Memorandum, Owen E. Maynard, MSC, to Manager, ASPO, Attn: W. A. Lee, "Off-Loading Block II SPS Components for Saturn IB Missions," June 15, 1965.

In a series of meetings at Downey, Calif., MSC, Grumman, and North American worked out most of the interface between the two spacecraft. Among the most significant items yet unresolved were: the thermal environment of the LEM during boost; and the structural loads and bending modes between the docked spacecraft.

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15-18

Letter, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, Resolution of CSM/LEM Interfaces, MSC/NAA/GAEC Coordination Meetings No. 27 and 29, June 15-18 and June 24-25, 1965, respectively," July 28, 1965, with enclosure: "Minutes of Coordination Meeting . . .," June 24-25, 1965; "Monthly Progress Report No. 29," LPR-10-45, p. 1.

At Bethpage, N.Y., officials from Grumman and the Flight Projects Division (FPD) discussed the status of LEM-1. During early May, the company had agreed to devise a comprehensive development plan for the spacecraft, one that included hardware status; manufacturing and checkout sequences; requirements for facilities, ground support equipment, and software; and projected schedules. By mid-June, Grumman was still unprepared to discuss details, however, and requested another month to work on the plan. FPD could no longer remain patient: "It is the intention of this office," the division reported to ASPO, "to conduct a monthly LEM-1 status meeting . . . until the LEM-1 program plan is clearly defined."

16

Memorandum, J. Thomas Markley, MSC, to H. L. Reynolds, "Detailed LEM-1 working schedule," June 7, 1965; letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, LEM-1 Status Meeting," June 25, 1965; "ASPO Weekly Management Report, June 10-17, 1965."

To prevent the CSM's contacting the LEM's radar antenna (a problem disclosed during docking simulations), deviations in the CSM's roll attitude would be limited to eight degrees or less.

16

"ASPO Weekly Management Report, June 17-24, 1965."

MSC ordered North American to revise the deployment angles of the adapter panels: 45 degrees for separation, docking, and LEM withdrawal; and—at most—60 degrees for abort separation. (See December 7, 1964.)

16

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 275, Revision 1," June 16, 1965; letter, H. G. Osbon, NAA, to NASA MSC, Attn: C. L. Taylor, "Contract NAS 9-150, R&D for Project Apollo Spacecraft Results of Action Item from Eleventh Flight Mechanics, Dynamics, Guidance and Control Panel Meeting," June 29, 1965, with enclosure.

MSC directed Grumman to modify the LEM's pulse code modulation and timing electronics assembly to enable it to telemeter data from the abort electronics assembly (AEA). Thus, if data from the AEA disagreed with those from the spacecraft's guidance computer, the two sets could be recon-

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1965 ciled on the ground (using inputs from the Manned Space Flight Network),
June relieving the astronauts of this chore.

Letter, James L. Neal, MSC, to GAEC, Attn: John C. Snedeker, "Contract NAS 9-1100, Contract Change Authorization No. 112, Provide Capability in PCMTEA to Telemeter AGS Computer Digital Data," June 16, 1965.

16 The net effect of a decision by ASPO Manager Joseph F. Shea in May was that the total fuel cell effort at both Pratt and Whitney and North American should be no more than \$9.7 million during FY 1966. The decision as to the distribution of the funds was left to the discretion of the fuel cell subsystem manager.

Memorandum for Record, J. Thomas Markley, "C&SM Fuel Cell Effort," June 16, 1965.

16-23 Structures and Mechanics Division (SMD) reported that Grumman had found two thermal problems with the LEM:

(1) On the basis of current predictions, the spacecraft's skin and several antennas would overheat during the boost phase of the mission. SMD engineers, after analyzing the problem, believed that an "acceptable LEM environment" could be achieved by lessening the heat transferred from the inner panels of the adapter and by increasing that emitted by the outer panels.

(2) Also, Grumman had reported that, when exposed to exhaust plumes from the SM's reaction control engines, the LEM's skin would overheat in about five seconds. "Since the LEM withdrawal . . . requires 20 to 26 sec RCS firing," SMD understated, "it is apparent that a problem exists." One suggested solution involved improved insulation.

"ASPO Weekly Management Report, June 17-24, 1965"; memorandum, Joseph N. Kotanchik, MSC, "Review of requirement for Grumman Aircraft Engineering Corporation (GAEC) ground support equipment (GSE) Item LDW-410-12050, Thermal Control System," June 30, 1965.

16-July 15 North American submitted a design proposal for a scientific airlock for the CM (applicable to 014 and all Block II spacecraft). Structural design was scheduled to begin shortly.

NAA, "Apollo Monthly Progress Report," SID 62-300-39, August 1, 1965, p. 4.

16-July 15 North American reported two service propulsion engine failures at AEDC and a third at WSMR. At the first location, both failures were attributed to separation of the thrust chamber from the injector assembly; in the latter instance, weld deficiencies were the culprit. Analysis of all these failures was continuing.

Ibid., p. 11.

MSC directed Hamilton Standard Division to study the feasibility of incorporating a manual override in the current pressure relief valve. During lunar surface activity, a failed relief valve would prevent further operation of the suit.

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TWX, Richard S. Johnston, MSC, to Hamilton Standard Division, Attn: R. E. Breeding, June 17, 1965.

Officials from Bellcomm, MSFC, and the Apollo offices in Houston and in Washington planned primary and alternate missions for the Saturn IB (applicable to SA-201 through SA-208). On July 16, the Office of Manned Space Flight specified launch vehicles (both Saturn IB and V hardware) for Apollo missions.

17

NASA OMSF, Apollo Program Directive No. 4, "Apollo Controlled Milestones and Hardware Quantities—Change Approval," July 16, 1965; memorandum, B. Kaskey, Bellcomm, to File, "Apollo Alternate Missions Meeting, Case 217 (U)," June 22, 1965.

A Development Engineering Inspection (DEI) was held on spacecraft 002 at North American, Downey, California. The NASA Board consisted of W. M. Bland, Jr., Chairman; R. H. Ridnour, J. Chamberlin, S. A. Sjoberg, F. J. Bailey, O. G. Morris, O. E. Maynard, and O. Tarango.

17

A total of 20 Request for Changes (RFCs) were submitted and reviewed; 12 of them resulted from the design review conducted at MSC prior to the DEI, and eight resulted from the inspection of the vehicle. The final disposition of the RFCs was: seven approved for immediate action; five approved for study; three rejected; and five determined not applicable.

Memorandum, W. M. Bland, Jr., MSC to Distr., "Results of Spacecraft 002 Development Engineering Inspection," sgd. E. M. Fields, June 23, 1965.

Crew Systems Division engineers evaluated various battery combinations for the portable life support system. The division recommended a three-hr main and a one-hr backup arrangement, which would save about 9 kg (20 lbs) in the total weight of the vehicle.

17

Memorandum, Richard S. Johnston, MSC, to Chief, Systems Engineering Division, "PLSS battery sizing," June 17, 1965.

NASA representatives briefed officials from the Atomic Energy Commission on the Apollo experiments program and discussed means of coordinating the Commission's work on a radioisotope generator to power those experiments.

17-24

"ASPO Weekly Management Report, June 17-24, 1965."

- 1965** Crew Systems Division began evaluating space suits for the Apollo program (submitted by Hamilton Standard, David Clark, and International Latex). (See July 8–15.)
- June**
- 17–24** *Ibid.*
- 21** North American’s Rocketdyne Division conducted the 1000th test firing of the Saturn V’s first-stage engine, the F–1, MSFC.
- Space Business Daily*, June 23, 1965, p. 275; *History of Marshall . . . January 1–December 31, 1965*, p. 240.
- 21** Joseph F. Shea, ASPO Manager, established as a firm mission requirement the capability to connect the space suit to the LEM’s environmental system and to the portable life support system while in a vacuum. This capability was essential for operational flexibility on the moon’s surface.
- Memorandum, Joseph F. Shea, MSC, to Chief, Crew Systems Division, “Suit Connections,” June 21, 1965.
- 21** The following definitions were specified for use in evaluating design reliability, for design tradeoff studies, and in appropriate Interface Control Documentation:
- Mission success—all primary mission objectives must have been accomplished and both the crew and command module safely recovered.
 - Alternate mission—if a contingency prevented completion of all primary mission objectives, but did not require immediate termination of the mission, an alternate mission plan would be followed but alternate missions would not be included in design reliability calculations.
 - Abort—the only objective after an abort decision was the safest recovery of the crew considering the contingency which caused the abort.
- Memorandum, William A. Lee and Harry L. Reynolds, MSC, to Chief, Systems Engineering Division, “Mission success and crew safety definitions,” June 21, 1965.
- 21–July 1** Crew Systems Division (CSD) conducted a series of flight tests to determine whether the cabin layout of the LEM was suitable for crew performance in zero and one-sixth g environments. Together with its report of satisfactory results, the division made several observations that it thought “appropriate”:
- CSD suggested hand grips in a number of places to aid the crew
 - Additional restraints were needed to supplement the Velcro pile on the cabin floor

• Some problems with crew performance and mobility, present during one-g simulations, were absent in low- or zero-g environments (e.g., moving from one crew station to another).

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MSC, "ASPO Weekly Management Report, July 8-15, 1965."

MSC advised Grumman of additional functions for the computer in the LEM's abort guidance section (to be added only if a part of its memory was left over after the basic requirements were digested). These functions, in order of priority, MSC listed as:

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- Midcourse corrections
- Automatic abort from a coasting descent
- Display of CSM-LEM range and range rate
- Automatic terminal rendezvous (with manual velocity control).

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, LEM Abort Guidance Section Functional Requirements," June 22, 1965.

NASA Headquarters established an Ad Hoc Surveyor/Orbiter Utilization Committee and MSC was requested to submit names of two proposed members. It was suggested that the nominees be familiar with the mission planning and constraints of the Apollo program. The first meeting was planned for late July.

22

On July 29, MSC Director Robert R. Gilruth submitted the names of William A. Lee and William E. Stoney, Jr. He noted that the same two individuals were being nominated to serve as MSC members on the Apollo Site Selection Board. Gilruth expressed a desire that the meetings of the two groups could be coordinated to the extent that travel would be minimized.

Letter, Homer E. Newell, Associate Administrator for Space Science and Applications, to MSC, Attn: Dr. Robert R. Gilruth, "Members of Ad Hoc Surveyor/Orbiter Utilization Committee," June 22, 1965; letter, Gilruth to Newell, "Members of Ad Hoc Surveyor/Orbiter Utilization Committee," July 29, 1965.

In a memorandum concerning Configuration Control Panel and Configuration Control Board actions, J. Thomas Markley, Chief of ASPO's Program Control Division, pointed out that many proposals coming before the two groups were not being adequately evaluated for program impact by the responsible subsystem or technical area manager. He said, in part, "We must keep the number of changes to a minimum and incorporate only those that are necessary to meet program objectives. We are beyond the time when we can afford the luxury design improvement changes, unless they can show substantial savings to the overall program. . . ."

23

Memorandum, Markley to Distr., "CCB/CCP Actions," June 23, 1965.

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23

The operational requirement for Block I and Block II CSM HF orbital communications capability was investigated. ASPO requested that appropriate contract direction and specification change notices be submitted immediately to eliminate this capability from the Block II CSM and the practicality of eliminating the HF orbital capability from the Block I CSM be investigated.

Memorandum, William A. Lee, MSC, to Subsystem Manager, CSM Communications Subsystem, "Requirement for Block I and Block II CSM HF Orbital Communications Capability," June 23, 1965.

24-July 1

Dalmo-Victor submitted to MSC a report on modifications necessary to extend to lunar distances the operating range of the CSM's high-gain antenna. The Instrumentation and Electronic Systems Division was reviewing the report.

MSC, "ASPO Weekly Management Report, June 24-July 1, 1965."

24-July 1

MSC completed a cursory analysis of LEM landing gear load-stroke requirements at touchdown velocities of 2.43 m (8 ft) per sec vertical and 1.22 m (4 ft) per sec horizontal. This study was conducted to determine the lowest crush loads at 8-4 velocity to which the gear could be designed and still meet its landing performance requirements.

Ibid.; memorandum, William G. McMullen, MSC, to Manager, ASPO, "Elimination of TM-5 vehicle from the LEM Landing Gear Subsystem Test Program," July 7, 1965.

25

NASA announced the appointment of Col. C. H. Bolender as Mission Director for the first and second Apollo/Saturn IB flights. Bolender was assigned to the Mission Operations Organization in the Office of Manned Space Flight, NASA.

NASA News Release 65-211.

25

MSC approved North American's concept for thermal control of the valves in the CM's reaction control system (essential for long-duration missions). The crew could electrically heat the valves for about ten minutes before CSM separation and before the system was pressurized, thereby forestalling possible freezing of the oxidizer when it contacted the valve.

Letter, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, Effects of Spacecraft Venting Systems on RCS Propellant Requirements, Determination of," June 23, 1965.

25

Harry L. Reynolds, Assistant Manager of ASPO, said it was "becoming increasingly clear that we are going to have a difficult job keeping the LEM weight below the control weight." He said the Grumman effort was not

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adequate and suggested that R. Bullard of MSC be given LEM weight control as a full-time responsibility.

Memorandum, Reynolds to Chief, Systems Engineering Division, "LEM Weight Control," June 25, 1965.

25

ASPO informed Grumman, NAA, AC Spark Plug, and MIT that effective June 21, 1965, General Electric Company, Apollo Support Department, Daytona Beach, Fla., had assumed responsibility for the preparation and conduct of all automatic checkout equipment (ACE) training for NASA and its contractors.

To satisfy conditions of its contract, General Electric would:

- Survey NASA and contractor ACE training requirements and prepare for ASPO endorsement a standard set of lesson plans (course outlines) for three distinct ACE training courses—(1) for ACE operators and operational checkout procedures writers, (2) for personnel who had site assignments but were not operators, and (3) for all other individuals who did not satisfy the aforementioned assignment considerations.

- Issue with ASPO approval a lesson plan for each ACE training course. These plans would be considered baseline documents and deviations would not be permitted without prior approval from ASPO.

- Prepare one study guide which would contain common reference information for all three ACE training courses.

- Issue coordinated ACE training schedules approved by ASPO.

- Distribute monthly status reports to each participating organization. This report would contain a training schedule for the next three months as well as a discussion of achievements. To control established plans and implement changes, the coordinator for each participating organization would be responsible for determining local training requirements and coordinating those needs with other contractors or NASA elements who desired training at that facility.

- Issue a citation which would acknowledge satisfactory course completion to those qualifying students.

Purpose of selection of a single ACE training contractor and establishment of a standard set of courses was to provide participating organizations a sufficient amount of training and a universal understanding of ACE.

Letters, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, ACE Training," June 25, 1965; M. E. Dell, MSC, to AC Spark Plug, Attn: Hugh Brady, "Contract NAS 9-497, ACE Training," June 28, 1965; M. E. Dell, MSC, to MIT, Attn: M. B. Trageser, "Contract NAS 9-4065, ACE Training," June 28, 1965; J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, ACE Training," June 29, 1965.

25

NASA announced negotiations with Douglas Aircraft Company for nine additional S-IVB stages to be used as the third stage of the Saturn V launch



Douglas engineers are shown installing the electrical system in the forward area of the S-IVB stage.

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vehicle being developed at Marshall Space Flight Center. Work was to include related spares and launch support services. The S-IVB contract, presently valued at \$312 million, would be increased by \$150 million for the additional work.

NASA News Release 65-209, "NASA to Negotiate with Douglas for more S-IVB Stages," June 25, 1965; *Space Business Daily*, June 28, 1965, p. 295.

25

MSC approved North American's proposed location of the antenna for the radar transponder in the CSM, as well as the transponder's coverage. This action followed a detailed review of the relative positions of the two spacecraft during those mission phases when radar tracking of the LEM was required.

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Radar Transponder Antenna Location on CSM," June 25, 1965.

28

Owen E. Maynard, Chief of the Systems Engineering Division, vetoed a demand by the Flight Control Division for redundancy in the LEM's pulse code modulation telemetry system. Two factors determined Maynard's

action: (1) cost and schedule impacts, and (2) the resultant weight and power increases that redundancy would impose. Also it would produce only a "marginal" increase in the total reliability of the spacecraft.

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Memorandum, Owen E. Maynard, MSC, to Chief, Flight Control Division, "LEM PCM telemetry redundancy," June 28, 1965.

The first ground-test version of the Saturn V's first stage is shown being removed from its vertical assembly tower at NASA's Michoud Operations Facility June 27, 1965. The stage was 10 m (33 ft) in diameter and 42 m (138 ft) tall.





At the right is the launch of PA-2; below, the boiler-plate spacecraft as it rests on the desert floor at WSMR.



Systems Engineering Division chief, Owen E. Maynard, reported to the Instrumentation and Electronic Systems Division (IESD) the results of a study on a LEM communications problem (undertaken by his own group at IESD's request). During phases of powered descent to certain landing sites (those in excess of 20 degrees east or west longitude), the structure of the spacecraft would block the steerable antenna's line of sight with the earth. Communications with the ground would therefore be lost. Maynard concurred with IESD that the problem could best be solved by rotating the LEM about its thrust axis.

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Memorandum, Owen E. Maynard, MSC, to Chief, Instrumentation and Electronic Systems Division, "Providing adequate earth coverage from the LEM S-band steerable antenna during lunar descent and ascent," June 28, 1965.

John H. Disher, Director of the OMSF Apollo Test Office, stressed two broad areas open to concern in the Apollo spacecraft heatshield development program: (1) structural integrity, and (2) flight-test confirmation of the Block II design.

28

The structural integrity question centered around the following problems: welding, ablative material integrity, and impact strength.

MSC had planned to qualify the Block II heatshield by flight tests of modified Block I spacecraft 017 and 020. Some of the Block II changes could not be incorporated into modified Block I spacecraft in time to meet the current schedule and limitations of facilities would not permit full evaluation of all modifications by ground testing.

Disher suggested to Apollo Program Director Samuel C. Phillips that ASPO Manager Joseph Shea be asked to present physical descriptions of the Block I and Block II heatshields, and interim versions as applied to specific spacecraft, as well as the test plan that would ensure adequacy of heatshields to meet mission requirements.

Memorandum, Disher to Phillips, "Apollo Spacecraft Heat Shield," June 28, 1965.

MSC directed North American to design the CM to store one integrated thermal meteoroid garment (TMG), rather than merely the thermal covering alone. The crewmen would carry the TMG into the LEM for use during extravehicular operations.

29

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 371," June 29, 1965.

NASA launched Apollo mission PA-2, a test of the launch escape system (LES) simulating a pad abort at WSMR. All test objectives were met. The escape rocket lifted the spacecraft (boilerplate 23A) more than 1524 m (5000 ft) above the pad. The earth landing system functioned normally,

29



The Langley Research Center's Lunar Landing Research Facility.

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lowering the vehicle back to earth. This flight was similar to the first pad abort test on November 7, 1963, except for the addition of canards to the LES (to orient the spacecraft blunt end forward after engine burnout) and a boost protective cover on the CM. PA-2 was the fifth of six scheduled flights to prove out the LES. [Mission objectives in Appendix 5.]

Memorandum, George E. Mueller, NASA, to Administrator, "Apollo Spacecraft Pad Abort Test, Mission PA-2, Post Launch Report No. 1," July 2, 1965; MSC, "Postlaunch Report for Apollo Mission PA-2 (BP-23A)," July 29, 1965, pp. 1-1, 2-1, 3-1, and 10-1.

29

North American reported to MSC that no structural changes to the spacecraft would be required for uprating the thrust of the Saturn IB's H-1 engine from 90 718 to 92 986 kgs (200 000 to 205 000 lbs). Effects on the performance of the launch escape vehicle would be negligible.

Letter, H. G. Osbon, NAA, to NASA MSC, Attn: C. L. Taylor, "Contract NAS 9-150, R&D for Project Apollo Spacecraft; Spacecraft Structural Impact of Increase of H-1 Engine," June 29, 1965.

29

NASA formally announced the selection of six scientist-astronauts for the Apollo program, chosen from a group nominated by America's scientific

community. Qualifications and recruiting procedures had been worked out earlier by NASA and the National Academy of Sciences' Ad Hoc Committee on Scientific Qualifications of Scientist-Astronauts. To be eligible, candidates must have been born on or after August 1, 1930; be citizens of the United States; be no more than 1.83 m (6 ft) tall; and have an educational level of a doctorate or the equivalent in experience. The six, only one of whom was on active military service, were Owen K. Garriott, Edward G. Gibson, Duane E. Graveline, Lt. Cdr. Joseph P. Kerwin (USN), Frank Curtis Michel, and Harrison Schmitt.

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Letter, Homer E. Newell, NASA, to Robert R. Gilruth, MSC, August 19, 1964, with attachment, "Suggested Public Announcement of the Scientist-Astronaut Program," August 19, 1964; letter, Newell to Harry H. Hess, NAS, August 19, 1964; NASA News Release 64-315, "NASA Reports Some 900 Persons Interested in Scientist-Astronaut Program," December 16, 1964; MSC News Release 64-195, December 16, 1964; MSC News Release 65-63, June 29, 1965.

Langley Research Center put into operation its \$3.5 million Lunar Landing Research Facility. The huge structure (76.2 m [250 ft] high and 121.9 m [400 ft] long) would be used to explore techniques and to forecast various problems of landing on the moon. The facility would enable a test vehicle to be operated under one-sixth g conditions.

30

Astronautics and Aeronautics, 1965, p. 303; Michael David Keller, *Fifty Years of Flight Research: A Chronology of the Langley Research Center, 1917-1966* (HNN-65), November 1966, p. 89.

In a memorandum to T. Tarbox, John Ryken, Bell Aerosystems Company LLRV Project Manager, said he understood that Dean Grimm of MSC believed that the LLRV was not configured to have the jet engine provide simulation of a constant-lift rocket thrust in addition to providing the 5/6th g lift. Ryken forwarded to Tarbox a copy of a report, "LLRV Automatic Control System Service and Maintenance Manual," plus notes on the system in the hope that these would help him and NASA personnel better understand the system. He also included suggestions about reducing aerodynamic moments which Grimm felt might interfere with LEM simulation.

30

Interoffice Memo, Bell Aerosystems Company, J. Ryken, Bell, to T. Tarbox, Bell, "LLRV," June 30, 1965.

The Development Engineering Inspection (DEI) for Little Joe II 12-51-3 was satisfactorily conducted at General Dynamics/Convair, San Diego, Calif. The vehicle had been assigned for Mission A-004, an abort mission in the power-on tumbling boundary region. The DEI was conducted with emphasis on changes which had been effected as a result of the malfunction encountered during the A-003 mission. The following served on the DEI Board: J. A. Chamberlin, Chairman, S. A. Sjoberg, R. F. Gordon, F. J.

July

1



An S-IVB Facilities Vehicle arrived at Cape Kennedy from Seal Beach, Calif. Built like a flight stage (except for having no engine installed), it was used at the Cape to check out modifications being made to Launch Complex 34, from which Saturn S-IBs would be launched with S-IVBs as the second stage. The stage had previously been used in a checkout of Douglas Aircraft's Sacramento, California, S-IVB test facility.

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Bailey, R. C. Duncan, W. M. Bland, R. A. Gardiner, and L. P. Gallagher, Secretary.

Memorandum, Chief, Checkout and Test Division, MSC, to Distr., "Development Engineering Inspection for LJ II 12-51-3," sgd. James J. Shannon for W. M. Bland, June 25, 1965; "Weekly Activity Report, June 27-July 3, 1965," sgd. Joseph F. Shea.

1

On the basis of information from the two Apollo spacecraft manufacturers, the Systems Engineering Division (SED) reported a possible thermal problem with the Saturn V during ascent:

- On Saturns 501 and 502, the temperatures of the SM and the adapter would exceed design limits. (These limits were based on heating rates for 504, a heavier vehicle with a consequently cooler trajectory.)
- And on 504, heating rates on the adapter would create an "unacceptable thermal environment" for the spacecraft within.

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SED laid down study procedures to determine the best solution to this problem (either by modifying the spacecraft or the launch trajectory—or both).

Memorandum, Owen E. Maynard, MSC, to Distr., "Saturn V ascent heating problem," July 1, 1965; memorandum, Aaron Cohen, MSC, to Chief, Systems Engineering Division, "Item 2.10, SESAME No. 2 Meeting Minutes, SM and SLA/LEM Potential Boost Heating Problems," July 26, 1965, with enclosure: "MSC/NAA Meeting, SM/SLA/LEM Boost Heating," July 15, 1965.

Within its Office of Manned Space Flight, NASA organized an Apollo Site Selection Board. As an advisory body to the Associate Administrator for Manned Space Flight, George E. Mueller, the group would recommend landing sites for Apollo. 1

Instruction, George E. Mueller, NASA, to Distr., "Establishment of Apollo Site Selection Board," July 1, 1965.

NASA Associate Administrator for Manned Space Flight George E. Mueller told MSC Director Robert R. Gilruth he was establishing an Operations Executive Group. This group would consist of senior executives whose organizations were carrying out the manned space flight operations. 1

It was Mueller's objective that the group meet on a regular basis and review program status, resource requirements, management, and flight operations to provide executive management with the background needed to make effective policy decisions. A second objective was to ensure that the executives in the operations area knew each other well enough to work directly in the rapid solution of time-critical problems.

Mueller planned that one-day meetings would be held at two to four month intervals at locations that would acquaint members with facilities and equipment.

Letter, Mueller to Gilruth, July 1, 1965.

Grumman completed its study of oxygen storage systems for the LEM (see June 11) and reviewed with MSC the company's recommendation (one 20 684-kilonewton per sq m [3000 psi] tank in the descent stage, two 6894-kilonewtons per sq m [1000 psi] tanks in the ascent stage). One drawback to the design, which the Crew Systems Division termed an "apparently unavoidable bad feature," was that, by the time of the final cabin repressurization, the repressurization time would increase to about 12 minutes (though this was admittedly a conservative estimate). Although requesting more data from Grumman on temperatures and cabin pressures, the Center approved the configuration. 1-8

MSC, "ASPO Weekly Management Report, July 1-8, 1965."

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2

The NASA Director of Bioscience Programs pointed out that the National Academy of Sciences' report on back contamination placed emphasis on the potential hazard from the moon because of the short stay on the moon. From this report, it was evident that NASA had problems which must be solved in the very near future.

It was recommended that NASA accept the operational responsibility for back contamination and that there be a clear-cut assignment soon.

It was felt that failure of NASA to establish adequate authority to handle this problem and thus to satisfy the public, the press, the scientific community, and other regulatory agencies could result in direct control of back contamination by those agencies and cause unnecessary constraints upon the manned lunar and planetary missions.

Memorandum, Director of Bioscience Programs, NASA, to Associate Administrator for Space Science and Applications, "Responsibility for Space Quarantine," July 2, 1965.

2

ASPO Manager Joseph F. Shea ordered Crew Systems Division to develop some type of protective devices that the astronauts might use to shield their eyes during a solar flare. ASPO regarded the risk of cataracts during these solar events as extraordinarily high. Although not mandatory, it was desirable that the crew could still see while wearing the devices. Should a flare occur while the crew manned the LEM, mission ground rules called for an abort back to the safety of the CSM; therefore, such devices would be needed for the CM alone.

Memorandum, Joseph F. Shea, MSC, to Chief, Crew Systems Division, "Incidence of cataracts in Apollo crewmembers," July 2, 1965.

4-10

The Weekly Activity Report for the period indicated that (1) the CM 002 was transferred internally within North American from manufacturing to the test organization on July 8; (2) the CM 009 checkout at North American continued with the central timing equipment and signal conditioner check-out completed, and the new 40-ampere-hour batteries for CSM 009 and 011 were shipped to KSC and North American, respectively; and (3) the Grumman subcontract to Eagle-Picher for the LEM batteries was approved by NASA.

"Weekly Activity Report, July 4-10, 1965," sgd. J. Thomas Markley for Joseph F. Shea.

7-9

Langley Research Center completed CSM active docking simulations and lunar orbital docking runs.

Memorandum, Michael K. Lake, MSC, to Chief, Spacecraft Operations Branch, "Apollo Docking Simulation," July 23, 1965, with enclosure.

Illustrative of continuing design and managerial problems, MSC and North American representatives attempted to resolve thermal problems with the Block II environmental control system (ECS), primarily the ECS radiator. The week-long talks were fruitless. MSC's arguments and supportive evidence notwithstanding, the contractor steadfastly opposed the water-glycol approach, favoring a nonfreezing liquid (Freon). MSC, similarly, was hardly satisfied with North American's intransigence—and less so with the company's effort and performance. "A pertinent observation," reported Crew Systems Division, "is that . . . it will be extremely difficult to complete any other development in support of Block II schedules unless their [North American's] attitude is changed."

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"ASPO Weekly Management Report, July 8-15, 1965"; memorandum, Owen E. Maynard, MSC, to Chief, Crew Systems Division, "Design criteria for backup ECS radiator development program," July 6, 1965; memorandum, Frank H. Samonski, Jr., MSC, to Chief, Systems Engineering Division, "Viscosity data of RS-89A (water-glycol)," July 23, 1965.

At a design review on the VHF radio equipment for the LEM, conducted by RCA, Grumman refused to vote its approval. Grumman's most serious objection centered on thermal loads, which under extreme conditions could far exceed specification limits. RCA thereupon began exploring several approaches, including new materials, relocation of components, and redesigned heat sinks. Grumman was asked to keep MSC well informed on problems, corrective actions, and anticipated impacts.

8-9

TWXs, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, July 12, 16, 19, and 22, 1965.

An RCS oxidizer tank failed during a test to demonstrate propellant compatibility with titanium tanks. This was the first of seven tanks to fail from a group of ten tanks put into test to investigate a failure that occurred during February 1965. These results caused an intensive investigation to be undertaken.

11

Memorandum, Darrell Kendrick, MSC, to Chief, Propulsion and Power Division, "Trip to Bell Aerosystems Company (BAC) on July 14 and 15, 1965 regarding S/M F (S/N 26) RCS Tank Shell Failure," July 26, 1965.

During the period the NASA/Department of the Army agreement for use of Army helicopters to airlift LEM adapters was signed by both parties; the Apollo Block II space suit preliminary design review was successfully held by David Clark Company; and evaluation testing of the Apollo Block II space suits submitted by David Clark Company, Hamilton Standard Division and International Latex was completed, with data being reduced.

11-17

"Weekly Activity Report, July 11-17, 1965," sgd. J. Thomas Markley for Joseph F. Shea.

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12 Joseph F. Shea, ASPO Manager, informed Flight Crew Operations that the capability had been firmly established for connecting and disconnecting the suit oxygen umbilicals in a vacuum. Crew Systems Division was modifying the connector (using a two-position release) to satisfy this requirement. This change would ensure safe umbilical operation while in an unpressurized spacecraft.

Memorandum, Donald K. Slayton, MSC, to Manager, ASPO, "Lunar Surface Operations," June 11, 1965; memorandum, Shea, MSC, to Asst. Dir. for Flight Crew Operations, "Lunar Surface Operations," July 12, 1965.

- 13** Crew Systems Division (CSD) completed its study on the feasibility of controlling the amount of bacteria vented from the LEM. Division researchers found that, by placing special filters in the environmental control system (ECS) of the spacecraft, emission levels could be greatly lowered. This reduction would be meaningless, however, in view of effluents from the extravehicular mobility unit (EMU)—the moon would still be contaminated by the space travelers. Because of weight penalties—and because of their dubious value—CSD recommended that bacteria filters not be added to the LEM's ECS. The Division further advised that, at present, neither the amount of bacteria emitted from the EMU nor a means of controlling this effluence was yet known.

Memorandum, Robert E. Smylie, MSC, to Chief, Systems Engineering Division, "Feasibility of controlling effluent bacteria from the LEM cabin and environmental control subsystem," July 13, 1965, with enclosure: "Control of Effluent Micro-Organisms from the LEM Cabin and Environmental Control System."

- 13** A Little Joe II failure investigation presentation was made at MSC July 13 in which General Dynamics/Convair (GD/C) and MSC's Engineering and Development (E&D) Directorate presented results of independent failure investigations of the mishap which occurred during Apollo Mission A-003 (Boilerplate 22) on June 22, 1965, at WSMR.

The GD/C investigation results were presented by J. B. Hurt, Little Joe II Program Manager, in the form of flight movies and a slide talk. The data made the following points:

- At approximately one second after liftoff, the Fin IV elevon moved in a direction to cause the observed clockwise rotation and at 2.5 seconds reached the fully deflected position where it remained until vehicle breakup
- Although computer simulations of the flight with Fin IV fully deflected did not precisely duplicate the observed dynamic motions, sufficient correlation existed to conclude that Fins I, II, and III functioned normally while Fin IV alone caused loss of the mission.
- The complete attitude control system, exclusive of the Fin IV hydro-electrical servo loop, performed correctly as designed.

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- The most probable cause for the failure was a malfunction in Fin IV hydro-electrical servo-loop due to an internal mechanical failure of the servo-valve.

The E&D investigation results were presented by O. P. Littleton of the Guidance and Control Division. In summary, results of the E&D investigation were stated to have confirmed the findings of GD/C although different computer methods were used. Littleton agreed with the conclusions of GD/C, but emphasized that an electrical malfunction within the Fin IV hydro-electrical servo-loop could not be discounted as a possible source of failure at that time.

Memorandum for Record, Bill J. McCarty, MSC, "Little Joe II Failure Investigation Presentation," July 20, 1965.

Structures and Mechanics Division (SMD) presented meteoroid protection figures for the Apollo CSM. (During April, General Electric [GE] had developed reliability estimates for the LEM, based on revised design criteria, for the 8.3-day reference mission. The probability for mission success, GE had found, was .9969.) SMD's figures were:

14

	Block I <hr/> (14-day earth orbital flight)	Block II <hr/> (8.3-day lunar mission)
CM	.99987	.99989
SM	.9943	.9941

The division consequently placed the meteoroid protection for the entire mission at .99417 (Block I, CSM only) and .99089 (Block II, CSM and LEM). Apollo's goal was .99.

All of the above figures, both GE's and SMD's, were derived from the inherent protection afforded by the spacecraft's structure. Thus no additional meteoroid shielding was needed. (Meteoroid protection would still be required, of course, during extravehicular operations.)

"ASPO Weekly Management Report, July 8-15, 1965."

Willis B. Foster, NASA's Director of Manned Space Science Programs, informed MSC's Maxime A. Faget that he had asked the following persons to continue to serve as members of an Ad Hoc Committee as an advisory group to Foster with regard to the design and construction of the Lunar Sample Receiving Laboratory: E. C. T. Chao (Chairman), Lorin Clark

14

1965 (alternate chairman), James Arnold, Clifford Frondel, Briggs Phillips, P. R. Bell, and alternates Jonathan Klein and Larry Hall.

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Letter, Foster to Faget, "Membership of the Headquarters Advisory Committee on Lunar Sample Receiving Laboratory," July 14, 1965.

15 North American began redesigning the side hatch mechanism in the CM to satisfy the requirement for extravehicular transfer from Block II spacecraft. Two basic modifications to the Block I mechanism were required: (1) enlarging it to overcome thermal warpage; and (2) adding some hinge retention device to secure the hatch once it was opened.

Memorandum, R. D. Langley, MSC, to Manager, ASPO, "Side Access Ablative Hatch," July 6, 1965; letter, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, Shipment of S/C 006 Side Access Ablative Hatch to MSC," July 15, 1965; memorandum, Owen E. Maynard, MSC, to Manager, ASPO, "Side access ablative hatch," July 23, 1965.

15 ASPO Manager Joseph F. Shea informed Grumman that a proposal they had made during the LEM Program Review on July 6 regarding broader qualification scheduling and parts deviations had been reviewed by NASA and it was considered "not in the best interests of the program to relax the requirements to the extent proposed by GAEC."

Shea cited a paragraph of the Contract Technical Specification which specified: "Qualification tests supporting a particular flight vehicle shall be completed prior to that vehicle being delivered from the Contractor."

It was NASA's desire that LEM program scheduling be such that all ground test logic constraints required in support of launch dates would be completed at least six weeks prior to scheduled launch dates. Shea pointed out that the LEM program schedules as presented by Grumman at the July 6 Review were not in complete accord with dates previously provided June 7 in a datafax signed by Shea.

Shea required the following delivery dates from Grumman: LEM-1, November 15, 1966; LEM-2, February 15, 1967; LEM-3, April 15, 1967; LEM-4, July 15, 1967; LEM-5, October 15, 1967; LEM-6, December 15, 1967; LEM-7, February 15, 1968; LEM-8, April 15, 1968; LEM-9, June 15, 1968; LEM-10, August 15, 1968; and LEM-11, October 15, 1968.

Grumman was requested to provide NASA, no later than August 2, 1965, their plan for support of a LEM program development schedule which would incorporate these requirements.

Letter, Joseph F. Shea, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, LEM Development Program Requirements," July 15, 1965.

North American recommended to MSC that, for the time being, the present method for landing the CM (i.e., a passive water landing) be maintained. However, on the basis of a recent feasibility study, the contractor urged that a rocket landing system be developed for possible use later on. North American said that such a system would improve mission reliability through the increase in impact capability on both land and water.

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TWX, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, July 9, 1965; NAA, "Apollo Monthly Progress Report," SID 62-300-40, September 1, 1965, pp. 12-13.

MSC directed Grumman to provide stowage within the LEM for those tools needed for transfer between the two spacecraft (either intra- or extra-vehicular). The tool kit, similar to that in the CM, would be stored in the LEM at earth launch.

16

Letters, James L. Neal, MSC, to GAEC, Attn: John C. Snedeker, "Contract NAS 9-1100, Contract Change Authorization No. 122, Extravehicular Crew Transfer Provisions," and "Contract NAS 9-1100, Contract Change Authorization No. 123, Stowage of Inflight Tools in the LEM," July 16, 1965.

On the basis of wind tunnel tests at Arnold Engineering Development Center (AEDC), North American now considered as negligible the effects of structural protuberances on the CM's rolling moment and on propellant consumption.

16-August 15

"Apollo Monthly Progress Report," SID 62-300-40, pp. 6-7.

In order to use the LEM as a backup for the service propulsion system (SPS) to abort the mission during the 15-hour period following translunar injection, Grumman informed North American that some redesign of the spacecraft's helium system would likely be required. This information prompted North American designers to undertake their own analysis of the situation. On the basis of their own findings, this latter group disagreed with the LEM manufacturer:

16-August 15

- Before transposition and docking, the two spacecraft would already be on a confirmed free-return trajectory.
- During the 15-hour interval, moreover, LEM propulsion would be required only in the event of failures in the SPS *and* some time-dependent, mission-critical system.

The probability of two such failures during the abort period, North American concluded, was not sufficient to warrant redesigning the helium system.

Ibid., pp. 12-13.

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Russia launched *Zond III*, but neither its objectives nor its achievements were announced until some time later. About 36 hours after launch, the spacecraft began photographing the far side of the moon (at a range of between 11 600 and 10 000 km [7217 and 6217 mi]). After passing the moon, it entered a heliocentric orbit and thus became an artificial planet. On July 29, *Zond III* transmitted its pictures back to earth, as planned. Those pictures showed clearly the heavily cratered nature of the surface. This mission dramatized the advances in space photography that the U.S.S.R. had made since its first far-side effort six years earlier.

Astronautics and Aeronautics, 1965, pp. 337, 378–379, 392–393; Tikhonravov *et al.*, *Ten Years of Space Research in the USSR*, pp. 20–21.

19

NASA was acquiring eight KC–135 aircraft and three ships to help maintain communications during Apollo moon flights. In addition, two ships of the existing DOD instrumentation fleet were being remodeled for support of the Apollo lunar mission’s reentry phase. The KC–135 jet transports would be used during reentry to combat the effects of the plasma sheath blackout which had drowned out communications on previous manned launchings. In addition, three primary ground stations were being prepared at Goldstone, Calif.; Canberra, Australia; and Madrid, Spain.

Astronautics and Aeronautics, 1965, p. 340; memorandum, Samuel C. Phillips, NASA, to Assoc. Admin. for Manned Space Flight, “Apollo Instrumentation Ship Schedules,” July 23, 1965, with enclosures; memorandum, Arnold W. Frutkin, NASA, to Julian Scheer, “Designation of Spanish tracking station,” July 23, 1965.

19

MSC directed Grumman to implement changes in weights of the LEM:

- Total LEM 14 515 kg (32 000 lbs)
- Ascent stage inert 2193 kg (4835 lbs)
- Descent stage inert 2166 kg (4775 lbs)

Memorandum, James L. Neal, MSC, to GAEC, Attn: John C. Snedeker, “Contract NAS 9–1100, Contract Change Authorization No. 124, Addition of Control Weights to Specification,” July 19, 1965.

19–20

North American conducted zero-g tests at Wright-Patterson AFB to evaluate the design of the CM’s unitized crew couch and restraint hardware.

“Apollo Monthly Progress Report,” SID 62–300–40, p. 4.

19

NASA Headquarters authorized North American to subcontract the Block II CSM fuel cells to Pratt and Whitney. Estimates placed the cost at \$30 million.

TWX, George J. Vecchiotti, NASA, to NASA Office, Downey, Calif., Attn: George A. Abbott, July 19, 1965.

At a LEM-1 review held at Bethpage, N.Y., Grumman briefed MSC officials on the status of design drawings and hardware procurement. Also, the company prepared a detailed schedule for manufacturing and installation of various systems on the spacecraft.

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MSC, "ASPO Weekly Management Report, July 15-22, 1965"; letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, LEM I Status Meeting Number Two," August 6, 1965.

North American reported that qualification testing had been completed on two items of electrical hardware, the CSM battery charger and the pyrotechnic battery.

21

NAA, "Project Apollo Spacecraft Test Program Weekly Activity Report (Period 19 July 1965 through 25 July 1965)," p. 3.

MSC officially notified Grumman that, as part of the Apollo scientific program, an experiments package would be left on the moon by the crewmen of the LEM. The Center outlined weight and storage requirements for the package, which would be stored in the descent stage of the vehicle along with the lunar geological equipment. And MSC emphasized the need for dissipating waste heat given off by the system's radioisotope generator. (The radioisotope generator was a firm requirement, despite the fear voiced by many scientists that the radiation it gave off would disrupt the experiments.)

21

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Request for Preparation of Interface Control Documents for the Lunar Surface Experiments Package (LSEP), and the Lunar Geological Equipment," July 21, 1965; MSC, "ASPO Weekly Management Report, July 29-August 5, 1965."

Several lunar surface vehicles received national attention:

21

- NASA announced that it had dropped plans for developing a small rover to be carried to the moon aboard soft-landing Surveyor spacecraft. This action, the space agency said, stemmed from a desire to concentrate on the development of the spacecraft *per se* and on its scientific instrumentation.

- Bell Aerosystems Company announced that it had designed a rocket-propelled Lunar Flying Vehicle (LFV) to aid Apollo astronauts in their exploration of the moon. This work was the result of a year-long study that the company had conducted for MSFC. The LFV, nicknamed "Hopper," would be able to travel about 80 km (50 mi) without stopping. Bell announced also that it had received additional funds from NASA (almost a half million dollars) to continue work on another lunar vehicle, the so-called Manned Flying System. This latter craft, also primarily a tool for exploration, would be able to transport an astronaut and about 136 kg (300 lbs) of

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equipment (or two astronauts) for distances up to 24 km (15 mi) from the original landing site.

NASA News Release 54-245, "NASA Will Not Develop Surveyor Roving Vehicle," July 21, 1965; *Astronautics and Aeronautics*, 1965, p. 342.

22

MSC and Grumman discussed the LEM landing gear design and determined the landing velocity touchdown envelope.

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, subject: "Structural Design for Lunar Landing Dynamic Magnification Factor," July 22, 1965; TWXs, Young to Mullaney, July 30 and August 18, 1965; GAEC, "Monthly Progress Report No. 30," LPR-10-46, August 10, 1965, p. 8.

22

Agreements and decisions reached at the MSC briefing on the LEM optical tracker were:

- Development of the LEM rendezvous radar should be continued.
- One contractor should be selected for development of the optical tracker with schedules to support installation in early LEMs.
- A decision on the rendezvous radar versus the optical tracker was deferred.

TWX, Samuel C. Phillips, NASA, to MSC, Attn: Joseph F. Shea, subject: "LEM Optical Tracker," July 28, 1965.

23

MSC authorized North American to make a number of significant hardware changes:

- Delete hardware for transferring water from the CM to the LEM.
- Place filters in the propellant lines of the SM's reaction control system.
- Cease all work on an extravehicular probe (responsibility which MSC now assumed).
- Delete from the stabilization and control system (SCS) of all Block II CSMs the hybrid thrust vector control apparatus. (This change reduced the functional capability of the SCS and simplified the system's interface with the guidance and navigation system.)
- Delete the HF orbital antenna from CSMs 012, 014, and all Block II spacecraft.
- Change the propellant mixture in the service propulsion system of Block II spacecraft. The service propulsion engine would be modified, which would require additional developmental and qualification testing.
- Go ahead on thermal coating on the adapter (to achieve the desired thermal environment for the LEM during boost).

Letters, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorizations, 384, 385, 387, 388, 390, 391, 392, and 393," July 23, 1965.

MSC defined for Grumman the functions that the LEM's abort guidance section (AGS) must perform during earth orbital flights:

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- When both spacecraft were unmanned, the AGS must be able to hold the LEM's attitude during coast or while thrusting; it would not, however, have to control thrusting itself.

- During manned missions, whether or not the LEM itself actually was manned, the AGS must afford closed-loop control of the vehicle, again both while coasting and thrusting. Thrusting phases of these flights would demonstrate the section's guidance and navigational capabilities.

The basic lunar mission program still would be used. False position, velocity, and gravity data would be inserted to make the AGS behave as if it were flying around the moon. Finally, MSC emphasized that neither the AGS hardware, its permanent or "hardwired" memory, nor delivery schedules must be altered to meet this earth orbital capability.

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Abort Guidance Section operational requirements during earth orbital missions," July 23, 1965.

During a news conference, Kenneth S. Kleinknecht, Deputy Manager of the Gemini Project Office at MSC, affirmed that, although no firm decisions had yet been made, the concept of a circumlunar flight using a Gemini spacecraft was being seriously studied. The mission would use Titan II and III-C launch vehicles and would require rendezvousing in earth orbit. NASA, Martin-Marietta Corporation (builder of the Titan), and Aerojet-General Corporation (which manufactured upper stages for the III-C) all were studying the feasibility of such a flight. Later in the year, NASA Administrator James E. Webb eliminated the possibility of a Gemini circumlunar mission, ". . . our main reliance for operating at lunar distances . . . is the large Saturn V/Apollo system."

26

Howard Benedict, *The Times-Picayune*, New Orleans, July 26, 1965; letter, U.S. Representative Olin E. Teague to James E. Webb, August 18, 1965; letter, Webb to Teague, September 10, 1965.

At North American's drop facility, a malfunction in the release mechanism caused boilerplate 1 to impact on land rather than water. After a recurrence of this accident on August 6, a team of investigators began looking into the problem. Drops were suspended pending their findings. These incidents aggravated delays in the test program, which already was seven weeks behind schedule.

26

MSC, "ASPO Weekly Management Report, August 5-12, 1965."

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29 Failure of the Little Joe II launch vehicle on Mission A-003 and subsequent lack of positive failure cause identification and corrective action led to a lower than desirable confidence level in the capability of the controlled version of Little Joe II to accomplish the planned A-004 mission. The test objectives for A-004 were set forth (see Appendix 5).

Memorandum, Owen E. Maynard, MSC, to ASPO Manager, "WSMR test requirements and their relations to the AFRM-002 Mission," sgd. R. W. Williams, July 29, 1965.

- 29** General Electric (GE) received a supplement to its ACE-S/C (Acceptance Checkout Equipment-Spacecraft) contract. Total cost and fee for the amendment, which covered a reliability program for Apollo parts and materials, was \$1 382 600. This brought the total value of GE's contract to \$85.6 million.

MSC, "Quarterly Activity Report for Office of the Associate Administrator, Manned Space Flight, for Period Ending July 31, 1965," pp. 25-26.

- 30** MSC advised Grumman that the altitude at which the LEM crewmen would switch from automatic to manual control of the spacecraft during Phase II of the landing approach would be 213 m (700 ft).

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, July 30, 1965.

- 30** NASA launched *Pegasus III*, third of the meteoroid detection satellites, as scheduled at 8:00 a.m. EST, from Cape Kennedy. (See February 16 and May 25.) As earlier, an Apollo spacecraft (boilerplate 9) served as the payload's shroud. This flight (SA-10) marked the end of the Saturn I program, which during its seven-year lifetime had achieved 10 straight successful launches and had contributed immeasurably to American rocket technology.

NASA News Release 65-232, "Pegasus C," July 21, 1965; NASA News Release 65-253, "Pegasus III Launch Caps NASA's Saturn I Program," July 30, 1965; memorandum, George E. Mueller, NASA, to Administrator, "Pegasus III/SA-10 Saturn I Flight Mission Post Launch Report No. 1," August 16, 1965, with enclosure: Mission Operation Report No. R-725-65-03 M-931-65-10; "Apollo Monthly Progress Report," SID 62-300-40, p. 1; TWX, KSC, to Distr., "SA-10 Apollo Flash Report No. 1," sgd. E. R. Mathews, July 30, 1965.

- 30** During the preceding six months, officials in ASPO and the Engineering and Development Directorate evaluated the performance of the launch escape vehicle (LEV) during aborts on and near the launch pad. That performance, they had determined, was inadequate. To solve this problem, MSC ordered North American to incorporate a number of design changes in both the LEV and the spacecraft:

- Provide the capability for manual override of the main parachute deployment timer and for manual deployment of those parachutes (for both Saturn IB and V flights)

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- Provide for dumping helium from the CM's reaction control system (RCS) automatically
- Modify the CM RCS to permit rapid dumping of its fuel (similar to the existing oxidizer dump). But fuel and oxidizer must not be dumped simultaneously. (This change applied only to Block II CMs.)
- Provide the capability to cut out the LEV's pitch control motor on Block I vehicles (similar to that already in Block II spacecraft)
- Design a removable device that, while on the pad, would keep the launch escape motor's propellant temperature above 70 degrees.

Memoranda, Owen E. Maynard, MSC, to Distr., "LEV pad and near pad abort additional analysis and/or testing required for implementation of a 609.6 m (2000 ft) constant altitude main chute deployment," April 23, 1965; John D. Hodge, MSC, to Asst. Dir. for Flight Operations, "Implementation of a 609.6 m (2000 ft) constant altitude main chute deployment," June 8, 1965; Christopher C. Kraft, Jr., MSC, to ASPO, Attn: O. E. Maynard, "Apollo Launch Escape Vehicle (LEV) pad and near-pad abort capability," July 16, 1965; letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 397," July 30, 1965.

ASPO Manager Joseph F. Shea informed LEM Subsystems Managers that recent LEM schedule changes and program review activities had led to some confusion with regard to schedule requirements and policies. Shea pointed out that in some instances subsystem delivery schedules had been established which were inconsistent with the overall program. Where this had occurred, prompt action by the Subsystems Managers was required to recover lost ground. Shea then laid down specific ground rules to be followed, and requested that waivers of these ground rules be submitted no later than August 15, along with a demonstration that reasonable alternatives had been investigated. Only the ASPO Manager would approve any waivers.

31

Memorandum, Joseph F. Shea, MSC, to LEM Subsystems Managers, "Subsystem Qualification and Delivery Schedules," July 31, 1965.

At a meeting between representatives of NASA and Public Health Service representatives, it was agreed:

31

- That the PHS had responsibility for the health of the nation and for any potential threat to that health from extraterrestrial life, particularly from back contamination.
- That the Office of the Surgeon General, PHS, would submit to the NASA Administrator a proposal for action deemed necessary.
- That the Department of Agriculture had a similar responsibility for the nation's crops and animals of economic importance and that the Department of Agriculture would probably accept arrangements made by PHS, and be brought into the matter at the point they considered action to be necessary.

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James Goddard, Chief of the Communicable Disease Center of the PHS, stated he was prepared to staff any required quarantine activity at the Lunar Sample Receiving Laboratory but there was no discussion of the source of the personnel.

Memorandum for the Record, Orr E. Reynolds, NASA Headquarters, August 17, 1965.

During
the
Month

Two change orders were issued to Grumman under the LEM contract, which brought the total estimated cost and fixed fee to \$573 246 377.

"Quarterly Activity Report for Office of the Associate Administrator, Manned Space Flight, for Period Ending July 31, 1965," p. 25.

During
the
Month

Several astronauts participated in landing touchdown studies conducted in the LEM landing simulator to verify data collected in previous studies and to determine changes in controls and displays to improve the touchdown envelope. Studies involved landing runs from an altitude of 305 m (1000 ft) with manual takeover at 213 m (700 ft), at which time the pilot could select a precise landing site.

"Monthly Progress Report No. 30," LPR-10-46, p. 4.

During
the
Month

Crew Systems Division completed evaluation of the three Block II space suits submitted by Hamilton Standard, David Clark, and International Latex. Also, the contractor presented to MSC the results of drop tests with the LEM's support and restraint system.

North American technicians began installing a CM mockup aboard a KC-135 at Wright-Patterson Air Force Base. The structure would be used in a zero-g flight test program (scheduled to begin within a week) to evaluate the Block I space suit *re* mobility, crew performance, and interfaces with the couch and restraints and with the guidance and navigation station. (See July 19.)

Ibid., p. 5; "ASPO Weekly Management Report, July 8-15, 1965."

August

2

NASA announced plans to install Apollo Unified S-Band System equipment at its Corpus Christi, Tex., tracking station. The Unified S-Band equipment included a 9-m (30-ft) diameter parabolic antenna and would enable handling of seven different types of communications with two different vehicles, the CM and the LEM. The communications would: track the spacecraft; command its operations and confirm that the command had been executed; provide two-way voice conversation with three astronauts; keep a continuous check on the astronauts' health; make continuous checks on the spacecraft and its functions; supply a continuous flow of information

from the Apollo onboard experiments; and transmit television of the astronauts and the exploration of the moon.

1965

August

NASA News Release 65-250, "NASA to Install Apollo Unified S-Band Tracking at Corpus Christi Station." August 2, 1965; *Space Business Daily*, August 3, 1965, p. 156.

NASA's office at Downey, Calif., approved the contract with the Marquardt Corporation for the procurement of Block II SM reaction control system engines. Estimated cost of the fixed price contract would be \$6.5 million. Marquardt was supplying the Block I SM engines.

2

TWX, Henry S. Smith, NASA-Downey, to NASA Headquarters, Attn: Director of Procurement and Supply Division, August 2, 1965.

Hamilton Standard shipped the first prototype portable life support system to Houston, where it would undergo testing by the Crew Systems Division.

2

MSC News Release 65-68, August 2, 1965; *Space Business Daily*, August 5, 1965, p. 172.

MSC informed Grumman of package dimensions and weight restrictions for the scientific equipment and packages to be stored in the LEM.

2

TWXs, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, August 2, 1965.

NASA named three firms, Bendix Systems Division, TRW Systems Group, and Space-General Corporation to design prototypes of the Apollo Lunar Surface Experiments Package (ALSEP). Each company received a \$500 000, six-month contract. After delivery of the prototypes, MSC would select one of the three to develop the ALSEP flight hardware.

3

NASA Headquarters Release No. 65-260, "Three Firms Selected to Design Apollo Lunar Surface Package," August 4, 1965; letter, Samuel C. Phillips, NASA, to Robert O. Piland, MSC, "Selection of Contractors for Apollo Lunar Surface Experiments Package," September 10, 1965.

Grumman reported the status of its effort to lighten the LEM. Despite some relief afforded by recent program changes (e.g., revised velocity budgets and the replacing of fuel cells with batteries), the contractor admitted that significant increases resulted as the design of the spacecraft matured. Grumman recommended, and MSC approved, a Super Weight Improvement Program (SWIP) similar to the one that the company had used in its F-111 aircraft program. By the end of the month, the company reported that SWIP had trimmed about 45 kg (100 lbs) from the ascent and about 25 kg (55 lbs) from the descent stages of the spacecraft. Grumman assured MSC that the SWIP team's attack on the complete vehicle, including its

3

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August

equipment, would be completed prior to the series of LEM design reviews scheduled for late in the year.

ASPO, "Minutes, NASA/GAEC Program Management Meeting, August 3, 1965"; GAEC, "Monthly Progress Report No. 31," LPR-10-47, September 10, 1965, p. 1.

- 4 During the next 10 months, 200 employees of MSFC would be transferred to MSC to augment the Houston staff for the operational phase of the Apollo program. Completion of the first phase of the Saturn program (with the successful launch of SA-10) made it possible for Marshall to release qualified personnel to satisfy MSC's needs.

Space Business Daily, August 9, 1965, p. 187; memorandum, Wernher von Braun, MSFC, to Distr., "Marshall's Changing Role in the Space Program," August 13, 1965.

- 5 During tests of the Apollo earth landing system (ELS) at El Centro, Calif., boilerplate (BP) 6A sustained considerable damage in a drop that was to have demonstrated ELS performance during a simulated apex-forward pad abort. Oscillating severely at the time the auxiliary brake parachute was opened, the spacecraft severed two of the electrical lines that were to have released that device. Although the ELS sequence took place as planned, the still-attached brake prevented proper operation of the drogues and full inflation of the mains. As a result, BP-6A landed at a speed of about 50 fps.

"ASPO Weekly Management Report, August 5-12, 1965."

- 5 The Saturn V's booster, the S-IC stage, made a "perfect" full-duration static firing by burning for the programmed 2.5 minutes at its full 33 360-kilo-newton (7.5-million-lbs) thrust in a test conducted at MSFC. The test model demonstrated its steering capability on command from the blockhouse after 100 sec had elapsed; the firing consumed 2.133-million liters (537 000 gallons) of kerosene and liquid oxygen.

Space Business Daily, August 9, 1965, p. 185.

- 5-12 North American developed a plan to process NASA- and contractor-initiated design changes through a Change Control Board (CCB). Indications were that the contractor's Apollo Program Manager would implement the plan on August 19. Elevating the level of management on the CCB, together with a standard approach to processing changes, was expected to improve the technical definition and documentation of design changes. In addition, program baselines were being established to permit a more informed control of technical requirements.

"ASPO Weekly Management Report, August 5-12, 1965."



The S-IC stage during static firing at MSFC.

North American and MSC attended a design review at Ling-Temco-Vought on the environmental control system radiator for the Block II CSM. After reviewing design and performance analyses, the review team approved changes in testing and fabrication of test hardware.

1965

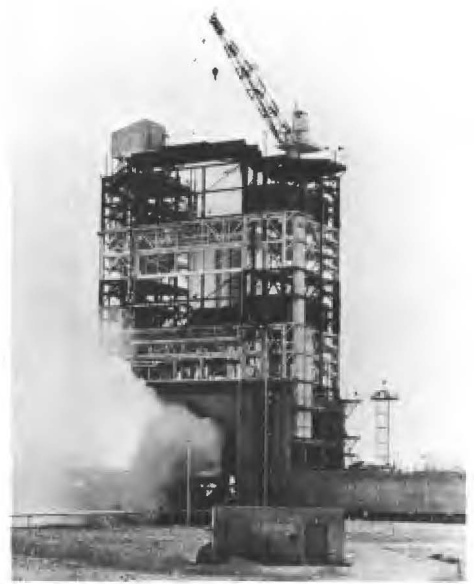
August

6

Memorandum, Richard J. Gillen, MSC, to Chief, Crew Systems Division, "Trip to Ling-Temco-Vought, Dallas, Texas, on August 6, 1965, Block II ECS radiator," August 20, 1965; MSC, "ASPO Weekly Management Report, August 26-September 2, 1965."

Crew Systems Division (CSD) reported that changing the method for storing oxygen in the LEM (from cryogenic to gaseous) had complicated the interface between the spacecraft's environmental control system (ECS) and the portable life support system (PLSS). Very early, the maximum temperature for oxygen at the PLSS recharge station had been placed at 80 degrees. Recent analyses by Grumman disclosed that, in fact, the gas temperature might be double that figure. Oxygen supplied at 160 degrees, CSD said, would limit to 2½ hours the PLSS operating period. Modifying the PLSS, however, would revive the issue of its storage aboard both spacecraft.

6



At the left, the S-II stage captive firing; at the right, the S-IVB stage static firing.

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August

Seeking some answer to this problem, CSD engineers began in-house studies of temperature changes in the spacecraft's oxygen. There was some optimism that Grumman's estimates would be proved much too high, and MSC thus far had made no changes either to the ECS or to the PLSS.

Memorandum, Richard E. Mayo, MSC, to Chief, Systems Engineering Division, "ECS thermal control configuration for 'battery' LEM," August 9, 1965; "ASPO Weekly Management Report, August 5-12, 1965."

9

Two Saturn milestones occurred on the same day. At Santa Susana, Calif., North American conducted the first full-duration captive firing of an S-II, second stage of the Saturn V. And at Sacramento, Douglas static-tested the first flight-model S-IVB, second stage for the Saturn IB. This latter marked the first time that a complete static test (encompassing vehicle checkout, loading, and firing) had been controlled entirely by computers.

TWX, Wernher von Braun, MSFC, to NASA Headquarters, Attn: George Mueller, August 11, 1965; *Space Business Daily*, August 12, 1965, p. 207.

10

MSC notified North American that, should one of the CM's postlanding batteries fail, the crew could lower the power requirements of the spacecraft during recovery and thus stay within the capabilities of the two remaining batteries.

TWX, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, August 10, 1965.

ASPO forwarded to Grumman the following schedule dates which should be used for submission of detailed vehicle test plans:

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<i>AS Mission</i>	<i>Vehicle Test Plan</i>	<i>Schedule Date</i>
206	LEM-1	9-1-65
207	LEM-2	12-1-65
503	LEM-3	2-1-66
504	LEM-4	5-1-66
505	LEM-5	7-1-66
506	LEM-6	11-1-66

10

When determination of LEM test articles to be used on Missions 501 and 502 had been finalized, test plan dates would be forwarded. Current dates for 501 and 502 detailed vehicle test plans were 8-15-65 and 11-1-65, respectively.

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullancy, "Vehicle Test Plan Schedule Dates," August 10, 1965.

Resident ASPO quality assurance officers at North American began investigating recent failures of titanium tanks at Bell Aerosystems. Concern about this problem had been expressed by the Apollo Test Directorate at NASA Hq in July and MSC started an investigation at that time. The eventual solution (a change in the nitrogen tetroxide specification) was contributed to by North American, Bell Aero Systems, the Boeing Company, MSFC, MSC, Langley Research Center, and a committee chaired by John Scheller of NASA Hq. The penstripe method to find cracks on the interior of the vessels was used to solve the problem. The quality assurance people viewed the failures as quite serious since Bell had already fabricated about 180 such tanks.

12

MSC, "Minutes of Senior Staff Meeting, August 6, 1965," John B. Lee, Recorder, p. 3; memorandum, L. E. Day, NASA to Melvyn Savage, "Apollo N₂O₄ Tank Problems," August 18, 1965; "ASPO Weekly Management Report, August 5-12, 1965"; memorandum, Director, Apollo Soyuz Test Project Engineering, NASA Hq, to Acting Director, NASA Historical Office, "Volume III of *The Apollo Spacecraft: A Chronology*," sgd. Charles H. King, Jr., May 7, 1973.

Samuel C. Phillips, Apollo Program Director, listed the six key checkpoints in the development of Apollo hardware:

12

- (1) Preliminary Design Review (PDR)—a review of the basic design conducted before or during the detailed design phase.
- (2) Critical Design Review (CDR)—a review of specifications and engineering drawings preceding, if possible, their release for manufacture.
- (3) Flight Article Configuration Inspection (FACI)—a comparison of hardware with specifications and drawings and the validation of accept-

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August

ance testing. FACIs could be repeated to ensure that deficiencies had been corrected. Also, this inspection would be conducted on every configuration that departed significantly from the basic design. Items successfully passing the FACI were accepted, provided they met requirements in the Apollo Configuration Management Manual.

(4) Certification of Flight Worthiness (COFR)—to certify that each vehicle stage or spacecraft module was a complete and qualified piece of hardware.

(5) Design Certification Review (DCR)—to certify that the entire space vehicle was airworthy and safe for manned flight. DCRs would formally review the development and qualification of all stages, modules, and subsystems.

(6) Flight Readiness Review (FRR)—a two-part review, scheduled for each flight, to determine that both hardware and facilities were ready. Following a satisfactory FRR, and when decided upon by the mission director, the mission period would begin (which would commit deployment of support forces around the world).

NASA OMSF, Apollo Program Directive No. 6, "Sequence and Flow of Hardware Development and Key Inspection, Review, and Certification Checkpoints," August 12, 1965.

12

Grumman received approval from Houston for an all-gaseous oxygen supply system in the LEM. While not suggesting any design changes, MSC desired that portable life support systems (PLSS) be recharged with the cabin pressurized. And because the oxygen pressure in the descent stage tanks might be insufficient for the final recharge, the PLSSs could be "topped off" with oxygen from one of the tanks in the vehicle's ascent stage if necessary.

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Gaseous Oxygen Supply Configuration," August 12, 1965.

12-13

MSC rejected North American's second design concept for a panel retention system in the LEM adapter. (The contractor's first proposal had drawn an unsatisfactory verdict early in June.) These successive rejections, largely on the basis of weight and vibration factors, illustrated the company's continuing difficulties with the system. MSC "suggested" to North American that it circumvent these problems by attaching the retention cable directly to the skin of the adapter.

"Critical Design Review for the Block II Spacecraft/LEM Adapter, 12-13 August 1965."

18

At a third status meeting on LEM-1, Grumman put into effect "Operation Scrape," an effort to lighten that spacecraft by about 57 kg (125 lbs). "Scrape" involved an exchange of parts between LEM-1 and LTA-3. The

former vehicle thus would be heavier than the latter; LTA-3, on the other hand, would have the same structural weight as LEMs 2 and forthcoming.

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August

MSC, "ASPO Weekly Management Report, August 12-19, 1965"; letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, LEM I Status Meeting Number Three," August 30, 1965; "Monthly Progress Report No. 31," LPR-10-47, pp. 28-29.

Owen E. Maynard, Chief of the Systems Engineering Division, asked that part of the LEM Mission Programmer, the Program Reader Assembly, be deleted. The assembly was no longer needed, Maynard said, to meet Apollo mission requirements.

18

Memorandum, Owen E. Maynard, MSC, to Subsystem Manager, LEM SCS, "LEM Mission Programmer," August 18, 1965.

The preliminary Design Engineering Inspection (DEI) for CSM 011, Mission AS-202, was held. This was a major program milestone for the mission. The review board met on August 24 and the formal DEI was conducted August 30, 31, and September 1 (see entry for those dates).

18-24

Memorandum, Carl R. Huss, JSC, to JSC Historical Office, "Comments on Volume III of *The Apollo Spacecraft: A Chronology*," June 6, 1973.

The Apollo Resident Office at KSC was notified that it was ASPO Manager Joseph F. Shea's desire that a Configuration Control Panel be established and chaired at KSC to consider and process engineering changes to Apollo spacecraft and associated hardware undergoing checkout and test at KSC.

19

The ASPO Configuration Management Plan was being revised to reflect the action. The newly formed CCP's authority would be restricted to review of end item hardware (including ground support equipment configuration changes) to determine if the change was mandatory in the conduct of tests at KSC, and the approval of the contractor's plan for making the mandatory change to specific Apollo hardware end items at KSC.

Memorandum, William M. Bland, Jr., MSC, to Assistant Head of MSC Apollo Resident Office, KSC, "Apollo Spacecraft Configuration Control Panel at KSC," August 19, 1965.

MSC assigned two LEM test articles (numbers 10 and 2, respectively) to the SA-501 and SA-502 missions. Prior to flight, the spacecraft would be refurbished by Grumman, which would require four to five months' work on each vehicle.

19-26

MSC, "ASPO Weekly Management Report, August 19-26, 1965"; "Monthly Progress Report No. 31," LPR-10-47, p. 38; memorandum, C. H. Perrine, MSC, to H. Davis, "Use of LTA-10 for Facilities Verification Vehicle," August 31, 1965.

- 1965**
August
20 Douglas Aircraft Company static-fired the S-IVB in a test at Sacramento, Calif., simulating the workload of a lunar mission. The stage was run for three minutes, shut down for half an hour, then reignited for almost six minutes.

Astronautics and Aeronautics, 1965, p. 386.

- 21** *Gemini V*, piloted by L. Gordon Cooper, Jr., and Charles Conrad, Jr., roared into space from Cape Kennedy. During their eight-day flight the astronauts performed a number of orbital and simulated rendezvous maneuvers to evaluate the spacecraft's rendezvous guidance and navigation equipment. A second principal objective of the mission was to evaluate the effects on the crew of prolonged exposure in space. *Gemini V* was significant as well for another reason: although the hardware experienced some troubles during the early part of the flight (which threatened to terminate the mission prematurely), *Gemini V* was the first spacecraft to use fuel cells as its primary source of electrical power. The operational feasibility of fuel cells would be essential for the success of long-distance (i.e., lunar) manned space flight.

Grimwood, et al., Project Gemini: A Chronology, pp. 209-211.

- 23** MSC and Apollo spacecraft contractors were in process of planning and implementing an extensive ground-based test program to certify the spacecraft for flight. All possible efforts were being made to benefit from the experience of related spacecraft programs in planning the Apollo test program. In view of the similarities of the Surveyor mission and the LEM mission, Jet Propulsion Laboratory was asked to cooperate by providing: (1) background information concerning the manner in which their qualification test program had been performed, (2) the major complete vehicle and partial vehicles used in the ground test programs, and (3) significant results obtained from such programs.

Letter, Joseph F. Shea, MSC, to NASA Resident Office, JPL, "Surveyor ground test programs," August 23, 1965.

- 23** Joseph F. Shea, ASPO Manager, summarized ground rules on the schedules for qualifying and delivering equipment for Block II spacecraft:

- All components installed on the Block II test vehicle (2TV-1) and on Block II flight vehicles must be production hardware. (Prototype units were unacceptable.)
- Any changes from the configuration of CSM 103 in 2TV-1, 101, or 102 must be essential to the specific mission requirements of those vehicles.
- Delivery schedules must be compatible with North American's needs. (North American was allowed some leeway in installing components, pro-



Top, an overall view of Mission Operations Control Room in MCC, Houston, during the *Gemini V* flight with the location of the spacecraft visible on the tracking display at upper left. Bottom, Astronauts Charles Conrad, Jr. (left), and L. Gordon Cooper, Jr., receive a congratulatory call from President Lyndon B. Johnson after splashdown.

1965

August

vided that such reordering was feasible and did not affect overall checkout and delivery schedules for the vehicle.)

- Qualification testing must be scheduled so that all equipment was qualified before February 15, 1967.
- Launch-constraining ground tests must be scheduled for completion at least six weeks before that launch.

Shea alone had authority to waive these schedule rules.

Memorandum, Shea, MSC, to Distr., "Subsystem qualification and delivery schedules for Block II," August 23, 1965.

24

MSC requested that Grumman review the current LEM landing and docking dynamic environments to assure: (1) no loss of the abort guidance system attitude reference due to angular motion exceeding its design limit of 25 degrees per second during indicated mission phases; and (2) a mission angular acceleration environment, exceeding the gyro structural tolerances, would not be realized.

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, August 24, 1965.

26–September 2

Grumman advised that prelaunch heat loads on LEM-1 exceeded the capability of the spacecraft's prelaunch Freon boiler. That boiler had originally been designed for loads anticipated from fuel-celled LEMs. When batteries replaced fuel cells, MSC had recommended deleting the boiler; Grumman had urged that the item be retained on LEM-1, however, because that spacecraft would have optional equipment onboard at launch. "It appears," Crew Systems Division (CSD) reported, "that the number of items of equipment required to be on [LEM-1] at earth launch has snowballed": the boiler's maximum capability was about 900 Btus per hour; the spacecraft's heat load was estimated at something like 6000. "GAEC is presently investigating what can be done to reduce these loads," CSD said.

"ASPO Weekly Management Report, August 26–September 2, 1965."

26–September 2

Qualification testing was completed on the LEM's helium storage tank.

Ibid.; memorandum, Joseph G. Thibodaux, Jr., "Quantity gaging for the Descent Propulsion Supercritical Helium Pressurization System," August 19, 1965, with enclosure.

27

Owen E. Maynard, Chief of the Systems Engineering Division (SED), drafted a set of guidelines for Apollo developmental missions. While these guidelines pertained mostly to Block II development, and were so labeled, to some extent they dealt with Block I flights as well. These Development Mission Guidelines covered the overall mission, as well as specific phases, with one section devoted solely to the LEM. (Maynard was careful to distinguish these guidelines from "ground rules" in that, rather than being

mandatory requirements, their intent was "to afford test planning a guide and somewhat of an envelope . . . and not hard and fast rules.")

1965

August

SED was considering including these guidelines in the Apollo Spacecraft Master Test Plan when that document was next revised.

Memorandum, Maynard, MSC, to Distr., "Block II Development Mission Guidelines," August 27, 1965.

North American reported that ground testing of the service propulsion engine had been concluded. Also, changing the propellant ratio of the service propulsion system had improved the engine's performance and gimbal angles and had reduced the weight of the Block II SM. (See July 23.)

27

Memorandum, Owen E. Maynard, MSC, to Asst. Manager, ASPO, "SPS engine gimbaling in stack," August 25, 1965; TWX, M. L. Raines, WSTF, to MSC, Attn: R. R. Gilruth and others, August 30, 1965; NAA, "Apollo Monthly Progress Report," SID 62-300-41, October 1, 1965, pp. 8, 10.

Several important activities were noted during the reporting period: (1) Qualification of the new reefing line cutters was progressing satisfactorily and scheduled for completion in October 1965. (The cutter had been used successfully on the last two earth landing system tests conducted at El Centro); (2) the helium storage tank for the LEM reaction control subsystem successfully passed qualification tests; and (3) the Aero Spacelines' new aircraft, "Super Guppy," made its maiden flight from Van Nuys, Calif., to Mojave Airfield, Calif. The new aircraft had the capability of airlifting the spacecraft-LEM-adaptor as well as providing vital backup for the "Pregnant Guppy" aircraft.

29-September 4

"Weekly Activity Report, August 29-September 4, 1965," Joseph F. Shea.

NASA's Associate Administrator for Manned Space Flight, George E. Mueller, informed MSC's Director Robert R. Gilruth that an official emblem had been adopted for the Apollo Program, a composite based on the best proposals submitted by NASA and contractor personnel.

30

Letter, Mueller to Gilruth, August 30, 1965.

Spacecraft 011's design engineering inspection was held at North American. The review combined structures, mission (SA-202), and ground support. The Review Board approved 55 changes (53 of which were assigned to North American).

30-September 1

"Apollo Monthly Progress Report," SID 62-300-41, p. 4; memorandum, C. H. Bolender, NASA, to E. E. Christensen and S. C. Phillips, "Trip Report on Visit to NAA Downey," September 7, 1965.



The Apollo Program emblem. The large letter A is superimposed on the constellation Orion so that its three central stars form the bar of the A. The face on the moon represents the mythical Apollo.

1965
August
31–September 1

At an implementation meeting at MSC on the LEM's guidance and control system, Grumman again made a pitch for its concept for the landing point designator (i.e., scale markings on the vehicle's window). On September 13, the company received MSC's go-ahead. Grumman was told to coordinate closely with both MSC and MIT on the designator's design to ensure that the scale markings would be compatible with the spacecraft's computer.

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, subject: "Action Item L52, Requirements for Landing Point Designator (LPD)," September 13, 1965.

**During
the
Month**

An explosion damaged a LEM reaction control system thruster being fired in an up attitude in altitude tests at MSC.

"Monthly Progress Report No. 31," LPR-10-47, p. 1.

**During
the
Month**

Grumman completed an analysis of radiation levels that would be encountered by the LEM-3 crew during their earth orbital mission. Grumman advised that doses would not be harmful. To lessen these levels even further, the contractor recommended that during some parts of the mission the two astronauts climb back into the CM; also, the planned orbit for the LEM (556 by 2500 km [300 by 1350 nm]) could be changed to avoid the worst part of the Van Allen Belt.

Ibid., p. 40.

**September
1**

North American conducted another in their series of impact tests with boilerplate 28. This drop tested the toroidal section of the spacecraft (heat-shield and equipment bay structure) in impact at high angle and maximum

horizontal velocity. The spacecraft suffered no visible damage. Some water leaked into the vehicle, but this was blamed on the boilerplate structure itself and the apex-down attitude after impact.

"Apollo Monthly Progress Report," SID 62-300-41, p. 1; MSC, "ASPO Weekly Management Report, September 2-9, 1965."

A LEM ascent engine exploded during altitude firings at Arnold Engineering Development Center (AEDC). In subsequent investigations, Bell Aerosystems researchers concluded that the failure probably resulted from raw propellants being accidentally forced into the engine at the end of the second run, thus damaging the injector. The explosion, which occurred at the start of the third run, in turn followed an uncontrolled flow of propellants into the engine. As a result of this accident, Bell made several changes in hardware fabrication. Also, the company planned additional firings, under conditions similar to those at AEDC when the explosion occurred, to try to determine exactly the cause.

1

MSC, "Minutes of Senior Staff Meeting, September 10, 1965," p. 1; memorandum, A. L. Madyda, MSC, to Chief, Propulsion and Power Division, "Report on trip to Bell Aerosystems, September 13-14, 1965," September 16, 1965; memorandum, Madyda, to Chief, Propulsion and Power Division, "Trip to Bell on September 30, 1965," October 4, 1965.

MSC advised officials at North American's Tulsa Division that their concept for external panel retention cables on the adapter was unacceptable. While the Tulsa people agreed with Houston's objections, because of orders from Downey they had no authority to change the design. Structures and Mechanics Division reported that North American's "continued apathy . . . to redesign the system" threatened a schedule delay.

1-8

"ASPO Weekly Management Report, September 2-9, 1965."

MSC's Flight Operations Division requested an investigation of the feasibility of performing an abort from an inoperative S-IVB booster on the AS-206 unmanned LEM mission.

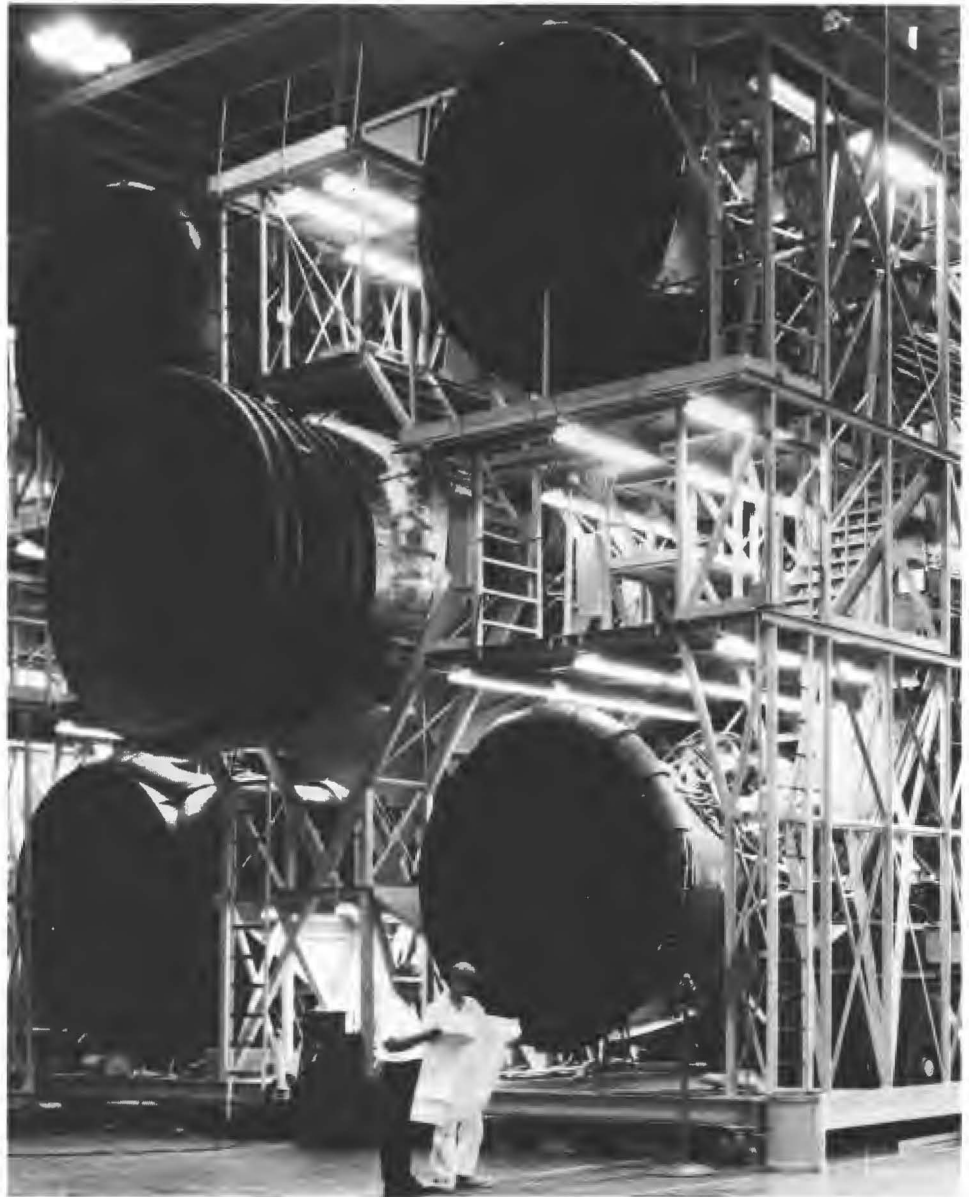
2-9

Ibid.; memorandum, R. W. Lanzkron, MSC, to Chief, Systems Engineering Division, "AS-206 Preliminary Abort Requirements," September 10, 1965.

NASA Associate Administrator for Manned Space Flight George E. Mueller summarized for Administrator James E. Webb the status of the LEM tracking systems. The LEM rendezvous radar system, which had been under development since 1963, was expected to be available when needed for flight missions. Technical studies had shown that an Optical Tracker System offered weight and reliability advantages with no reduction in LEM performance. Hughes Aircraft Company was developing an Optical Tracking System as a back-up to the rendezvous radar.

3

Memorandum, Mueller to Webb, "LEM Tracking Systems," September 3, 1965.



The "business end" of the Saturn V launch vehicle's first stage, showing the nozzles of the five F-1 engines, is seen at MSFC's main assembly building. Only the center engine in this picture had the uncooled extension of the nozzle in place. The five Rocketdyne engines consumed 13.6 metric tons (15 tons) of propellant a second.

1965

September

3

To aid in defining abort limits for the emergency detection system, MSC authorized North American to determine the ultimate strength of the spacecraft based on failure trajectories of the Saturn IB and Saturn V vehicles.

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 407," September 3, 1965; memorandum, Owen E.

Maynard, MSC, to Chief, Flight Control Division, "Range Safety Destruct Time Delay for Saturn IB & V," September 27, 1965.

1965

September

3

MSC requested Grumman to review the following ascent and descent pressurization system components in the propulsion subsystem for materials compatibility with certain propellants: (1) helium explosive valve; (2) pressure regulator; (3) latching solenoid valve; (4) pressure relief and burst disc; and (5) quad check valve.

Recent reports from various programs had shown that propellant vapors had seeped into mid-portions of their pressurization systems, causing corrosion and leakage problems. The SM and LEM had recently revised portions of their programs to incorporate this compatibility requirement.

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Internal compatibility of LEM Ascent and Descent Propulsion Subsystem pressurization system components with fuel and oxidizer propellant vaporizer, Hydrazine-Unsymmetrical Dimethyl Hydrazine and Nitrogen Tetroxide, respectively," September 3, 1965.

William A. Lee, ASPO, pointed out to the MSC Thermo-Structures Branch that Grumman was engaged in a strenuous weight reduction effort and that, when feasible, MSC should accept the proposed changes. In the area of thermal control, Grumman was investigating the use of etched aluminum surfaces to replace thermal paint. It was expected that the change was feasible and that approximately 11 kg (24 lbs) of inert weight would be saved on each stage of the LEM. In addition, Grumman was investigating the applicability of this technique to the landing gear components.

8

Grumman was also studying substitution of an aluminum-mylar nonrigid outer heatshield with plastic standoffs for current rigid ascent and descent heatshields. The potential inert weight saving would be about 84 kg (185 lbs). Lee requested that Thermo-Structures Branch stay in close contact with these developments.

Memorandum, William A. Lee, MSC, to Thermo-Structures Branch, Attn: J. A. Smith, Jr., "LEM weight reductions in the area of thermal control," September 8, 1965.

Assistant ASPO Manager William A. Lee told the General Instrumentation Branch of the Instrumentation and Electronic Systems Division Grumman was preparing a proposal for use of the LEM vehicle as an electrical ground. The plan was to adopt a single wire system selectively for those circuits not susceptible to electrical transients. Lee said Grumman estimated a weight savings of 27 kg (60 lbs) in the ascent stage and 9 kg (20 lbs) in the descent stage. The proposal was expected to be available to NASA by October 1 and Lee had committed NASA to a decision within three weeks of receipt of the plan.

8

Memorandum, William A. Lee, MSC, to General Instrumentation Branch, Attn: A. H. Campos, "Use of LEM vehicle structure as electrical ground return," September 8, 1965.

- 1965**
September
9-10
- MSC requested Grumman and North American to study the possibility of taking the guillotine that Grumman had developed for the LEM's inter-stage umbilical and using it as well to sever the two umbilicals linking the LEM to the adapter. In this manner, North American's effort to develop these cutters might be eliminated; LEM-adapter interface would be simplified; and a significant monetary savings could be effected without schedule impact.
- MSC, "ASPO Weekly Management Report, September 9-16, 1965"; ASPO, "Abstract of Proceedings, Ground Test Requirements Meeting No. 4, September 9 and 10, 1965," September 16, 1965.
- 9-16**
- Northrop-Ventura canceled a parachute test because of problems with the reefing line rings and the main parachute bags. North American was looking into these problems which, it was anticipated, would affect both blocks of spacecraft.
- MSC, "ASPO Weekly Management Report, September 9-16, 1965."
- 10**
- Because of recent changes in the design of the space suit, Motorola, under its contract for suit communications antennas, began concentrating on the development of antennas for the back pack rather than on the helmet.
- Letter, Richard S. Johnston, MSC, to R. E. Breeding, Hamilton Standard Division, "Technical directive on SSC helmet mounted antenna," September 10, 1965; MSC, "ASPO Weekly Management Report, September 16-23, 1965."
- 10**
- Owen E. Maynard, Chief of Systems Engineering Division, advised ASPO Manager Joseph F. Shea of the major technical problems currently plaguing Apollo designers:
- Spacecraft weight growths—these, Maynard said, exceeded predictions "by a serious margin." Pessimistically, he added that the performance of many systems was but "marginally acceptable."
 - Lunar landing criteria—the unknowns involved precluded conservative thinking on the LEM.
 - Integration of scientific experiments—Maynard blamed the "piecemeal" integration of experiments for the lack of comprehensive planning and for many late hardware changes.
 - Water landing criteria—because of the range of variables, present design margins were questionable.
 - Land landing—i.e., development of the landing rockets.
 - Thermal design—conflicts existed between temperature control and attitude constraints for the spacecraft.
 - Propulsion performance—no unit, Maynard reported, had yet achieved the specific impulse which was required of it.
 - Space suit development—design of the suit, and of the thermal-meteoroid garment and the portable life support system, Maynard said, had

“gyrated violently, resulting in spacecraft design compromises to accommodate questionable space suit performance.”

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Memorandum, Maynard, MSC, to Manager, ASPO, “Apollo principal technical problems,” September 10, 1965.

NASA began recruiting additional pilot-astronauts, to begin training the following summer.

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MSC News Release 65-79, “NASA to Select Additional Pilot-Astronauts,” September 10, 1965.

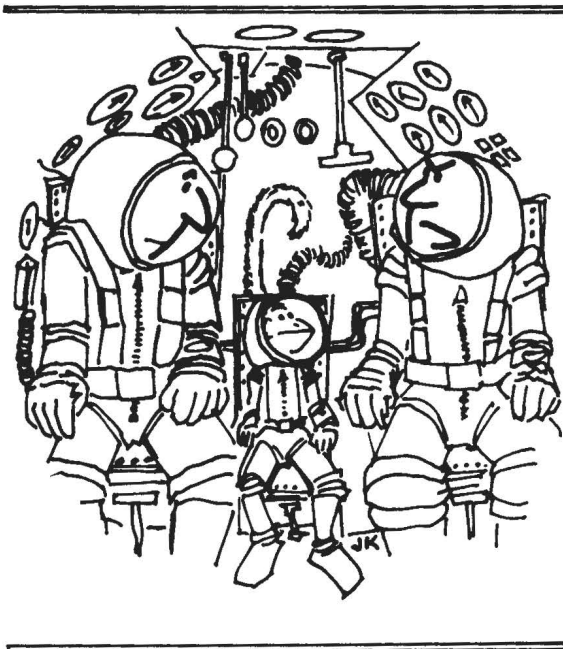
Hurricane Betsy hit the United States and Apollo Program Director Samuel C. Phillips presented an interim report to NASA Associate Administrator Robert C. Seamans, Jr., concerning the effects of the storm on NASA property and programs:

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- Michoud (La.) Plant—all of the buildings suffered moderate to severe damage. So far as could be determined, Saturn hardware in process was not damaged to any appreciable extent. Damage was estimated at between \$2 and \$4 million. Time lost by the storm and due to cleanup and repairs would probably affect program schedules by two or more weeks.

With the continued frustrations of fighting the weight problem on both the CM and LEM it was necessary that both NASA and contracting personnel maintain a sense of humor. The above was used in slide form at a meeting at MSC.

“ I KNOW
WE HAVE A
WEIGHT
PROBLEM... ”



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- Transportation—the barge *Promise* tied up at the Michoud dock broke free and was beached. Externally, no damages were visible. The dock area was heavily damaged.

- Production of Liquid Hydrogen—Air Products, Inc., plant under construction across the canal from Michoud was reported to be under nine feet of water. Extent of the damage was unknown.

- Reentry Ships *Huntsville* and *Watertown*—these vessels were under modification at the Avondale Shipyard, New Orleans. Both broke loose and were hard aground. The *Watertown* was battered but the holds were dry; it looked like it could be salvaged. The *Huntsville* had a 9-m (30-ft) gash in the side plus three other holes. The engine rooms were flooded. Navy salvage crews did not think the vessel was salvageable.

- Cape Kennedy—damage from the storm was minor. The storm did cause a shutdown of site activation activities on Complex 34, costing four critical days.

Memorandum, Phillips to Seamans, "Impact of Hurricane Betsy on Apollo," September 13, 1965.

- 13 ASPO Manager Joseph F. Shea announced a new plan for controlling the weight of Apollo spacecraft. Every week, subsystem managers would report to a Weight Control Board (WCB), headed by Shea, which would rule on their proposals for meeting the target weight for their systems. Three task forces also would report to the WCB on the way to lighten the spacecraft: (1) weight reduction task force; (2) requirements reduction task force; and (3) an operations task force.

Memorandum, Shea, MSC, to Distr., "Apollo Weight Control Program," September 13, 1965, with enclosure: "Apollo Weight Control Plan."

- 14 As a result of discussions with North American and Aerojet-General, MSC ordered several changes to the service propulsion engine:

- (1) redesign of the ablation chamber seals and the flange mountings
- (2) modifications to permit ground purging
- (3) redesign of the injection hub
- (4) doubling of the nominal valve opening time (from .3 to .6 sec).

These changes applied to all qualification test and all flight hardware.

TWX, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, subject: "SPS Engine Changes and Checkout," September 14, 1965.

- 14 At a status meeting at Grumman on LEM-1, MSC learned that, as a result of welding problems, the vehicle's ascent stage was about four weeks behind schedule.

Memorandum, R. A. Newlander to W. J. Gaylor, RASPO-Bethpage, "LEM-1 Status Meeting, 9/14/65," September 17, 1965; letter, R. Wayne Young, MSC, to GAEC, Attn:

R. S. Mullaney, "Contract NAS 9-1100, LEM-1 Status Meeting Number Four," September 21, 1965.

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Flight Crew Support Division defined the minimum time required to assure adequate crew training in the Apollo Mission Simulators. Individual part task training in the simulators required 36 hrs for each of six astronauts (prime and backup crews), a total of 216 hrs; each of the two crews would require 40 hrs of crew mission task training, 120 hrs of crew specific mission training, and nine hrs each of crew integrated mission (with ground crews) training, a total of 169 hrs per crew or a total of 338 hrs.

It was estimated that the simulator would be operational on an average of 30 hours a week, based on experience in other programs. Thus, eight months of simulator availability would be required prior to the AS-204 launch date—one month of training verification plus 29 weeks for crew training.

The needed dates for simulators were: Apollo Mission Simulator No. 1, fully operational January 15, 1966, with spacecraft 012 modification kit delivery complete on March 18, 1966; Apollo Mission Simulator No. 2 delivery in 012 configuration April 15, 1966, to be fully operational June 6, 1966.

Memorandum, Warren J. North, MSC, to Chief, Systems Engineering Division, "Simulator training requirements to support the Apollo missions," September 15, 1965.

MSC's Assistant Director for Flight Operations, Christopher C. Kraft, Jr., told ASPO Manager Joseph F. Shea that postlanding operational procedures require that recovery force personnel have the capability of gaining access into the interior of the CM through the main crew hatch. This was necessary, he said, so recovery force swimmers could provide immediate aid to the crew, if required, and for normal postlanding operations by recovery engineers such as spacecraft shutdown, crew removal, data retrieval, etc.

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Kraft said the crew compartment heatshield might char upon reentry in such a manner as to make it difficult to distinguish the outline of the main egress hatch. This potential problem and the necessity of applying a force outward to free the hatch might demand use of a "crow bar" tool to chip the ablator and apply a prying force on the hatch.

Since this would be a special tool, it would have to be distributed to recovery forces on a worldwide basis or be carried aboard the spacecraft. Kraft requested that the tool be mounted onboard the spacecraft in a manner to be readily accessible. He requested that the design incorporate a method to preclude loss of the tool—either by designing the tool to float or by attaching it to the spacecraft by a lanyard.

Memorandum, Kraft to Shea, "Apollo Crew Hatch Tool," September 16, 1965.

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The Assistant Chief for Electronic Systems notified ASPO that the proposed Grumman plan to repackage the LEM pulse command modulated and timing electronic assembly (PCMTEA) had been discussed and investigated and that the Instrumentation and Electronic Systems Division (IESD) concurred with the proposal.

Following is the impact to the PCMTEA as a result of Grumman's proposed changes: (1) weight of the PCMTEA would be reduced 1.4 kg (3 lbs) and a further reduction of 4.99 kg (11 lbs) would result from repackaging; (2) volume of the PCMTEA would be reduced by approximately 8123 milliliters (500 cu in); (3) there would be no schedule impact to LEM-1, LTA-8, or the PCMTEA qualification test program because of the proposed changes; and (4) no firm cost estimates were available but IESD estimated repackaging cost would be about \$100 000.

Memorandum, Leonard E. Packham, MSC, to Assistant Manager, ASPO, "GAEC plan to repackage the LEM PCMTEA," September 16, 1965.

16-17

North American and its subcontractor, LTV, conducted a design review on the environmental control system radiator for the Block II CSM. Both parties agreed upon a backup effort (i.e., a narrower selective stagnation panel), which would be more responsive to thermal changes in the spacecraft. Testing of this backup design could follow that of the prototype and still meet the design release.

Memorandum, Frank H. Samonski, Jr., MSC, to Gary G. Metz, "Environmental control system (ECS) attitude constraints for Spacecraft 012," September 14, 1965; "ASPO Weekly Management Report, September 16-23, 1965."

16-17

A design review on the attitude controller for the LEM was held at Honeywell. Flight Crew Support Division reported that the device seemed "highly optimized functionally, operationally, and weight wise."

"ASPO Weekly Management Report, September 16-23, 1965"; GAEC, "Monthly Progress Report No. 32," LPR-10-48, October 10, 1965, p. 14; TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, October 14, 1965.

16-23

Systems Engineering Division (SED) reported that, on the basis of data from SA-4, 8, and 9 flights, the thermal coating of the spacecraft suffered considerable damage. This degradation was caused by the S-IV retro motor and/or the tower jettison motor. SED advised that a thorough analysis was scheduled shortly at TRW to look into the entire area of thermal factors and the performance of ablative coating. However, North American refused to acknowledge the existence of any such thermal problem, SED said. The

firm's "continued inactivity" was described as a "major obstacle" to solving the problem.

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"ASPO Weekly Management Report, September 16-23, 1965"; memorandum, James A. Smith, MSC, to Project Officer, C and SM, ASPO, "Technical Evaluation, Justification, and Plan of Action for Instrumentation to determine effects of TJM Impingement, RECP 461," September 27, 1965.

NASA and the Atomic Energy Commission (AEC) agreed that AEC would provide radioisotope thermoelectric generators which would power each Apollo Lunar Surface Experiments Package for an operating period of one year on the lunar surface.

16-23

"ASPO Weekly Management Report, September 16-23, 1965"; memorandum, Robert E. Vale, MSC, to Chief, Systems Engineering Division, "Radioisotope Thermoelectric Generator," September 27, 1965.

Grumman established the final design parameters for the landing gear of the LEM (both primary and secondary struts). It was anticipated that this newer design would be between 9 and 14 kg (20 and 30 lbs) lighter than the earlier gear.

16-23

"ASPO Weekly Management Report, September 16-23, 1965"; "Monthly Progress Report No. 32," LPR-10-48, pp. 10, 12.

North American evaluated the compatibility of spacecraft 012 with its mission, AS-204, the first manned Apollo flight. The manufacturer determined that, by using roll-stabilized attitude during most of the flight, the vehicle could remain aloft for about 13½ days. The only onboard expendables termed marginal were cryogenics and the propellant supply in the SM's reaction control system (which, for added safety, would offer a redundant means of braking the vehicle out of orbit).

16-October 15

NAA, "Apollo Monthly Progress Report," SID 62-300-42, November 1, 1965, p. 3; memorandum, Robert V. Battey, MSC, to Chief, Apollo Trajectory Support Office, "Spacecraft systems and attitude constraints for mission AS-204," September 14, 1965.

The basic structure of Apollo CM simulator "A," around which a full-scale mockup of the CM crew stations would be built, was delivered to MSC. Flight Crew Support Division would use the mockup for crew familiarization, procedures training, and equipment evaluation.

17

"ASPO Weekly Management Report, September 16-23, 1965."

MSC's Director, Robert R. Gilruth, sent a detailed history of actions taken in regard to development of the Apollo Extravehicular Mobility Unit, and

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CM simulator "A" in place at MSC. The simulator represented actual mission conditions and the internal and external environment (except for zero g). Motion sensations were simulated by a visual system and realism was maintained through simulation of such activities as booster engine and thruster firings, pyrotechnic noises, and the injection of smoke into the CM to simulate electrical fires.

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recommended three changes not consistent with the overall procurement plan previously approved by NASA Headquarters:

- Amend the existing Hamilton Standard contract to provide for the development, qualification, and fabrication of the portable life support system and associated equipment only. This contract would cover delivery of all flight equipment for the Apollo flight program.
- Award a separate contract to International Latex Corporation for the development and fabrication of test and flight space suits and associated equipment.
- MSC would assume responsibility for total program management, systems integration, and space suit qualification.

Basis for the recommendations was (1) a comparative suit evaluation of space suits submitted by International Latex, Hamilton Standard, and David Clark Company in June 1965; (2) a reassessment of the capabilities of In-

ternational Latex; and (3) previous difficulties of Hamilton Standard in adequate total system development but recognizing their competence in the portable life support systems work. MSC planned to establish a resident engineer at International Latex to provide on-contractor-site management of the contractor.

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Letter, Gilruth to NASA Headquarters, Attn: George E. Mueller, "Procurement plan for the Apollo Extravehicular Mobility Unit and EMU ground support equipment development and fabrication," sgd. George M. Low, September 20, 1965.

On the basis of studies by both MSC and Grumman on LEM landing criteria, Engineering and Development Directorate determined that contractor and customer alike favored reducing landing velocity requirements for the spacecraft. The two did not see eye to eye on how far these requirements should be reduced, however, and MSC would study the problem further.

20

Memorandum, James A. Chamberlin, MSC, to Distr., "Status of LEM landing studies," September 20, 1965.

A Grumman engineer tests the controls of a LEM simulator at the Grumman plant, Bethpage, N.Y. Sight reference of lunar landscape was visible on TV screens through the simulator windows.



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ASPO Manager Joseph F. Shea decided that no device to indicate a failure of the secondary gimbal motor in the service propulsion system (SPS) was necessary on Block I spacecraft. Two factors shaped Shea's decision: (1) procedures for inflight checkout of the vehicle called for gimbaling the service propulsion engine with both primary and secondary drive motors prior to SPS burns; (2) furthermore, all Block I (i.e., earth orbital) spacecraft would be capable of returning to earth by means of the SM's reaction control system. This decision did not alter the requirement for such devices on Block II spacecraft, however, and North American was incorporating warning lights on those vehicles to indicate such gimbal motor failures.

Memorandum, Shea, MSC, to Assistant Director for Flight Operations, "Service Propulsion System (SPS) Secondary Gimbal Motor Fail Indication," September 21, 1965.

27

NASA's Administrator James E. Webb, Deputy Administrator Hugh L. Dryden, and Associate Administrator Robert C. Seamans, Jr., selected Ling-Temco-Vought from a total of 17 proposers for contract negotiations

MSFC marked completion of its first Saturn V S-IC booster September 26, 1965, with a brief ceremony in front of the assembly shop. A wide-angle camera caught this view as the ceremony was about to start with MSFC Director Wernher von Braun at the microphone (left).



for a one-year cost-plus-award-fee contract with options to extend for two one-year periods, to provide operational laboratory support services for the Apollo spacecraft program at the White Sands (N. Mex.) Test Facility. The selection was based upon the presentation of a source evaluation board and comments of key officials concerned. The Associate Administrator for Manned Space Flight was asked to issue appropriate instructions to ensure that the contract negotiating team follow the negotiation objectives as presented to them.

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Memorandum, Deputy Associate Administrator, NASA, to Associate Administrator for Manned Space Flight, "Selection of Contractor to Provide Operational Laboratory Support Services for the Apollo Spacecraft Program at the White Sands Test Facility," sgd. Earl D. Hilburn, September 27, 1965.

North American proposed an additional pane of glass for the windows on Block II CMs. Currently, both blocks of spacecraft had one pane. Should meteoroids pit this pane, the window could fail during reentry at lunar velocities. The meteoroid protection group in Structures and Mechanics Division were evaluating North American's proposal, which would add about 10.43 kg (23 lbs) to the vehicle's weight. No such added protection was required on Block I spacecraft.

22-29

MSC, "ASPO Weekly Management Report, September 23-30, 1965"; "Apollo Monthly Progress Report," SID 62-300-41, p. 5.

The Critical Design Review (CDR) of the LEM, tentatively planned during the week of September 27, 1965, at Grumman, was rescheduled as a series of reviews beginning in November 1965 and ending in January 1966. The schedule was to apply with five teams participating as follows: Structures and Propulsion, November 8-11, Team Captain: H. Byington; Communications, Instrumentation, and Electrical Power, December 6-9, Team Captain: W. Speier; Stabilization and Control, Navigation and Guidance, and Radar, January 10-13, Team Captain: A. Cohen; Crew Systems, January 10-13, Team Captain: J. Loftus; and Mission Compatibility and Operations, January 24-27, Team Captain: R. Battey.

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Memorandum, Owen E. Maynard, MSC, to Distr., "Critical Design Review of LEM," September 24, 1965.

MSC directed Grumman to draw up a complete list of all nonmetallic materials used in the habitable area of the LEM, including type, use, location, weight, and source of all such materials.

27

Letter, James L. Neal, MSC, to GAEC, Attn: John C. Snedeker, "Contract NAS 9-1100, Contract Change Authorization No. 136, Exhibit E, Nonmetallic Materials in Habitable Area," September 27, 1965.

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Officials from the U.S. Public Health Service (PHS) and the Department of Agriculture met at MSC to discuss informally the problem of back contamination. They listened to briefings on the mission profile for Apollo; reentry heating rates; present thinking at the Center on the design of the Lunar Sample Receiving Station (LSRS); and MSC's plans (none) for quarantining the astronauts.

James Goddard, Assistant Surgeon General in PHS, presented three broad areas of concern: (1) quarantine procedures and accommodations inside the LSRS for both astronauts and technicians; (2) quarantine facilities aboard the recovery ships; and (3) the need to gather samples before the moon's surface was contaminated by the astronauts or the LEM's atmosphere. These matters were discussed in some detail. MSC's failure to plan for the astronauts' return, and Goddard's ideas on what procedures were needed, provoked "very extended and somewhat heated" discussions. It was generally agreed that Apollo astronauts could not entirely avoid lunar contaminants: the level of contamination inside the spacecraft's cabin, although low, nonetheless would be "significant." MSC then asked, hypothetically, what PHS's reaction would be if Apollo astronauts were recovered and returned in much the same manner that Gemini crews were. The representative from PHS's Foreign Quarantine Division replied "emphatically" that, in such a case, those crews would not be allowed back in the country.

On October 15, Lawrence B. Hall, Planetary Quarantine Officer in NASA's Office of Space Science and Applications, summarized for Deputy Administrator Hugh L. Dryden the September 27 meeting, and recommended that such informal discussions continue. "I believe," he told Dryden, "that . . . the Manned Spacecraft Center is more fully aware of the point of view of the regulatory agencies on this matter. Unfortunately, the regulatory agencies still do not understand the reasons for the Manned Spacecraft Center's reluctance to face this problem." [To appreciate MSC's "reluctance," see October 29, 1965.]

Memorandum, Hall, NASA, to Deputy Administrator, "Informal conference on back contamination problems," October 15, 1965, with enclosure: "Summary, Informal Conference on Back Contamination Problems," undated.

27

North American evaluated the CSM's communications capability with the unified S-band system using attitude data published with the AS-501 (spacecraft 017) preliminary reference trajectory. The trajectory selected to achieve the desired entry conditions had a maximum altitude at apogee of about 16 668 km (9000 nm). At this altitude, the maximum range to a Manned Spacecraft Flight Network (MSFN) station was about 20 372 km (11 000 nmi). Since a high-gain antenna was not installed on spacecraft 017, communications depended on the S-band omnidirectional antennas. In order to verify their adequacy, directions to the MSFN stations were com-

puted and system circuit margins were derived. North American concluded that the margins were inadequate to support high-bit-rate telemetry for about three hours of the mission. Modification of the planned CSM attitude produced significant improvement (about 17 decibels) in communications. The contractor also proposed a relocation of range ships to improve performance.

"Apollo Monthly Progress Report," SID 62-300-42, p. 3; TWX, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, subject: "Mission 501/Spacecraft 017 Compatibility Evaluation," September 27, 1965.

Representatives from MSC, David Clark, Hamilton Standard, and Westinghouse met at North American, where they negotiated and signed most of the interface control documents (ICD) for the space suit and associated equipment. Of the ICD's yet unresolved, only two involved problems that could have a significant effect on hardware design:

(1) The current design of the CM environmental control system, because it could not accept waste water from the portable life support system (PLSS), was therefore incapable of recharging the PLSS. ASPO must decide if the recharge requirement was to be kept or eliminated.

(2) The CM's waste management system was not compatible with the capacity of the urine bag in the space suit. This problem was assigned to Crew Systems Division.

MSC, "ASPO Weekly Management Report, September 30-October 7, 1965"; letter, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, "Contract NAS 9-150, Portable life support system (PLSS) water recharge (functional) ICD No. MH01-06153-416," October 12, 1965.

Ralph S. Sawyer, Chief of the Instrumentation and Electronic Systems Division, advised ASPO Manager Shea of current problems with antennas for the Apollo spacecraft:

- CSM high gain antenna—the infrared (IR) earth tracker originally proposed would not satisfy mission requirements. On September 23, Sawyer reported, North American had ordered Dalmo-Victor to halt development of IR systems and to proceed with work on an RF tracker.

- CSM S-band omnidirectional antennas—release of specifications was delaying subcontract award. North American might be unable to meet delivery for CSMs 017 and 020.

- North American's in-house development program—because of a lack of qualified personnel in California, North American proposed to develop VHF scimitar, S-band flush mounted, and C-band antennas at its Columbus, Ohio, facility.

- LEM S-band high-gain antenna—Dalmo-Victor predicted that pre-production models would weigh 11 kg (25.33 lbs), 3 kg (6.83 lbs) more than

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September the specification weight. Grumman already had ordered Dalmo-Victor to study ways of lightening the antenna.
- Memorandum, Sawyer, MSC, to Manager, ASPO, "Apollo antenna problem areas," September 29, 1965.
- 29** Apollo Program Director Samuel C. Phillips issued the flight directive for the AS-202 mission, which spelled out the general flight plan, objectives, and configuration of both spacecraft and launch vehicle.
- OMSF Directive M-D MA 1400.011, "Apollo Program Flight Mission Directive for Apollo-Saturn 202 Mission," September 29, 1965.
- 29** The Critical Design Review (CDR) of the Block II CSM was scheduled to be conducted in November and December 1965, with the first phase being held November 15-18, and the second phase December 13-17.
- The first phase activity would be a review of drawings, schematics, procurement specifications, weight status, interface control drawings, failure analysis, proposed specification change notices, and specification waivers and deviations. The second phase of the review would be a physical inspection of the mockup of the Block II CSM.
- The review would be conducted by review teams organized in the several areas and headed by team captains, as follows: Structures and Propulsion, O. Ohlsson; Communications, Instrumentation, and Electrical Power, W. Speier; Stabilization and Control, Guidance and Navigation, A. Cohen; Crew Systems, J. Loftus; and Mission Compatibility and Operations, R. Battey.
- Memorandum, Chief, Systems Engineering Division, MSC, to Distr., "Critical Design Review of Block II CSM," sgd. Harry W. Byington, September 29, 1965.
- 29-30** The Mission Operations Organization had been under continued review and discussion and on September 29 and 30 in New Orleans, La., a meeting was held between George E. Mueller, James C. Elms, Robert R. Gilruth, and George M. Low. General agreement was reached on a method of operation: The Mission Operations Director would represent the Associate Administrator for Manned Space Flight in all operational areas and would be responsible to the Associate Administrator for Manned Space Flight for the execution of all NASA manned spaceflight missions.
- The people responsive to the Missions Operations Director (in the same sense as Center Program Managers are responsible to Headquarters Program Directors) are:
- The Director of Launch Operations of the Kennedy Space Center, who is responsible for the preparation, checkout, countdown and launch

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of the space vehicle. In two of these areas, preparation and checkout, he is responsive to the Program Managers and Program Directors; whereas in the other two areas, countdown and launch, he is responsive to the Mission Operations Director.

- The Assistant Director for Flight Operations at the Manned Spacecraft Center, who represents the Director of MSC in all operational areas. These areas include flight operations and the flight operational aspects of flight crew and medical operations.
- The DOD Representative for Manned Space Flight, who is responsible for the National Ranges and the recovery forces.
- The Program Directors, who are responsive to the Mission Operations Director insofar as the readiness of flight hardware is concerned.

It was pointed out that there were multiple and sometimes divergent inputs from the Program Offices and the Mission Operations organization in OMSF to various elements at the Manned Spacecraft Center.

It was agreed that a better definition of responsibility between Program Office and Mission Operations Directorate in OMSF was required. It was also agreed that for all flight operational areas MSC would prefer to have the Assistant Director for Flight Operations act as its single point of contact. The Assistant Director for Flight Operations would represent Flight Crew Operations and Medical Operations in the mission operations area.

Memorandum, George M. Low, "Mission Operations Discussions," October 4, 1965;
Informal Memorandum, George M. Low to Distr., October 15, 1965, with enclosure.

Pressure loading and thermal tests were completed on the types of windows in the Block I CM. The pressure tests demonstrated their ability to withstand the ultimate stresses (both inward and outward) that the CM might encounter during an atmospheric abort. The thermal simulations qualified the windows for maximum temperatures anticipated during reentry at lunar velocities.

30-October 7

"ASPO Weekly Management Report, September 30-October 7, 1965."

Flight Projects Division advised that, on the basis of current weight studies, the aft heatshield on Block I CMs must be thinned. North American had said that this change would not affect schedules, but felt some concern about the heat sensors. Accordingly, Structures and Mechanics Division (SMD) ordered North American to proceed with this weight reduction on the hardware for spacecraft 011, 012, and 014 (but ensuring that the orbital decay required for Block I manned missions would still be met). The sensors on 011's heatshield would be adapted to the new thickness. SMD

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anticipated that these changes would cost about \$500 000 and would probably delay by about four weeks delivery of the 011 heatshield from Avco.

"ASPO Weekly Management Report, September 23-30, 1965"; "ASPO Weekly Management Report, September 30-October 7, 1965"; memorandum, R. W. Lanzkron and O. E. Maynard, MSC, to Manager, ASPO, "Weight Reduction for Block I Aft Heat Shield," October 8, 1965; memorandum, Joseph N. Kotanchik, MSC, to Manager, ASPO, "Flight Configuration of SC 011," October 18, 1965.

30

Crew Systems Division defined the survival equipment that MSC would procure for Apollo spacecraft. Fifteen survival sets would be needed for Block I and 30 for Block II CMs.

Memorandum, R. E. Smylie, MSC, to Chief, Crew Systems Division, "Apollo Block I and Block II survival equipment procurement," September 30, 1965.

**During
the
Month**

Bell Aerosystems reported on stability and ablative compatibility testing of the first bipropellant-cooled injector baffle for the ascent engine of the LEM. Combustion was stable; however, streaking on the injector face forced Bell to halt ablative testing after only 60 seconds of operation.

"Monthly Progress Report No. 32," LPR-10-48, pp. 1, 11.

**During
the
Month**

Thirteen flights were made with the lunar landing research vehicle. Two of those flights were devoted to nulling the lunar simulation system; the remaining 11 flights were devoted to research with the attitude control system in the rate command mode. Nine landings were made in the lunar simulation mode.

On flight 1-34-94F the lunar simulation mode worked perfectly and no drift was encountered during more than one minute of hovering flight. The landing was made in the simulation mode for the first time on this flight.

Letter, Office of Director, Flight Research Center, to NASA Headquarters, "Lunar Landing Research Vehicle progress report No. 27 for the period ending September 30, 1965," sgd. Paul F. Bikle, October 14, 1965.

September-October

Grumman advised MSC of major troubles plaguing development of the LEM's descent engine. These included problems of weight, chamber erosion, mixtures, valves, combustion instability, and throttle mechanisms (which Grumman said could delay delivery of LEM 1 and the start of qualification testing).

"Monthly Progress Report No. 32," LPR-10-48, pp. 3, 11; GAEC, "Monthly Progress Report No. 33," LPR-10-49, November 10, 1965, p. 3.

At a Customer Acceptance Readiness Review at North American, NASA formally accepted spacecraft 002. The vehicle was then demated and shipped to White Sands.

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1

"Apollo Monthly Progress Report," SID 62-300-42, p. 1.

Homer E. Newell, Associate Administrator for Space Science and Applications, notified Houston of the first two experiments selected for early Apollo landing flights: (1) a lunar gravimeter, which would measure variations in the moon's gravitational field; and (2) a seismic experiment. MSC informed Newell on November 2 that negotiations were being initiated.

1

Letter, Newell, NASA, to Director, MSC, "Selection of Scientific Investigations for Early Apollo Lunar Landing Missions," October 1, 1965; letter, Director, MSC, to Newell, NASA Headquarters, November 2, 1965.

MSC informed Grumman that the Center had awarded a contract to AC Electronics for the development of an optical tracking system for the LEM (as a possible alternative to the rendezvous radar). Until MSC reached a final decision on which mode to use, Grumman should continue building the LEM to accept either of these navigational devices. Flight Crew Operations Directorate requested the decision be deferred pending evaluation of an operational paper.

1

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Item 3; Selection of Rendezvous Radar or Optical Tracker for LEM Navigation Requirement," October 1, 1965; memorandum, Donald K. Slayton, MSC, to Manager, ASPO, "LEM Optical Tracker," October 1, 1965.

In the absence of a firm requirement, and because of limited utility, reported Robert C. Duncan, Chief of the Guidance and Control Division, the horizon photometer and star tracker were being deleted from the primary guidance system in Block I CSMs. (Block II guidance systems would still contain the devices.)

1

Memorandum, Robert C. Duncan, MSC, to Distr., "Apollo primary guidance system star tracker and horizon photometer," October 1, 1965.

The U.S. Geological Survey cooperated with Crew Systems Division (CSD) in testing the extravehicular mobility unit under simulated lunar conditions at Flagstaff, Arizona. As a result, CSD technicians determined a number of deficiencies in the thermal meteoroid garment, and recommended a number of changes to make the garment more functional and more durable, as well as better fitting and more comfortable.

3-9

Memorandum, James H. O'Kane, MSC, to Chief, Crew Systems Division, "Report of trip for USGS Apollo support in Arizona," November 1, 1965.

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4

MSC ordered Grumman to halt work on both linear-shaped charges and gas-driven guillotines as a method for severing the LEM's interstage umbilical. Instead, the contractor should use two mild-detonation guillotines or one dual-blade device.

Letter, James L. Neal, MSC, to GAEC, Attn: John C. Snedeker, "Contract NAS 9-1100, Contract Change Authorization No. 142, Mild Detonating Fuse Driven Guillotine," October 4, 1965.

5

As a result of a design meeting on September 2, MSC ordered North American to make a number of detailed hardware changes in the CM up-righting system for Block I spacecraft.

TWX, C. L. Taylor, MSC, to NAA, Space and Information Systems Division, Attn: J. C. Cozad, subject: "Flotation/Uprighting System Meeting Conducted at NAA September 2, 1965," October 5, 1965.

5

ASPO Manager Joseph F. Shea recommended to Apollo Program Manager Samuel C. Phillips that experiment M-5A (Bioassays Body Fluids) not be incorporated on mission AS-204, based on schedule impact resulting from structural modifications necessary to support the Urine Volume Measuring System. Redesign and rework of existing spacecraft hardware would have a schedule impact of two to four weeks.

Letter, Shea to Phillips, "Apollo In-Flight Experiments, Flight AS-204," October 5, 1965.

6

MSC requested that Grumman study the feasibility of a "fire-till-touchdown" landing procedure for the LEM. Grumman was to investigate especially performance factors surrounding crushing of the descent engine skirt, or possibly jettisoning the skirt, and was to recommend hardware modifications required for this landing mode.

TWX, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, October 6, 1965.

7-14

MSC's Reliability and Quality Assurance Division reported in August that, because beryllium would corrode in the humid environment of the spacecraft's cabin, the metal thus posed a toxicological hazard to the crew of the CM. During subsequent meetings with the Health and Physics Group, and Guidance and Control and Structures and Mechanics Divisions, it was agreed that, because of crew safety, beryllium surfaces in the guidance and control system must be coated to protect the metal from the humid atmosphere inside the cabin of the spacecraft.

"ASPO Weekly Management Report, August 12-19, 1965"; MSC, "Minutes of Senior Staff Meeting, October 1, 1965," p. 1; MSC, "ASPO Weekly Management Report, October 7-14, 1965"; memorandum, Joseph N. Kotanchik, MSC, to Chief, Guidance and Control Division, "Protective coating to prevent beryllium corrosion inside the Apollo Command Module," November 4, 1965.

The Instrumentation and Electronic Systems Division (IESD) proposed that the LEM's inflight VHF antenna might be used as a link to astronauts on the surface of the moon as well. (LEM communications had to provide VHF contact with the crew outside the spacecraft at ranges up to three nautical miles. The VHF antenna, however, had been designed only for the flight portions of the mission, and to meet this communications requirement another antenna was being added to the LEM—at a cost of between 1.36 and 2.26 kg [3 and 5 lbs].) IESD offered to study the coverage and range of the inflight antenna while on the lunar surface, and suggested that the three-mile range requirement might be relaxed. The additional VHF antenna might thereby be obviated.

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Also, IESD attended a preliminary design review at Autonetics on the signal conditioning equipment (SCE) for the Block II CSM. IESD concurred in several modifications to the Block I design (adding a redundant power supply; hermetic sealing of equipment; and repackaging to fit the equipment bay in Block II CSMs). These changes reduced the SCE's weight from 22 to 19 kg (47.5 to 41 lbs) and, because of more efficient power supply, lowered its power consumption from 65 to 35 watts. North American was studying ways of perhaps lightening the SCE even further.

“ASPO Weekly Management Report, October 7-14, 1965.”

Crew Systems Division (CSD) established vibration limits for the crew of the LEM. This action followed the final LEM vibration test with human subjects at Wright-Patterson AFB and a review of the test program by CSD and Grumman engineers.

7-14

Also, in what CSD described as “the start of a long range program for familiarizing Apollo suit technicians with field and launch operations,” the Division reported that it had sent an Apollo suit technician to Cape Kennedy to take part in the forthcoming Gemini VI mission.

Ibid.

A drop in the boilerplate 6A series, using flight-qualifiable earth landing system (ELS) components, failed because the braking parachute (not a part of the ELS) did not adequately stabilize the vehicle. MSC invited North American and Northrop-Ventura to Houston to explain the failure and to recommend corrective measures.

8

Ibid.

Because of the less-than-perfect firing of its retrorockets, *Luna VII*, another Russian moon probe, was destroyed on impact. The craft, launched four

8

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October days earlier, was thus the third failure, Western observers believed, in Russia's attempt to soft-land a spacecraft on the moon.

Space Business Daily, October 11, 1965, pp. 190, 194; *Astronautics and Aeronautics*, 1965, pp. 460, 463, 464–465, 467.

8 A test model of the Lunar Landing Research Vehicle, designed to simulate lunar landings, was flown by former NASA X-15 pilot Joseph Walker to an altitude of 91 m (300 ft). Built by Bell Aerosystems Company under contract to NASA, the research craft had a jet engine that supported five-sixths of its weight. The pilot manipulated solid-fuel lift rockets that supported the remaining one-sixth, and the craft's attitude was controlled with jets of hydrogen peroxide.

Astronautics and Aeronautics, 1965, p. 465.

12 On August 26, the attachments for the pilot parachute mortar had failed during static testing on CM 006. The fittings had been redesigned and the test was not repeated. This test, the final one in the limit load series for the earth landing system, certified the structural interface between the CM and the earth landing system for the 009 flight.

Memorandum, Joseph N. Kotanchik, MSC, to Manager, ASPO, "Launch configuration of SC 009," October 19, 1965; MSC, "ASPO Weekly Management Report, October 21–28, 1965."

12 To ensure compatibility with the spacecraft, MSC specified weight and storage details for the extravehicular visors. The devices, two of which would be carried on each mission and transferred from the CM to the LEM, would afford impact, thermal, and ultraviolet protection for the crew during operations in space or on the lunar surface.

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, EMU EV Visor Assembly," October 12, 1965.

14 NASA was negotiating with General Electric Company to provide 56-watt isotopic power generators for the Apollo Lunar Surface Experiment Packages. The Atomic Energy Commission would manage detailed design and development of the unit based on MSC studies of prototypes.

Astronautics and Aeronautics, 1965, p. 476.

15 Owen E. Maynard, Systems Engineering Division chief, summarized for ASPO Manager Joseph F. Shea the recovery requirements for Apollo spacecraft. The CM must float in a stable, apex-up attitude, and all of the vehicle's recovery aids (uprighting system, communications, etc.) must be operable

for 48 hrs after landing. In any water landing within 40 degrees north or south latitude, the Landing and Recovery Division had determined, the crew either would be rescued or recovery personnel would be in the water with the CM within this 48-hr period. Thereafter, Maynard said, the spacecraft had but to remain afloat until a recovery ship arrived—at most, five days.

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Memorandum, Maynard, MSC, to Manager, ASPO, "Post-landing flotation requirements," October 15, 1965.

NASA announced that it had selected Lockheed Electronics Company of Houston, Texas, to provide broad data-handling support at MSC. Negotiations on the contract (valued at more than \$3 million) began shortly thereafter.

15

MSC News Release 65-93, "NASA to Negotiate with Lockheed Electronics Co. for Computer Programming Support," October 15, 1965; letter, George E. Mueller, NASA, to Robert R. Gilruth, MSC, October 29, 1965.

MSC ordered Grumman to discontinue use of zinc and cadmium on all production LEMs. This action followed performance studies by the Reliability and Quality Assurance Division that showed a deleterious effect of space environments upon these metals.

18

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, The use of Cadmium or Zinc Plate in the Apollo Spacecraft," October 18, 1965.

To solve the problem of controlling bacteria in the LEM's waste management system (WMS), Crew Systems Division (CSD) recommended some type of passive control rather than periodically adding a germicide to the system. CSD described two such passive techniques, both of which relied on chemicals upstream from the WMS (i.e., in the urine collection device in the space suit). MSC began studying the feasibility of this approach, and ordered Grumman also to evaluate passive control in the contractor's own investigation of the bacteriological problem.

18

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Bacteriological Control for LEM Waste Management Subsystem," October 18, 1965, with enclosure.

A meeting was held at Flight Research Center to discuss several items relating to the Lunar Landing Research Vehicle (LLRV) and Lunar Landing Training Vehicle (LLTV). Attending were Dean Grimm, Robert Hutchins, Warren North, and Joseph Algranti of MSC; Robert Brown, John Ryken, and Ron Decrevel of Bell Aerosystems Company; and Gene Matranga, Wayne Ottinger, and Arlene Johnson of Flight Research Center.

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The discussions centered around MSC's needs for two LLRVs and two LLTVs and the critical nature of the proposed schedules; alternatives of assembling a second LLRV; clarifying the elements of the work statement; and preliminary talks about writing specifications for the LLTV.

From a schedule standpoint, it was decided that both LLRVs would be delivered to MSC on September 1, 1966. MSC planned to check out and fly the second LLRV (which needed additional systems checkout) with their

The new polycarbonate "bubble" helmet.



crew and pilot on a noninterference basis with LLRV No. 1, the primary training vehicle.

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NASA Internal Memorandum for those concerned, Gene J. Matranga, LLRV Project Manager, "Meetings held during the week of October 17 relating to the LLRV," October 26, 1965.

The MSC Mission Constraints Control Panel (MCCP) held its initial meeting. The panel's function was to resolve all conflicts between launch vehicle, spacecraft, and operational constraints. Also, once the preliminary reference trajectory was issued, the MCCP must approve all constraint changes. These would then be included in the mission requirements.

20

Memorandum, Robert V. Battey, MSC, to Distr., "Minutes of 1st Mission Constraints Control Panel Meeting," October 26, 1965, with enclosure.

To save weight, Crew Systems Division was studying the feasibility of using three one-man liferafts and a composite set of survival gear in Block I CMs.

20

Memorandum, R. E. Smylie, MSC, to Chief, Crew Integration Branch, Attn: J. Marshall, "Block I composite kit study," October 20, 1965.

Apollo spacecraft 009, first of the type that would carry three astronauts to the moon and back, was accepted by NASA during informal ceremonies at North American. Spacecraft 009 included a CM, SM, launch escape system, and adapter.

20

Astronautics and Aeronautics, 1965, p. 485.

To support studies on equipment stowage, North American agreed to maintain mockups of the crew compartments in the two blocks of CMs. The contractor's effort would be geared for the first manned flight for each series of vehicles (spacecraft 012 and 101).

20-21

"ASPO Weekly Management Report, October 21-28, 1965."

Samuel C. Phillips, Apollo Program Director, notified the Center directors and Apollo program managers in Houston, Huntsville, and Cape Kennedy that OMSF's launch schedule for Apollo-Saturn IB flights had been revised, based on delivery of CSMs 009 and 011:

21

- AS-201—January 1966
- AS-202—June 1966

Schedules for AS-203 through 205 (July and October 1966, and January 1967) were unchanged.

TWX, Phillips, NASA, to Kurt Debus, KSC, Robert Gilruth, MSC, and Wernher von Braun, MSFC, subject: "Saturn IB Launch Schedules," October 21, 1965.

- 1965**
October
21 MSC announced that the bubble-type helmet, designed by Crew Systems Division (CSD) engineers Robert L. Jones and James O’Kane, had been adopted for use in the Apollo extravehicular mobility unit. The new helmet was smaller and lighter than earlier types; extensive studies by CSD had demonstrated its superior comfort, visibility, and don/doff characteristics.

MSC News Release 65-96, October 21, 1965.

- 21** To enable MSC’s Mission Control Center (MCC) to handle Apollo flights, MSC announced that NASA’s contract with IBM for computer systems would be extended. For an additional \$80 million, IBM would convert the MCC to newer equipment and would use more advanced support techniques. The contract would contain provisions for conversion to an incentive fee type.

MSC News Release 65-97, October 21, 1965.

- 21** North American completed static structural tests on the forward heatshield for the Block I CM (part of the certification test network for airframes 009, 011, and 012), thus demonstrating the heatshield’s structural integrity when jettisoned (at the start of the earth landing system sequence).

“ASPO Weekly Management Report, October 21-28, 1965.”

- 22** NASA announced that it had selected 10 areas on the moon as subjects for Lunar Orbiter’s cameras during 1966. These areas encompassed most major types of lunar terrain. Most were suitable—and potential—landing sites for Surveyor and Apollo spacecraft.

NASA News Release 65-335, “NASA Selects 10 Potential Photo Areas for Lunar Orbiter,” October 22, 1965.

- 23-26** While delivering Apollo SM 009, the Pregnant Guppy aircraft was delayed at Ellington Air Force Base, Texas, for three-and-a-half days while waiting for an engine change. In view of the delay of the SM, the incident was reviewed during the succeeding weeks, and Aero Spacelines was requested to place spare engines not only at Houston, but also at other strategic locations on the normal air route from Long Beach, Calif., to KSC.

Letter, Edmund F. O’Connor, MSFC, to MSC, Attn: Joseph F. Shea, “Pregnant Guppy emergency engine change, October 23-26, 1965,” November 18, 1965.

- 26** MSC authorized North American to modify the Block II CSM design to provide for installation of a luminous beacon compatible with the LEM



The *Pregnant Guppy* aircraft, which was used extensively by NASA to transport spacecraft during all phases of the Apollo program.

tracking system. The CSM beacon could replace the rendezvous radar and transponder.

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Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, "Contract Change Authorization No. 455," October 26, 1965; memo, Owen E. Maynard, MSC, to Project Officer, CSM, "Deletion of automatic actuation capability of VHF recovery beacon (Block II)," October 8, 1965.

At a meeting with Grumman, MSC agreed with the contractor's basic design of the LEM's descent-stage base heatshield and its installation and access. MSC asked Grumman to demonstrate accessibility, installation, and removal of the heatshield on the M-4 mockup.

27

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Implementation of Action Items," November 3, 1965, with enclosure, "Abstract of LEM Base Heat Shield Review," undated.

Owen E. Maynard, Systems Engineering Division chief, advised his branch managers of the U.S. Public Health Service's (PHS) growing concern that Apollo spacecraft and crews might bring organisms back from the moon. (See September 27.) PHS feared that such organisms would be "capable of

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multiplying in the earth environment and [that] precautionary measures must be undertaken to prevent global exposure.” Therefore, Maynard told his group, PHS believed that the CM, its environment, and its crew must not be allowed to contact the earth’s environment. Maynard further advised that efforts were already underway to define the design of an isolation facility, and isolation facilities for the recovery ships were being contemplated.

As a result of this strong stand by PHS, Maynard said, “It appears that ASPO will soon be requested to show what spacecraft measures are being taken to assure that the CM environment will not be exposed to the earth atmosphere. The spacecraft,” Maynard told his group—who already knew as much—“has not been designed to preclude CM environment exposure.” Actually, much the opposite had long been assumed to be part of normal operating procedures. Maynard therefore ordered subsystem managers to review their individual systems to determine:

- If their system was potentially a carrier of moon germs
- What could be done to confine such organisms
- If a “strict no contamination edict” would affect the life and operation of systems
 - How postlanding procedures could be changed to prevent release of organisms from the spacecraft

Maynard cautioned systems managers to “assume that ASPO is morally obligated to prevent any possible contamination of the earth,” and not to reply with “the standard answer that no changes can be made within present weight, cost, and schedule limitations. Admittedly,” he said, “our first look may prove to be insurmountable.” Nonetheless, review must be performed so that recommendations can be made concerning all such systems.

Memorandum, Maynard, MSC, to PHS Branches, “Earth contamination from lunar surface organisms,” October 29, 1965.

**During
the
Month**

Seven flights were made with the Lunar Landing Research Vehicle at Flight Research Center during October. The first three were in support of X-15 conference activities, and the last four were for attitude control research. Five of the landings were made in the lunar simulation mode.

Letter, Office of Director, Flight Research Center, to NASA Headquarters, “Lunar Landing Research Vehicle progress report No. 28 for the period ending October 31, 1965,” sgd. Paul F. Bikle, November 2, 1965.

**November
1**

MSC’s Engineering and Development Directorate established the Lunar Sample Receiving Laboratory Office as an interim organizational element

pending development of a permanent organization for operation of the laboratory.

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MSC Announcement 65-140, "Establishment of the E&D Lunar Sample Receiving Laboratory Office," November 1, 1965.

Bell Aerosystems Company reported that the LEM ascent engine bipropellant cooled injector baffle met all basic specification requirements, including those for combustion efficiency, ablative compatibility, and stability. Bell conducted a successful firing with an engine that had previously been vibrated to simulate launch boost and lunar descent. The contractor also completed a duty cycle firing at AEDC with hardware conditions set to the maximum temperatures believed attainable during a lunar mission.

2

GAEC, "Monthly Progress Report No. 34," LPR-10-50, December 10, 1965, pp. 1, 13; letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Bell Aerosystems Contamination Problems," December 9, 1965.

MSC management gave Grumman the go-ahead to implement the LEM Certification Test Plan effective October 25.

4

Memorandum, Owen E. Maynard, MSC, to Distr., "LEM Certification Test Program Implementation," November 4, 1965.

In a letter to the Director of Flight Research Center, MSC Director Robert R. Gilruth said that recent Lunar Landing Research Vehicle (LLRV) flight results and problems with the handling qualities of the LEM had focused high interest on the LLRV activities at FRC.

4

Gilruth concurred with the recent decision to assemble the second LLRV and said MSC planned to support the assembly and checkout of the second vehicle with engineering and contractor personnel assigned to the Flight Crew Operations Directorate.

Gilruth expressed appreciation for the effort expended by FRC in initiating a three-month study contract with Bell Aerosystems to provide drawings for a follow-on vehicle and indicated MSC planned to contract for Lunar Landing Training Vehicles in June 1966.

Letter, Gilruth to Director, FRC, "Lunar Landing Research and Training Vehicles," November 4, 1965.

MSC's Configuration Control Board approved the reduction of maximum translunar flight time from 110 hrs to 100 hrs.

4

Memorandum, Robert V. Battey, to Manager, ASPO, "Response to your question on reduction of translunar flight time," November 1, 1965; MSC, "Minutes, Configuration Control Board Meeting No. 24, November 4, 1965."

- 1965**
November
4-12
- The design of the Block I space suit helmet ear cup and attachment was finalized. Based on evaluation of AFRM 007 acoustic test data, it was determined that existing Gemini-type "soft" ear cups were adequate for Block I flights. North American and David Clark Company specifications would be changed to reflect revised requirements. The majority of drawings for the suit had been reviewed and approved by MSC's Crew Systems Division. Remaining to be resolved and approved were selection of helmet visor material, installation of helmet microphones and earphones, communications harness, and fingertip glove lighting systems.
- MSC, "ASPO Weekly Management Report, November 4-12, 1965"; NAA, "Apollo Monthly Progress Report," SID 62-300-44, January 1, 1966, p. 6.
- 5**
- NASA announced that it would negotiate with International Latex Corporation for an estimated \$10 million contract to fabricate the Apollo space suit consisting of the liquid-cooled undergarment, constant wear garment, pressure garment assembly, and thermo-micrometeoroid protective overgarment. At the same time an estimated \$20 million contract was negotiated with Hamilton Standard Division of United Aircraft Corporation for continued development and manufacture of the portable life support system with a four-hour main power supply subjected to a maximum stowage soak temperature of 328 K (130°F).
- MSC News Release 65-102, November 5, 1965; TWX, Richard S. Johnston, MSC, to R. E. Breeding, Hamilton Standard Division, subject: "PLSS Power Supply Concept," November 8, 1965; NASA News Release 65-346, "NASA to Negotiate for Apollo Suit, Support System," November 5, 1965; "ASPO Weekly Management Report, November 4-12, 1965."
- 8**
- The development mission planning panel met to discuss the general constraints for missions AS-206 and AS-207. AS-206 spacecraft and operational constraints and mission rules were checked for compatibility. An investigation of the AS-207 preliminary mission profile showed that the ascent power requirements far exceeded the capacity of the ascent stage batteries. A modification to the mission profile was developed which would enable the mission objectives to be accomplished within the LEM battery capabilities. A tentative procedure for negotiating MSFC launch vehicle constraints was established between MSC and MSFC.
- "ASPO Weekly Management Report, November 4-12, 1965"; memorandum, Robert V. Battey, MSC, "Minutes of the Mission Constraints Panel Meeting #4," November 23, 1965, with enclosure; memorandum, Owen E. Maynard, MSC, to Distr., "Official Method for Negotiating Mission Constraints with MSFC," November 16, 1965.
- 9-12**
- Upon examination of the airlock gas connectors at the Portable Life Support System/Emergency Oxygen System Preliminary Design Review, ASPO representatives discovered a possible catastrophic failure. If an astronaut

unhooked the PLSS supply umbilical before the exhaust line was disconnected the suit would vent through the PLSS. A request for change was rejected by the preliminary design review board in spite of this situation. ASPO recommended to the Crew Systems Division that the connectors be modified or that the problem be solved another way to preserve crew safety.

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Memorandum, Owen E. Maynard, Systems Engineering Division, ASPO, to Apollo Support Office, Crew Systems Division, "RFC 111-1, Preliminary Design Review, PLSS/EOS, 9-12 November 1965," December 7, 1965.

North American conducted an Apollo Program Review for key subcontractors to convey the current status of the program and to discuss the subcontractors' specific participation and support to the program.

10

NAA, "Apollo Monthly Progress Report," SID 62-300-43, December 1, 1965, p. 3.

A North American layout of the volume swept by the CM couch and crewmen during landing impact attenuation showed several areas where the couch and/or crewmen struck the CM structure or stowed equipment. One area of such interference was that the center crewman's helmet could overlap about four inches into the volume occupied by the portable life support system (PLSS) stowed beneath the side access hatch. The PLSS stowage was recently changed to this position at North American's recommendation because the original stowage position on the aft bulkhead interfered with the couch attenuation envelope. The contractor was directed by MSC to explain this situation.

10

"ASPO Weekly Management Report, November 4-12, 1965"; TWX, C. L. Taylor, MSC, to NAA Space and Information Systems Division, Attn: J. C. Cozad, subject: "Impact Attenuation System Interference," November 10, 1965.

The Block I service propulsion system engine successfully completed the first altitude qualification tests at AEDC.

11

MSC, "ASPO Weekly Management Report, November 12-18, 1965."

A manned lunar mission metabolic profile test was run in the Hamilton Standard Division altitude chamber using the development liquid-cooled portable life support system (PLSS). The system was started at a chamber altitude of over 60 906 m (200 000 ft), and the subject adjusted the liquid bypass valve to accommodate the programmed metabolic rates which were achieved by use of a treadmill. Oxygen was supplied from an external source through the PLSS bottle and oxygen regulation system. This procedure was used because bottle qualification was not complete, so pressure was limited to 2068 kilonewtons per sq m (300 psig). An external battery

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- was used for power because the new batteries that were required by the change to the all-battery LEM were not yet available. The thermal transport system including the porous plate sublimator was completely self-contained in the PLSS. All systems operated within specification requirements and the test was considered an unqualified success.
- “ASPO Weekly Management Report, November 4–12, 1965.”
- 12** The portable life support system Preliminary Design Review was completed. The design was essentially complete and no major discrepancies were noted during the review.
- Ibid.*
- 12–18** MSC and Grumman representatives reviewed Grumman’s timeline analysis for the intravehicular LEM crew activities subsequent to lunar landing. This timeline was being rewritten for a test program to be conducted to determine what crew mobility problems existed within the LEM so that they could be better evaluated at the Certification Design Review.
- “ASPO Weekly Management Report, November 12–18, 1965.”
- 12–18** MSC directed Ryan Aeronautical Corporation to present to RCA and Grumman areas in which weight could be saved on the LEM landing radar. Of specific interest was the power supply and the possibility of its over-design.
- Ibid.*
- 15** MSC instructed North American to:
- Submit a preliminary design of Block II CSM jettisonable covers to protect the radiator and CM heatshield thermal coatings from degradation by the boost environment.
 - Furnish preliminary design of nonablative reaction control system (RCS) plume heat protection to prevent SM coating degradation on Block II CSMs.
 - Determine the effect on the overall SM and LEM adapter thermal design of coating degradation to a level specified by MSC and to propose design changes or mission constraints for Block I and Block II CSMs.
 - Determine the effect on the SM RCS thermal design of coating degradation to the level specified by MSC and to propose design changes or mission constraints for Block I and II CSMs.

Letter, J. B. Alldredge, MSC, to NAA, Space and Information Systems Division, “Contract Change Authorization No. 478,” November 15, 1965.

The manned portion of the coast and maneuver simulation program was completed, evaluating man-in-the-loop capabilities and their effects upon maneuver accuracy, maneuver time, and propellant consumption. The maneuvers and pilot techniques satisfied the midcourse attitude and translation control requirements for the Block I Spacecraft 012 manned mission. The study was conducted in eight phases, including more than 950 runs. Preliminary analysis of the results indicated there was compatibility between the pilots and the maneuver control equipment.

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"Apollo Monthly Progress Report," SID 62-300-44, p. 6.

Christopher C. Kraft, Jr., MSC's Assistant Director for Flight Operations, outlined results of recent studies of the problems associated with lunar landing. The programs studied were Surveyor, Lunar Orbiter, deployment of probes on a simulated manned lunar landing mission, deployment of probes during lunar orbit on an unmanned mission, and deployment of landing aids during the manned lunar landing mission.

22

The studies supported the conclusion that it was still desirable to have an earth launch window of several days to give launch opportunity flexibility. For this purpose, it would be necessary to have a group of longitudinally spaced landing areas available. However, if there were a particular advantage, such as site certification, in being limited to one area and, consequently, one launch opportunity per month, this was considered to be acceptable. At least one launch opportunity per month would be required. Therefore, the certified area would have to be within the area available from performance consideration. This might mean a night launch, which was confirmed as feasible.

Although the manned lunar landing mission ought not to depend upon a successful Surveyor program, information for Apollo as well as general scientific information should be expected from the program. The concept was not supported that probes were a necessary prerequisite to a lunar landing nor was the idea of a separate probe mission approved. If the Surveyor program failed to provide evidence of the suitability of at least one area and if the consensus favored gathering additional information from probes, the feasibility of carrying probes on the actual lunar landing mission should be fully considered, together with the development of aids to real-time assessment.

Memorandum, Christopher C. Kraft, Jr., MSC, to Manager of Special Design Efforts, "Problems associated with lunar landing," November 22, 1965.

Little Joe II Program Manager Milton A. Silveira suggested to ASPO Manager Joseph F. Shea that if the next Little Joe II flight test was successful

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there would be no further requirement for the Little Joe II to support the Apollo program. Silveira said planning had been made with General Dynamics/Convair to store the remaining three vehicles, parts, and tooling for one year in case a new requirement from ASPO or NASA should develop. The additional cost of one-year storage compared to normal program close-out was estimated to be small. ASPO concurred with the suggestion on December 1.

Memorandums, Silveira to Shea, "Little Joe II program close-out," November 22, 1965; J. Thomas Markley to Silveira, December 1, 1965.

- 23** North American informed MSC of a fire in the reaction control system (RCS) test cell during a CM RCS test for spacecraft 009. The fire was suspected to have been caused by overheating the test cell when the 10 engines were activated, approximately 30 sec prior to test completion. An estimated test delay of two to three weeks, due to shutdown of the test cell for refurbishment, was forecast. MSC informed the Apollo Program Director that an investigation was underway.

TWX, Joseph F. Shea, MSC, to NASA Headquarters, Attn: Apollo Program Director, sgd. William A. Lee, November 23, 1965.

- 24** MSC notified Grumman that all electrically actuated explosive devices on the LEM would be fired by the Apollo standard initiator. This would be a common usage item with the CSM and would be the single wire configuration developed by NASA and provided as Government-furnished equipment.

Letter, James L. Neal, MSC, to GAEC, Attn: John C. Snedeker, "Contract NAS 9-1100, Contract Change Authorization 159, Phase-in of Single Bridge Apollo Standard Initiator," November 24, 1965.

- 26** Grumman was directed by MSC to provide for the disposition and bacteriological control of the LEM urine containers by off-loading all containers to the lunar surface immediately prior to LEM ascent, locating them so their physical integrity would be assured during ascent stage launch. Incorporation of an appropriate germicide in all LEM urine containers would effectively sterilize the internal part of the container and the contained urine.

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Disposition and Bacteriological Control of LEM Urine Containers," November 26, 1965.

- 28** Ordnance separation tests on the first three spacecraft-LEM-adapters (SLA) in a series of four were completed at North American's Tulsa facility. The tests successfully demonstrated the deployment of the SLA's forward panels in preparation for the first spacecraft orbital flight.

"Apollo Monthly Progress Report," SID 62-300-44, p. 8; memorandum, Lyle D. White, MSC, to Chief, Systems Engineering Division, "SLA panel separation follow-up report,"

November 8, 1965; MSC, "ASPO Weekly Management Report, November 18-24, 1965";
 MSC, "ASPO Weekly Management Report, November 25-December 2, 1965."

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November

Usage of a multiple gas connector (MGC) with the extravehicular mobility unit (two per suit) was deleted. Instead of the MGC, a separate inlet and outlet suit/umbilical gas connector manufactured by Airlock, Inc., would be used (two inlets and two outlets per suit). This design change applied to all Block II space suits, environmental control systems, and portable life support systems. Hamilton Standard was directed to implement the change by means of a negotiated revision of a supplemental agreement to its contract.

30

Letter, R. Wayne Young, MSC, to GAEC, Attn: R. S. Mullaney, "Contract NAS 9-1100, Deletion of multiple gas connector (substitute separate Airlock, Inc., connectors)," November 30, 1965.

Apollo Mission Simulator No. 1 was shipped from Link Group, General Precision, Binghamton, New York, to MSC.

30

Memorandum, Owen E. Maynard, MSC, to Manager, ASPO, "Apollo Mission Simulator Status," November 30, 1965; "ASPO Weekly Management Report, November 18-24, 1965."

Grumman completed negotiations with Thompson-Ramo-Wooldridge for the LEM abort guidance system.

**During
the
Month**

"Monthly Progress Report No. 34," LPR-10-50, p. 19.

Ten flights were made with the lunar landing research vehicle. All flights were for attitude control and handling qualities research. Landings on all flights were made in the lunar landing mode.

**During
the
Month**

Letter, Office of Director, Flight Research Center, to NASA Headquarters, "Lunar Landing Research Vehicle progress report No. 29 for the period ending November 30, 1965," sgd. Paul F. Bickle, December 14, 1965.

A series of tests were run to determine the cause of stress corrosion of the reaction control system titanium tanks. Results showed that tanks exposed to chemically pure nitrogen tetroxide (N₂O₄) oxidizer suffered stress corrosion cracking, but tanks exposed to N₂O₄ containing small amounts of nitric oxide did not fail. The qualification testing program would soon resume.

**During
the
Month**

"Apollo Monthly Progress Report," SID 62-300-44, p. 10; NAA, "Project Apollo Spacecraft Test Program Weekly Activity Report (Period 15 November 1965 through 21 November 1965), p. 3.

NASA had essentially completed negotiations with North American on the incentive contract. Based on agreements reached with the contractor during

December

2

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negotiations, Master Development Schedule 9 was published, which included Block I and Block II spacecraft schedules, SLA schedules, SM Block II primary structure schedules, and a tabulated list of milestones containing former and new schedule dates.

Memorandum, C. L. Taylor, MSC, to each ASPO Branch Chief and each Subsystem Manager, "New NAA Schedule MDS-9," December 2, 1965.

2 Maj. Gen. Samuel C. Phillips, NASA Apollo Program Director, approved the deletion of the LEM TM-5 from the ground test program. He requested that MSC consider the following recommendations:

- A Langley Research Center drop test program using a full-scale LEM as part of the LEM test program.
- Expansion of the one-sixth scale model tests in the areas of non-symmetrical landings and soil landings.
- Planning of mechanism tests on LTA-3 with attention to their timelines.
- Investigation of use of the LTA-3 or LEM-1 for structural elasticity tests.

On December 23, ASPO Manager Joseph F. Shea replied regarding the recommendations:

- Langley had been requested by MSC to support the LEM ground test program by conducting tests of a simulated LEM on the Langley one-sixth gravity simulation test rig.
- Additional tests of one-sixth LEM drop models would be conducted to cover nonsymmetrical landings. Evaluation of LEM landing performance in soil was starting at MSC in a program that would include both analysis and experimental studies.
- MSC felt that sufficient demonstration of the mechanism capabilities of the landing gear would be provided by the planned dynamic tower tests and the Langley tests. The LTA-3 drop tests, however, would be used as a further means of demonstrating the mechanism's functionability.
- An analytical study to evaluate the structural "elastic spring-back" effects on LEM landing performance was being conducted by Grumman. If evaluation of this study showed the need for experimental testing, the use of the LTA-3 for elasticity tests would be investigated. The use of a flight article, such as LEM-1, for such tests was not considered desirable because of the possibility of structural damage.

TWX, Maj. Gen. Samuel C. Phillips, NASA Headquarters, to MSC, Attn: J. F. Shea, December 2, 1965; letter, Joseph F. Shea, MSC, to NASA Headquarters, Attn: Maj. Gen. Samuel C. Phillips, "Deletion of TM-5 from LEM Ground Test Program," December 23, 1965.

MSC was considering the use of both water and air bacteria filters in the LEM to reduce contamination of the lunar surface. Crew Systems Division (CSD) would attempt to determine by tests what percentage concentration of micro-organisms would be trapped by the filters. CSD hoped to begin limited testing in January 1966.

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3

At an MSC meeting attended by ASPO, CSD, and Lunar Sample Receiving Laboratory representatives, it was decided that the following directions would be sent to Grumman: (1) In order to prolong the prevention of lunar surface contamination, provisions should be made to store urine and lithium hydroxide canisters in the descent stage; and (2) the portable life support systems and associated extravehicular mobility items should be dumped onto the lunar surface after all lunar surface exploration had been completed.

Memorandum, Robert V. Battey, Chief, Systems Operations Branch, ASPO, to Chief, Systems Engineering Division, ASPO, "Status of Lunar Surface Contamination," December 3, 1965.

The Flight Readiness Review for Mission A-004 was conducted at White Sands Test Facility. The board concurred in proceeding with launch preparations. Subsequent to the review, the failure analysis of the autopilot subsystem revealed loose solder connections, and the launch was rescheduled for December 15, from the original December 8 planned launch. The launch was later scheduled for December 18; then, because of continued problems with the autopilot, was scrubbed until January. (See January 20, 1966, entry.)

3

"Project Apollo, Abstract of Proceedings, Mission A-004 (CSM 002/LJ II 12-51-3) Flight Readiness Review, December 3, 1965, at the White Sands Test Facility," Chairman, F. J. Bailey, Jr.; MSC, "ASPO Weekly Management Report, December 2-9, 1965"; TWX, Manager, ASPO, MSC, to NASA Headquarters, Attn: Director, Apollo Program Office, December 22, 1965.

The U.S.S.R. launched *Luna VIII*, an unmanned spacecraft, toward the moon December 3. The objectives were to test a soft lunar landing system and scientific research. Weighing 1552 kg (3422 lbs), the spacecraft was following a trajectory close to the calculated one and the equipment was functioning normally. *Luna VIII* impacted on the moon December 7. Indications were that it was destroyed instead of making a soft landing. Tass reported that "the systems were functioning normally at all stages of the landing except the final touchdown."

3-7

Astronautics and Aeronautics, 1965, pp. 536, 542.

Gemini VII, the fourth manned mission of that program, was launched from Cape Kennedy December 4 with command pilot Frank Borman and

4-18

At right, *Gemini VII* is shown just after liftoff at Cape Kennedy. Below, *Gemini VII* Astronauts Frank Borman, left, and James A. Lovell, Jr., happily relive part of their mission in the recovery helicopter after splashdown 14 days later.



pilot James A. Lovell, Jr., as the crew. Their primary objective was to evaluate the physiological effects of long-duration (14 days) flight on man. Secondary objectives included: providing a rendezvous target for the *Gemini VI-A* spacecraft (see December 15–16 entry), conducting 20 experiments, and evaluating the spacecraft's reentry guidance capability. The rendezvous was successfully accomplished during the 11th day of the mission. The crew established another first for American spacemen as first one, then the other, and finally both flew with their flight suits removed. The landing, on December 18, was little more than six mi from the planned landing point.

Grimwood, Hacker, with Vorzimmer, "*Project Gemini, A Chronology*" (NASA SP-4002), 1969, pp. 224–226.

Hamilton Standard successfully tested a life-support back pack designed to meet requirements of the lunar surface suit. The system functioned as planned for more than three hours inside a vacuum chamber, while the test subject walked on a treadmill to simulate the metabolic load of an astronaut on the lunar terrain. The 29.48-kg (65-lb) portable life support system supplied oxygen, pressurized to a minimum 25 510 newtons per sq m (3.7 lbs psi), controlled its temperature and relative humidity, and circulated it through the suit and helmet. The pack pumped cooled water through the tubing of the undergarment for cooling inside the pressure suit. A canister of lithium hydroxide trapped carbon dioxide and other air contaminants to purify the oxygen for reuse.

5

Astronautics and Aeronautics, 1965, p. 540.

George E. Mueller, NASA Associate Administrator for Manned Space Flight, notified MSC Director Robert R. Gilruth that NASA Administrator James E. Webb and Associate Administrator Robert C. Seamans, Jr., had selected Lockheed Aircraft Corporation, The Martin Company, McDonnell Aircraft Corporation, and Northrop Corporation for Phase I of the Apollo Experiments Pallet Procurement. The contracts would be for four months and each would be valued at about \$375 000.

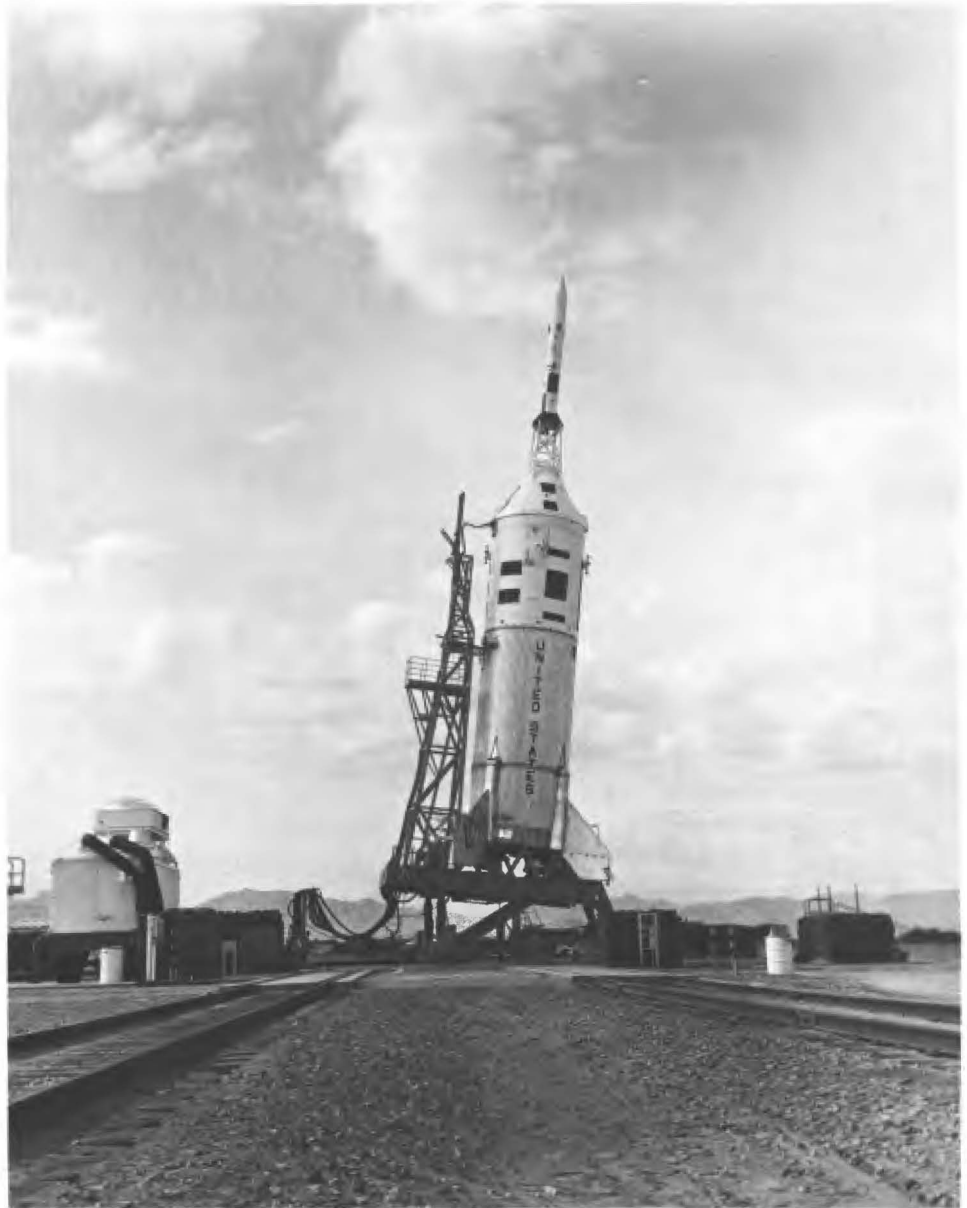
6

Letter, Mueller to Gilruth, December 6, 1965.

The Block II CSM Critical Design Review (CDR) was held at North American, Downey, Calif. The specifications and drawings were reviewed and the CSM mockup inspected. Review Item Dispositions were written against the design where it failed to meet the requirements.

6–17

As a result of the CDR North American would update the configuration of mockup 27A for use in zero-g flights at Wright-Patterson AFB. The



On December 5, 1965, the last scheduled Little Joe II-Apollo boilerplate was apparently ready for its scheduled December 8 launch at WSMR. Troubles were encountered and the launch finally took place January 20, 1966.

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flights could not be rescheduled until MSC approved the refurbished mockup as being representative of the spacecraft configuration.

MSC, "ASPO Weekly Management Report, December 16-23, 1965."

7

ASPO Manager Joseph F. Shea informed North American, Grumman, and Bell Aerosystems Company that NASA's Associate Administrator for Manned

Space Flight, George E. Mueller, had requested a presentation on the incompatibility of titanium alloys and nitrogen tetroxide and its impact on the Apollo Program, this to be done at the NASA Senior Management Council meeting on December 21.

In light of recent failures of almost all titanium tanks planned for use in the Apollo Program when exposed to nitrogen tetroxide under conditions which might be encountered in flight, the matter was deemed to be of utmost urgency.

A preliminary meeting was scheduled at NASA Headquarters on December 16 and one responsible representative from each of the prime contractors and subcontractors was requested to be present. Prior to the December 16 meeting, it would be necessary for each organization to complete the following tasks:

- Tabulate and analyze all tank tests to date and all related materials tests.
- Establish a format for presentation of the effects of time, temperature, and stress levels on failure.
- Obtain the best correlation between actual tank tests and related materials tests.
- Establish limits of operation and confidence levels for all current titanium tanks and relate these to all planned flights.
- Tabulate all titanium tank hardware in inventory and complete costs of development and manufacture of this hardware to date.
- Consider and recommend a course of action which would alleviate problems for early flights using existing hardware with minimum cost and schedule impact.
- Consider and recommend a course of action for future flights and indicate cost and schedule impact.
- If recommendations for future action include coatings, surface preparation, or alternate materials, present component weight increase and overall spacecraft increase.
- Consider changes in mission ground rules which would decrease time of tanks under pressure.
- Consider possibility of venting and repressurization and impact on pressurization system design, weight, cost and schedule.
- Review all missions and present pressurization times, stress levels, and thermal environment of all Apollo titanium tanks which contain nitrogen tetroxide.

TWX, Joseph F. Shea, MSC, to D. Myers, NAA; J. Gavin, Grumman; and J. Piselli, Bell Aerosystems Company, December 7, 1965.

MSC's Deputy Director George M. Low told Willis B. Foster of NASA Headquarters that the standing committee appointed by him had performed

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an invaluable service to the Center in identifying the requirements to be incorporated in the Lunar Sample Receiving Laboratory. Low said, "Additionally, we are indebted to individual members of that committee for providing detailed specialized inputs during the preliminary engineering phase just ended."

Low noted that the committee had prepared a report, "Review of the Preliminary Engineering Report (PER) of the Lunar Sample Receiving Laboratory (LSRL) by the Standing Committee of LSRL." He said that an examination of this report revealed that the committee had addressed itself to a detailed review task which far exceeded the scope envisioned when Foster conceived the idea for such a committee.

Low suggested that the committee be "discharged of any further responsibility relating to the facility design and construction." He added that MSC would look forward to providing Foster and his staff, as well as interested outside scientists, periodic briefings and reports of status and progress on the facility.

Letter, Low to Foster, "Manned Space Science Standing Committee for the Lunar Sample Receiving Laboratory," December 8, 1965.

- 8 An 889-kilonewton (200 000-lb) thrust J-2 engine was captive-fired for 388 sec on a new test stand at MSFC. The J-2 engine would be used to power the Saturn S-IVB stage for the Saturn V. Ten tests of the liquid hydrogen-liquid oxygen powered rocket engine had been conducted at MSFC since the J-2 engine test facility was put into use in August 1965.

Astronautics and Aeronautics, 1965, p. 543.

- 8 The service propulsion system burn time for AS-502 was confirmed to be 385 sec flight time. Previously the plan had called for a total of 515 sec—310 sec for SPS-1 and 205 sec for SPS-2. This action required that all mission plans be restudied and revised.

Memorandum, Carl R. Huss, JSC, to JSC Historical Office, "Comments on Volume III of *The Apollo Spacecraft: A Chronology*," June 6, 1973.

- 9-16 Investigations were continuing of the best alternative for resolving the AS-502 mission incompatibilities. The incompatibilities resulted from the restriction of the usable life of the Block I service propulsion system (SPS) engine to 385 to 400 sec total burn time. The alternatives were:

- Retain the current mission profile by burning the SPS engine for 500 sec, the minimum time the Block I engine was to be qualified for in ground tests.

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- Decrease the burn time to about 385 sec and permit the apogee of the AS-502 mission to increase well above the planned 16 668 km (9000 nmi). The increased flight time would result in increased dispersions at reentry, requiring some means to be found to decrease guidance dispersions during flight.

- Plan a primary AS-502 mission which stayed within the 400-sec burn time limitation and which did not achieve the desired reentry conditions for the heatshield test.

- Put a Block II SPS engine on CM 020. Because of the number of changes in the SPS subsystem between Block I and Block II, this would probably mean an extensive rework of the 020 SM.

- Develop engine modifications specifically for the 020 spacecraft that would permit firing the engine for 500 sec. This would mean a dead-end development over and above the Block I requirements.

The necessary information for reaching a decision among those alternatives was being collected.

MSC, "ASPO Weekly Management Report, December 9-16, 1965."

The Block II Apollo food storage problems were explored at North American. Methods of restraint were resolved to allow accessibility of the man-meal assemblies. The contractor, Melpar, Inc., would rework and reposition mockup man-meal assemblies to conform with suggestions by the Crew Provisions Office of the MSC Apollo Support Office and North American representatives.

9-16

Ibid.

Nine review item dispositions were submitted at the Block II critical design review concerning the earth landing system and shock attenuation system (struts). Six were on specifications, one on installation drawings, and two on capability. The two most significant were: (1) the contract for Block II parachutes had not been awarded and consequently top installation drawings were not yet available for review; and (2) specifications defining crew couch strut loading tolerances had not been released but the strut drawings had.

9-16

Ibid.

Preliminary results of the "fire-till-touchdown" study by Grumman indicated that this maneuver was not feasible. The engine might be exploded by driving the shock wave into the nozzles. The base heatshield temperature would exceed 1789 K (5000°F), which was high enough to melt portions of the structure, possibly causing destruction of the foot pads. The allowable pressure on the nonstructural elements of the base heatshield would be exceeded; and the descent engine flow field would tend to cause a "POGO"

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effect which would cause landing instability and could prevent engine cutoff.

As an outgrowth of the study, the landing probes would have to be made longer (137.1 to 187.9 cm [54 to 74 in] with automatic cutoff, 228.6 to 304.8 cm [90 to 120 in] with manual cutoff). The probe switches would be moved from the tip of the probe to the base, which was objectionable from the standpoint of a possible false reading due to probe dynamics.

MSC, "ASPO Weekly Management Report, December 16-23, 1965."

10

At-sea operational qualification tests, using boilerplate 29 to simulate spacecraft 009, were completed. All mechanical system components performed satisfactorily, except for the recovery flashing light. Test results were: (1) uprighting system—during the first mission cycle, the vehicle was uprighted in three minutes, during the second, in two minutes; (2) VHF antenna deployment—the antennas were in the erect position when the test started. Communication was achieved with a fly-by plane; (3) the sea dye marker canister deployed as expected when the HF was erected; and (4) the recovery flashing light was deployed before the test started; when switched on the light did not flash. Post-test analysis indicated a water-short in the wiring installed by MSC.

MSC, "ASPO Weekly Management Report, December 9-16, 1965."

15

Grumman was invited to provide NASA with a cost-plus-incentive-fee proposal to provide four LEMs subsequent to LEM-11, with the proposal due at MSC by the close of business on the following day. The proposal should be based on a vehicular configuration similar to LEM-11 in all respects, including supporting activities, contractual provisions, and specifications applicable to LEM-11. The required shipment dates for the four vehicles would be December 13, 1968, February 11, 1969, April 11, 1969, and June 10, 1969, respectively.

TWX, James L. Neal, MSC, to GAEC, Attn: J. C. Snedeker, December 15, 1965.

15

NASA Associate Administrator for Space Science and Applications Homer E. Newell informed MSC that an experiment proposed by Ames Research Center had been selected as a space science investigation for, if possible, the first manned lunar landing as a part of the Apollo Lunar Surface Experiments Package. Principal investigator of the proposed experiment, the magnetometer, was C. P. Sonett of Ames with Jerry Modisette of MSC as associate.

The Apollo Program Director was being requested by Newell to authorize the funding of flight hardware for this experiment.

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Letter, Homer E. Newell, NASA Headquarters, to Director, MSC, Attn: Experiments Program Manager, "Selection of Apollo Lunar Science Magnetic Field Investigations," December 15, 1965.

CSM ultimate static testing began. A failure occurred at 140 percent of the limit load test which simulated the end of the first-stage Saturn V boost. The loads were applied at room temperature. Preliminary inspection revealed a core compression failure and upper face sheet separation of the aft bulkhead directly beneath both SM oxidizer tank supports.

15

A second failure was also observed where the radial beams between the oxidizer and fuel tanks joined the bulkhead and shell. The bulkhead close-outs were peeled for a distance of approximately two inches. No decisions were made regarding repairs, test schedule, etc. These tests were constraints on spacecraft 012.

MSC, "ASPO Weekly Management Report, December 9-16, 1965."

Gemini VI-A, the fifth manned flight and first rendezvous mission in the Gemini Program, was launched from Cape Kennedy on December 15, with Astronaut Walter M. Schirra, Jr., serving as command pilot and Astronaut Thomas P. Stafford, pilot. Their primary objective was to rendezvous with the *Gemini VII* spacecraft, and secondary objectives included station-keeping with the other spacecraft, evaluating spacecraft reentry guidance capability, and performing three experiments.

15-16

A coelliptic maneuver was performed 3 hours and 47 minutes after launch; the terminal initiation was performed an hour-and-a-half later; braking maneuvers were started at 5 hours and 50 minutes into the flight and rendezvous was technically accomplished six minutes later. The two spacecraft began stationkeeping maneuvers which continued for three and a half orbits while they were separated by as much as 100 m and as little as .3 m.

Grimwood et al., *Project Gemini, A Chronology, 1969*, p. 227; *Gemini VII/Gemini VI, Long Duration/Rendezvous Missions*, MSC Fact Sheet 291-D, January 1966 [Ivan D. Ertel].

The NASA Director of Mission Operations notified the Directors of MSC, MSFC, and KSC that the communication satellite operational capability for Apollo mission support was scheduled for September 30, 1966.

16

Letter, E. E. Christensen, NASA, to KSC, MSFC, and MSC, Attn: Directors, "Communications Satellite Planning Status," December 16, 1965, with enclosure: "Communications Service by Communications Satellites for Support of Project Apollo," November 30, 1965.

At right, *Gemini VI-A* takes a picture of *Gemini VII* during rendezvous and stationkeeping activities on December 15 at an altitude of 257.5 km (160 mi). Below, the *Gemini VI-A* spacecraft, with the crew still inside, is hoisted aboard the recovery ship U.S.S. *Wasp*.



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Apollo Program Director Samuel C. Phillips said the Apollo Weight and Performance management system, jointly developed by the Apollo Program Office and the Centers had proved itself as a useful management tool. He considered that the system had matured to the point that changes in organiza-

tional responsibility were needed. He set a target date of December 31, 1965, to complete the following actions:

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- The focal point for the work had been in Apollo Program Control. Since it was a systems engineering function, Phillips was transferring this responsibility to his Apollo Systems Engineering organization.
- The APO Directorate of Systems Engineering would provide a quarterly weight and performance report and a monthly summary report on an integrated program basis.
- MSC would be responsible for and provide to the Apollo Program Office the weight and performance material which had been directed to Apollo Program Control.

Phillips acknowledged that an important element of the Apollo Weight and Performance management system had been the prediction analysis (weight growth) assessment effort performed by GE Apollo Support Division, under contract to the Apollo Program Control Office. Phillips felt, however, that weight growth analyses were a Center responsibility, and there was no continuing need for GE to perform in this area since the prediction analysis methodology had been established.

Phillips told ASPO Manager Joseph F. Shea that if he wished to continue to use GE's service in this area, he would support his request with the stipulation that GE's prediction analysis operation be supervised by MSC personnel.

Letter, Phillips to Shea, December 16, 1965.

A working group was formed at MSC to determine the effects of lunar soil properties on LEM landing performance. Various potential sources of lunar surface information, including Surveyor spacecraft, would be investigated in an effort to evaluate LEM landing performance in a lunar soil. The effect of footpad size and shape on landing performance in soil would also be studied.

16-23

MSC, "ASPO Weekly Management Report, December 16-23, 1965."

The requirement to use the LEM rendezvous radar for surface or skin track and for tracking in the cooperative mode during powered LEM mission phases was deleted from the Grumman Technical Specification and the Master End Item Specification.

16-23

Ibid.

The following responsibilities were transferred from MIT to AC Electronics: (1) design responsibility for the Block I and Block II eyepiece com-

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partment; (2) responsibility for all Block II and LEM system coatings which were exposed to the spacecraft or space environment; and (3) design responsibility for the LEM navigation base.

Ibid.

- 17 The MSC Systems Development Branch rejected a proposal that the Development Flight Instrumentation (DFI) on LEM-3 be deleted for the following reasons: (1) LEM-3 would be the first full-weight LEM launched on a Saturn V vehicle. This would be the only chance of obtaining necessary information about the responses of LEM during launch. (2) The AS-503 mission would offer the only opportunity of obtaining information on the characteristics of a fully loaded, mated LEM and CSM prior to attempting a lunar landing. (3) Three LEMs with DFI were considered the minimum number acceptable in the program to provide flexibility in flight planning and ability to accommodate the loss of LEMs 1 or 2 without a major impact on the program.

Memorandum, Chief, Systems Development Branch, MSC, to Bob Williams, MSC, "DFI on LEM-3," December 17, 1965.

- 19 Apollo Program Director Samuel C. Phillips informed J. L. Atwood, President of North American Aviation, Inc., that he and the team working with him in examining the Apollo Spacecraft and S-II stage programs had completed their task "in sufficient detail . . . to formulate a reasonably accurate assessment of the current situation concerning these two programs." Phillips and a task force had started this study at North American November 22, 1965.

Phillips added: "I am definitely not satisfied with the progress and outlook of either program and am convinced that the right actions now can result in substantial improvement of position in both programs in the relatively near future.

"Inclosed are ten copies of the notes which we compiled on the basis of our visits. They include details not discussed in our briefing and are provided for your consideration and use.

"The conclusions expressed in our briefing and notes are critical. Even with due consideration of hopeful signs, I could not find a substantive basis for confidence in future performance. I believe that a task group drawn from NAA at large could rather quickly verify the substance of our conclusions, and might be useful to you in setting the course for improvements.

“The gravity of the situation compels me to ask that you let me know, by the end of January if possible, the actions you propose to take. . . .”

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Letter, Phillips to Atwood, December 15, 1965; Hearings before the Committee on Aeronautical and Space Sciences, United States Senate, Ninetieth Congress, First Session, “To Hear Officials of North American Aviation, Inc., Prime Contractor to NASA in the Apollo Program,” Apollo Accident, Part 5, pp. 414–415, May 4, 1967.

Robert C. Duncan, Chief of MSC’s Guidance and Control Division, revealed that recent discussions between himself, NASA Associate Administrator for Manned Space Flight George E. Mueller, and ASPO Manager Joseph F. Shea had resulted in a decision to continue both radar and optical tracking systems into the hardware development phase. It was also agreed that some specific analytical and hardware homework must be done. The hardware action items were being assigned to Robert A. Gardiner and the analytical action items to Donald C. Cheatham.

20

The primary objective was to design, develop, and produce rendezvous sensor hardware that was on time and would work, Duncan said; second, that “we must have a rendezvous strategy which takes best advantage of the capability of the rendezvous sensor (whichever type it might be).”

The greatest difficulty in reducing operating laboratory equipment into operating spacecraft hardware occurred in the process of packaging and testing for flight. This milestone had not been reached in either the radar or the optical tracker programs.

Duncan said, “We want to set up a ‘rendezvous sensor olympics’ at some appropriate stage . . . when we have flight-weight equipment available from both the radar contractor and the optical tracker contractor. This olympics should consist of exposing the hardware to critical environmental tests, particularly vibration and thermal-cycling, and to operate the equipment after such exposure.” If one or the other equipment failed to survive the test, it would be clear which program would be continued and which would be canceled. “If both successfully pass the olympics, the system which will be chosen will be based largely upon the results of the analytical effort. . . . If both systems fail the olympics, it is clear we have lots of work to do,” Duncan said.

Memorandum, Robert C. Duncan, MSC, to Engineering and Development Directorate, Attn: Assistant Chief for Engineering and Development and Assistant Chief for Project Management, “Competition of radar and optical tracker system for the LEM,” December 20, 1965.

Robert C. Seamans, Jr., was sworn in as Deputy Administrator of NASA, succeeding Hugh L. Dryden who died December 2. Seamans would also

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retain his present position as Associate Administrator for an indefinite period of time.

NASA Administrator James E. Webb administered the oath of office. He had announced in Austin, Tex., on December 10, that President Lyndon B. Johnson had accepted his recommendation that Seamans be named to the number two NASA post.

Astronautics and Aeronautics, 1965, p. 546; TWX, NASA Headquarters, Public Information Office, to all NASA Centers and Offices, December 21, 1965.

30

Because earth landing system qualification drop tests on boilerplate 6A and boilerplate 19 had failed to demonstrate that Block I recovery aids would not be damaged during landing, MSC notified North American that certain existing interim configuration recovery aid mockups must be replaced by actual hardware capable of fulfilling test requirements. The hardware included: two VHF antennas; one flashing light; one RF antenna, non-deployable; sea marker, swimmer umbilical, nondeployable. In addition, existing launch escape system tower leg bolts should be replaced by redesigned Block I tower bolts, including protective covers, to demonstrate that the redesigned bolts and covers did not degrade the performance of the earth landing system. North American was to reply with a total change plan by January 5, 1966.

TWX, J. B. Alldredge, MSC, to NAA, Attn: J. C. Cozad, December 30, 1965.

30-January 6

As a result of joint efforts by the Resident ASPO and MSFC Resident Manufacturing Representative, a simulated forward bulkhead for the CM inner-crew compartment was fabricated by North American and sent to MSFC for use in developing a head for the magnetic hammer which would be compatible to the extremely thin skins used on the compartment. The need for the magnetic hammer arose from the "canning" and "wrinkles" found after welding on the forward bulkhead. A tryout for the magnetic hammer on the simulated bulkhead was scheduled the first week in January.

MSC, "ASPO Weekly Management Report, December 30, 1965-January 6, 1966."

30-January 6

A potential problem still existed with the boost environment for the LEM and the associated spacecraft-LEM-adapter (SLA) thermal coating. Systems Engineering Division authorized North American to proceed with implementation of an SLA thermal coating to meet the currently understood SLA requirements. Grumman would review the North American study in detail for possible adverse impact on the LEM and would negotiate with MSC.

Ibid.

Grumman and MSC reached agreement to continue with Freon for pre-launch cooling of LEM-1. By changing to a different Freon the additional heat sink capability was obtained with minor changes to flight hardware. The ground support equipment for supplying Freon had to be modified to increase the flow capability, but this was not expected to be difficult. Plans were to use the same prelaunch cooling capability for LEM-2 and LEM-3.

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30-January 6

Ibid.

NASA Headquarters had directed that crew water intake be recorded on all Apollo flights. To meet this requirement the Government-furnished water gun would have to be modified to include a metering capability. A gun with this capability was successfully flown on the *Gemini VI* and *Gemini VII* flights and could be used without change in the CM and LEM if it could withstand the higher water pressure. Incorporation of the gun could require bracket changes in the CM and the LEM.

30-January 6

Ibid.

The SM reaction control system engine qualification was completed with no apparent failures.

31

Ibid.

During the month 16 flights were made in the LLRV. Of these, 11 were devoted to concluding the handling qualities evaluation of the rate-command vehicle attitude control system. The other five flights were required to check out a new pilot, Lt. Col. E. E. Kluever of the Army, who would participate in the remaining research flight testing performed on the LLRV at Flight Research Center. On December 15 the craft was grounded for cockpit modifications which would make the pilot display and controllers more like those of the LEM.

During
the
Month

Letter, Office of Director, Flight Research Center, to NASA Headquarters, "Lunar Landing Research Vehicle progress report No. 30 for the period ending December 31, 1965," sgd. Joseph Weil, January 19, 1966.

MSC and Grumman completed negotiations to convert the LEM contract from cost-plus-fixed-fee to cost-plus-incentive fee. In addition to schedule and performance incentives, bonus points would be awarded for cost control during FY 66 and FY 67. Four LEMs were also added to the program. LEM mockup-3 would be used as the KSC verification vehicle; LEM test article-2 and LEM test article-10 (refurbished vehicles) would be used in the first two flights of the Saturn V launch vehicle.

During
the
Month

A total of 167 contract change authorizations (CCAs) to the Grumman contract had been issued by December 31. Negotiation of the proposal for

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the conversion to a cost-plus-incentive-fee included all CCAs through No. 162, and CCA amendments dated before December 9. Proposals for CCAs 163-167 were in process and would be submitted according to contract change procedures.

Ibid., pp. 1, 22.

During
the
Quarter

ASPO Manager Joseph F. Shea reported to Apollo Program Director Samuel C. Phillips on changes in spacecraft weights:

- The CM control weight was 4989 kg (11 000 lbs) and current weight 4954 kg (10 920 lbs), up 126.55 kg (279 lbs) from September.
- The SM control weight was 4627 kg (10 200 lbs), and current weight was 4591 kg (10 122 lbs), down 44.45 kg (98 lbs). The total amount of usable propellant, control weight, was 16 642 kg (36 690 lbs), and current weight was 16 468 kg (36 305 lbs), up 53.98 kg (119 lbs).
- The LEM control weight was 14 515 kg (32 000 lbs) and current weight was 14 333 kg (31 599 lbs), down 81.65 kg (180 lbs).
- The spacecraft-LEM-adaptor control weight was 1724 kg (3800 lbs) and the current weight was 1624 kg (3580 lbs), up 22.68 kg (50 lbs).
- The total spacecraft injected control weight was 43 091 kg (95 000 lbs), and current weight was 42 422 kg (93 526 lbs), up 77.11 kg (170 lbs).
- The launch escape system control weight was 3719 kg (8200 lbs), and current weight 3741 kg (8245 lbs), up 20.41 kg (45 lbs).
- The total launch control weight was 46 811 kg (103 200 lbs), and current weight was 46 163 kg (101 771 lbs), up 97.52 kg (215 lbs).

Memorandum, Joseph F. Shea, MSC, to NASA Headquarters, Attn: Maj. Gen. Samuel C. Phillips, "Weight and Performance Data Submittal (January 1966)," January 22, 1966.

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An OMSF memorandum spelled out operational constraints for Apollo experimenters to prevent experiment-generated operational problems. The author, E. E. Christensen, investigated the area at the request of NASA Associate Administrator for Manned Space Flight George E. Mueller and developed some general conclusions, based on experience gained in the Gemini experiments program.

Christensen said the following items should be considered: (1) The experimenter should be required to produce all hardware and paperwork on schedule or resign himself to the fact that the experiment would be deferred to a later flight. (2) Training hardware should be identical to flight hardware except for flight certification documentation. (3) The experimenter should be informed that control fuel and power resources are limited aboard the spacecraft and his requirements should specify minimum usage. (4) The experimenter should be informed that recording and telemetry facilities are definitely limited and he should provide for alternate modes of data

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collection. (5) The experimenter should be requested to submit, as early as possible, detailed operational requirements, including timeline data, to MSC for inclusion in the flight plan and to allow a maximum time for solution of operational problems. (6) The experimenter should indicate both minimum and optimum experiment data requirements to allow mission planners some latitude in mission design. (7) The experimenter should be informed that every effort would be made to fly assigned experiments, but that certain prime mission requirements might be generated in flight and take precedence. In this event NASA would make every effort to reassign a deleted experiment to a later mission. (8) The experimenter should be informed that flight crew prime mission time demands can be exacting and that experiments requiring conscious efforts on the part of the crew may have to be compromised so as not to interfere with primary mission objectives.

Christensen suggested that NASA Headquarters could assist by providing guidance to MSC regarding the assignment of experiment priorities on each mission and the extent of allowable degradation of experimentation. He indicated that he felt the following experiments appeared to contain potential operational problems: S5, Synoptic Terrain Photography; M9A, Human Otolith Function; S14, Frog Otolith Function; S16, Trapped Particles Asymmetry; S17, X-ray Astronomy; and S18, Micrometeorite Collection.

Memorandum, Christensen to Director, Apollo Program, "Operational constraints for Apollo experiments/experimenters," January 3, 1966.

MSC directed International Latex Corporation to use the following cross section of materials in fabricating the A6L thermal meteoroid garment, outside to inside: One layer of six-ounce Nomex cloth; seven layers of H.R.C. super-insulation, starting with one-fourth mil aluminized mylar and alternating with 1.5-mil unwoven dacron spacers; two layers of seven-ounce neoprene rip stop nylon (one side coated with neoprene).

TWX, Richard S. Johnston, MSC, to International Latex Corporation, January 3, 1966;
 TWX, Richard S. Johnston, MSC, to International Latex Corporation, January 20, 1966.

Contractor personnel began an exercise to identify problem areas associated with activity within the LEM. Subjects using pressurized suits and portable life support systems ran through various cockpit procedures in the LEM mockup. Evaluations would continue during the week of January 10, using astronauts. The purpose of the exercise was to identify and gather data on problem areas in support of the Critical Design Review scheduled to be held at Grumman in late January.

MSC, "ASPO Weekly Management Report, December 30, 1965-January 6, 1966."

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- 3-7** MSC, "ASPO Weekly Management Report, January 6-13, 1966."
- 3-14** The LEM landing gear subsystem was reviewed during the LEM Critical Design Review at MSC and Grumman. The review disclosed no major design inadequacies of the landing gear. The review included: lunar landing performance, structural and mechanical design, structural and thermal analysis, overall subsystem test program including results of tests to date, and conformance of landing gear design to LEM specifications.
- MSC, "ASPO Weekly Management Report, January 20-27, 1965."
- 5** The Apollo Joint Operations Group (JOG) was disestablished by its co-chairmen. JOG had been established in February 1964 to exchange up-to-date status information on operational problems and to provide a means for their solution.
- Subsequent to the establishment of JOG, responsibility for the Panel Review Board was transferred to the Apollo Program Director, and the Operations Management Group and Operations Executive Group were established. Those activities satisfied the requirements of both the Apollo Program Director and Mission Operations Director and provided the operational problem status and solution capability.
- Letter, from Chairmen, Apollo Joint Operations Group, to Permanent Membership, Apollo Joint Operations Group, "Disestablishment of the Apollo Joint Operations Group," sgd. Samuel C. Phillips and E. E. Christensen, January 5, 1966.
- 6-13** The 500-second limitation for the Block I service propulsion system (SPS) engine qualification program was increased to 600 seconds for the last three altitude qualification tests. The spacecraft 020 SPS mission duty cycle required a 310-second burn and a 205-second burn. Discussions with Systems Engineering Division indicated that the long SPS burns were needed to support a full-duration S-IVB mission and there was little likelihood the requirement could be modified. The Block II engine delivery schedules prohibited obtaining a Block II engine in time to support spacecraft 020.
- MSC, "ASPO Weekly Management Report, January 6-13, 1966."
- 6-13** Apparently the only available spacecraft-LEM-adaptor (SLA) thermal coating material which would meet the emissivity requirements for LEM flights was 24-carat gold. North American (Tulsa, Oklahoma) was predicting 18-week and 10-week schedule slips, respectively, for the first two Block II SLAs and a \$10-12 million cost impact. A meeting would be held at Tulsa

January 17 between North American, Grumman, and MSC to determine the course of the action to be taken.

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Ibid.

George M. Low, Deputy Director of MSC, outlined the general purpose and plans for the Lunar Sample Receiving Laboratory during a telephone conversation with Oran W. Nicks, NASA Director of Lunar and Planetary Programs:

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- The Laboratory would prepare the sample boxes which would be sent to the moon on Apollo missions for the collection of samples.
- These boxes with enclosed samples would be returned to the facility where they could be opened in the desired vacuum environment.
- The facility could provide a capability for low level radiation counting and other urgent examinations.
- Samples would be prepared in the facility for distribution to scientists around the country and abroad who would have previously been selected to conduct analyses.
- The facility would serve as a repository for the sample material, and its personnel would act as curators for the samples and scientific data generated.
- A modicum of Laboratory facilities would be available for use by guest investigators who wished to study samples for special purposes at MSC.
- The sample facility would incorporate a quarantine section to properly assay the lunar materials, and to ensure preventing contamination on earth. In addition, it was probable that astronaut quarantine accommodations would be an adjunct to the currently conceived facility.

Memorandum, Director, Lunar and Planetary Programs, to Distr., "Telephone Conversation with Mr. George Low on January 7, 1966, re Lunar Sample Receiving Laboratory," January 10, 1966.

The first fuel cell system test at White Sands Test Facility was conducted successfully. Primary objectives were: (1) to verify the capability of the ground support equipment and operational checkout procedure to start up, operate, and shut down a single fuel cell power plant; and (2) to evaluate fuel cell operations during cold gimbaling of the service propulsion engine.

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TWX, Martin L. Raines, Manager MSC WSTF, to MSC, "Preliminary Report, First Fuel Cell System Test at WSTF," January 11, 1966.

Soviet life-support systems used in Vostok and Voskhod spacecraft appeared to use a sodium superoxide compound as a source of oxygen, A. W. Petrocelli, General Dynamics Corporation, told *Missiles and Rockets*. Petrocelli estimated the Russians had published three times more basic research papers

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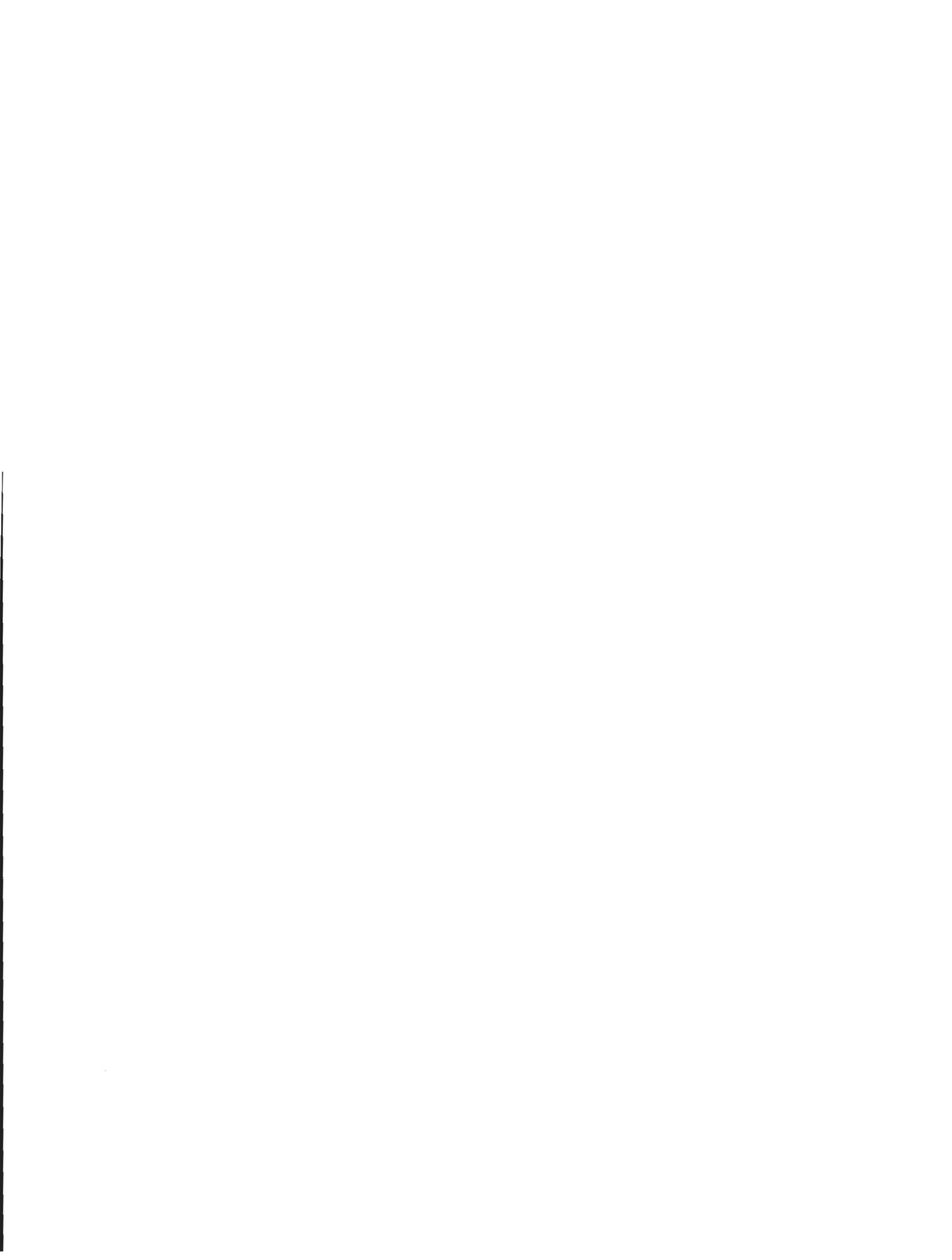
- 1966**
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- than U.S. scientists on these materials and were continuing efforts to improve life-support systems by studying compounds such as new superoxides, peroxides, and ozonides. He also said they were searching for better carbon dioxide absorbers.
- Missiles and Rockets*, p. 33, January 10, 1966.
- 13**
- A decision made at a Program Management Review eliminated the requirement for a land impact program for the CM to support Block I flights. Post-abort CM land impact for Saturn IB launches had been eliminated from Complex 37 by changes to the sequence timers in the launch escape system abort mode. The Certification Test Specification and related Certification Test Requirements would reflect the new Block II land impact requirements.
- MSC, "ASPO Weekly Management Report, January 20-27, 1965."
- 13-20**
- Mission requirements for AS-503 were reviewed to determine if the LEM test objectives which caused the crew to be in the LEM at high altitudes (3704 to 12 964 km [2000 to 7000 nm]) could be deleted. The reason for keeping the crew out of the LEM at those altitudes was the possibility they might be exposed to a total radiation dose which might prevent them from flying a later lunar mission.
- MSC, "ASPO Weekly Management Report, January 13-20, 1965."
- 13-20**
- The service propulsion subsystem (SPS) maximum total burn time was set at 515 sec for Mission AS-502, instead of 385 sec. The higher limit was expected to be attained due to the Block I testing burn time being extended to 600 sec. An SPS propellant loading of 16 783 kg (37 000 lbs) and the 515-sec burn limit had been included in the Apollo Mission Data Specifications, which was in the publication cycle for support of the AS-502 Reference Trajectory.
- Ibid.*
- 13-20**
- The LEM electrical power system use of the primary structure as the electrical ground return was approved after Grumman presentations were made to ASPO and Engineering and Development personnel. The descent-stage batteries would not use a descent-stage structure ground to preclude current flow through the pyrotechnic interstage nut and bolt assemblies. The ascent and descent stage batteries would be grounded to primary structure in the near vicinity of the ascent-stage batteries. In addition, several selected manually operated solenoids would ground. All other subsystems would remain grounded to the "single-point" vehicle ground. This change



Final suborbital test of the Apollo Program occurred at WSMR on the morning of January 20. Launch of Little Joe II, left, and recovery operations, above, completed a successful test program for NASA.

- 1966**
January would be implemented by Grumman with no cost or schedule impact and would effect a weight savings of approximately 7.7 kg (17 lbs).
Ibid.
- 13-27** Hamilton Standard Division was directed by Crew Systems Division to use a 2.27-kg (5-lb) battery for all flight hardware if the power inputs indicated that it would meet the four-hr mission. The battery on order currently weighed 2.44 kg (5.4 lbs). This resulted in an inert weight saving of 1.45 kg (3.2 lbs) and a total saving on the LEM and CSM of 5.44 kg (12 lbs).
 MSC, "ASPO Weekly Management Report, January 20-27, 1965."
- 14** The Grumman contract revision, converting the contract to cost-plus-incentive-fee, was signed. The period of the contract was extended through December 1969.
 "Quarterly Progress Report No. 1," LPR-10-52, p. 2.
- 20** Apollo Mission A-004 was successfully accomplished at White Sands Missile Range. This was the first flight test utilizing the Apollo Block I type spacecraft and the sixth and final test of the Apollo CSM development program at WSMR. Primary test objectives were: (1) to demonstrate satisfactory launch escape vehicle performance for an abort in the power-on, tumbling boundary region; and (2) to demonstrate the structural integrity of the launch escape vehicle airframe for an abort in the power-on, tumbling boundary region. The Little Joe II launch vehicle boosted the 4536-kg (5-ton) unmanned spacecraft to a 24-km (15-mi) altitude. The only significant anomaly recorded was loss of RF telemetry about two seconds after abort.
 TWX, White Sands Missile Range, New Mexico, to Distr., "MSC Apollo Mission A-004 (LJ II/SC 002) flight status," sgd. John Lobb for Joseph F. Shea, January 22, 1966; MSC, "ASPO Weekly Management Report, January 20-27, 1965."

APPENDIXES



APPENDIX 1—GLOSSARY OF ABBREVIATIONS

AEDC	Arnold Engineering Development Center
AFRM	airframe
AP	Associated Press
ASPO	Apollo Spacecraft Program Office
Btu	British thermal units
cm	centimeter, centimeters
CM	command module
CSM	command and service modules
cu m	cubic meter, cubic meters
DOD	Department of Defense
ELS	earth landing system
F	Fahrenheit
fps	feet per second
ft	foot, feet
g	specific gravity
GAEC	Grumman Aircraft Engineering Corporation
GE	General Electric
HF	high frequency
IBM	International Business Machines Corporation
in	inch, inches
ITT	International Telephone and Telegraph Corporation
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
K	Kelvin scale
kg	kilogram, kilograms
KSC	Kennedy Space Center
lb	pound
lbs	pounds
LEM	Lunar excursion module
LLRV	Lunar Landing Research Vehicle
LTA	LEM test article
m	meter, meters
MDF	mild detonating fuse
mi	mile, miles
MIT	Massachusetts Institute of Technology
MSC	Manned Spacecraft Center
MSFC	Marshall Space Flight Center
NAA	North American Aviation, Inc.
NASA	National Aeronautics and Space Administration
nm	nautical miles
OMSF	Office of Manned Space Flight

psia	pounds per square inch average
RCA	Radio Corporation of America
RCS	reaction control system
RF	radio frequency
SID	Space and Information Systems Division (NAA)
SM	service module
sq m	square meter, square meters
SSC	space suit communications
VHF	very high frequency
WSMR	White Sands Missile Range
WSTF	White Sands Test Facility
yd	yard, yards

APPENDIX 2—SPACECRAFT WEIGHTS BY QUARTER

SEPTEMBER 1964–DECEMBER 1965

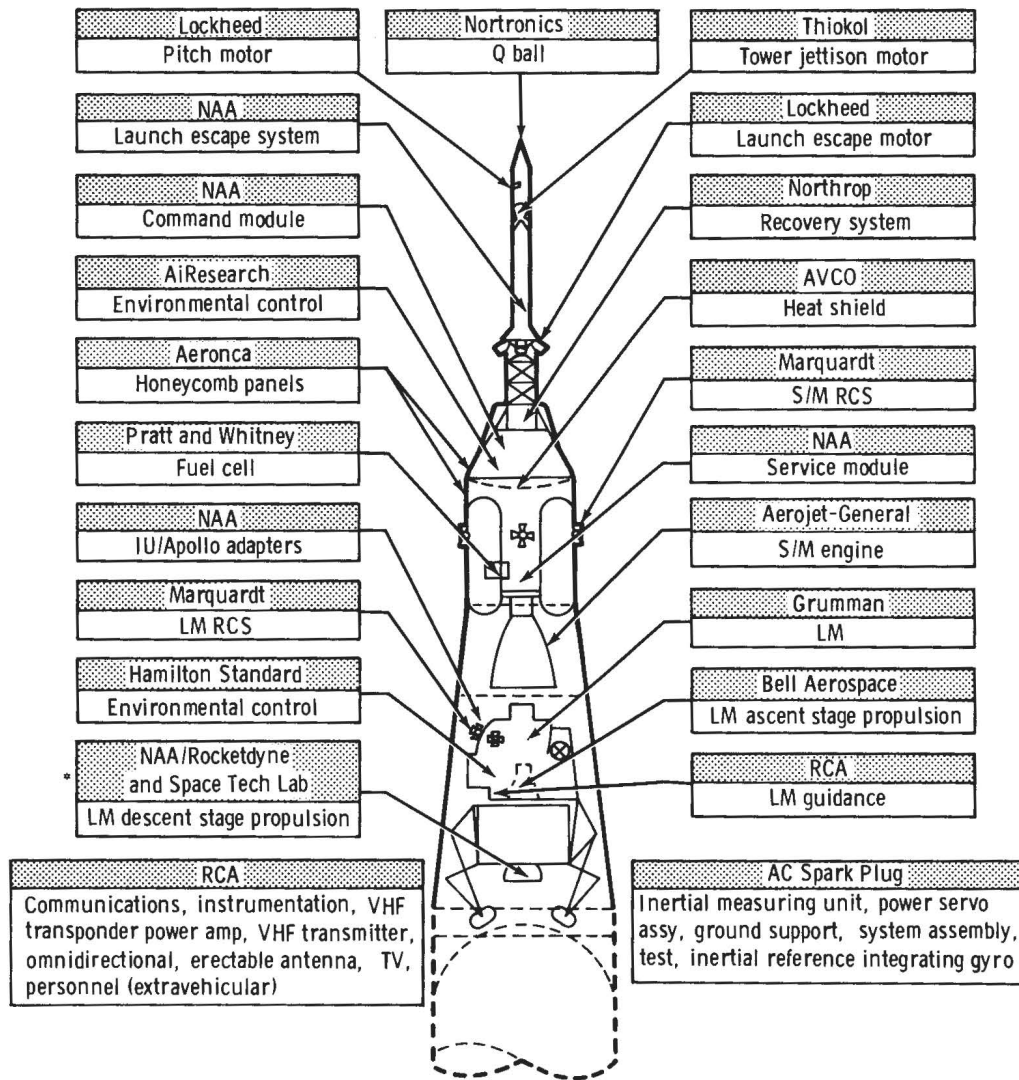
Item	September 1964		December 1964	
	Control Weight, kgs (lbs)	Current Weight, kgs (lbs)	Control Weight, kgs (lbs)	Current Weight, kgs (lbs)
Command Module	4990 (11 000)	4576 (10 090)	4990 (11 000)	4568 (10 070)
Service Module	4627 (10 200)	4559 (10 050)	4627 (10 200)	4581 (10 100)
SM Useful Propellant	17 468 (38 510)	16 894 (37 244)	16 894 (37 244)	16 869 (37 190)
S-IVB Adapter	1724 (3800)	1678 (3700)	1724 (3800)	1678 (3700)
Lunar Exc. Module	13 281 (29 500)	13 250 (29 431)	13 281 (29 500)	13 236 (29 181)
Total Spacecraft Injected	42 638 (94 000)	40 057 (90 515)	42 189 (93 010)	40 919 (90 211)

Item	March 1965		June 1965	
	Control Weight, kgs (lbs)	Current Weight, kgs (lbs)	Control Weight, kgs (lbs)	Current Weight, kgs (lbs)
Command Module	4990 (11 000)	4695 (10 350)	4990 (11 000)	4658 (10 270)
Service Module	4627 (10 200)	4527 (9980)	4627 (10 200)	4550 (10 030)
SM Useful Propellant	17 468 (38 510)	17 227 (37 980)	17 468 (38 510)	17 309 (38 160)
S-IVB Adapter	1724 (3800)	1553 (3425)	1724 (3800)	1556 (3430)
Lunar Exc. Module	13 281 (29 500)	13 768 (30 354)	13 281 (29 500)	13 972 (30 802)
Total Spacecraft Injected	42 189 (93 010)	41 771 (92 089)	43 091 (95 000)	42 140 (92 902)

THE APOLLO SPACECRAFT: A CHRONOLOGY

Item	September 1965		December 1965	
	Control Weight, kgs (lbs)	Current Weight, kgs (lbs)	Control Weight, kgs (lbs)	Current Weight, kgs (lbs)
Command Module	4990 (11 000)	4833 (10 654)	4990 (11 000)	4953 (10 920)
Service Module	4627 (10 200)	4683 (10 324)	4627 (10 200)	4591 (10 122)
SM Useful Propellant	16 642 (36 690)	16 474 (36 320)	16 642 (36 690)	16 468 (36 305)
S-IVB Adapter	1724 (3800)	1610 (3550)	1724 (3800)	1624 (3580)
Lunar Exc. Module	14 515 (32 000)	14 420 (31 791)	14 606 (32 200)	14 333 (31 599)
Total Spacecraft Injected	43 091 (95 000)	42 474 (93 639)	43 091 (95 000)	42 423 (93 526)

APPENDIX 3—MAJOR SPACECRAFT COMPONENT MANUFACTURERS



Honeywell Company	Collins Radio	Link	Beech Aircraft	Bell Aerosystems
Stabilization, control	Telecommunications	Spacecraft mission simulators	Supercritical gas storage	RCS positive expulsion fuel tanks
Allison and Airite Products	Radiation Inc.	Simmonds Precision Products	RCA	Westinghouse Electric
Fuel components	Telemetry data processing for Apollo S-II stage	Propellant mixture controls	TV cameras, main communications antenna	Static inverter
Elgin National Watch	RCA	MIT	Raytheon	Kollsman Instrument
Sequencer	Radar, engineering services	Associate prime-guidance, navigation	Computer	Optics

*STL named sole contractor January 1965.



APPENDIX 4—FLIGHT SUMMARY*

[October 1, 1964, through January 20, 1966]

Date	Name	General Mission	Launch Vehicle (Site)	Performance		
				Vehicle	Payload	Mission Results
<i>1964</i>						
Dec 8	Apollo (BP-23)	Suborbital Apollo capsule test	Little Joe II (WSMR)	S	S	S
<i>1965</i>						
Jan 19	Gemini-Titan II	Suborbital Gemini spacecraft test	Titan II (ETR)	S	S	S
Feb 17	<i>Ranger VIII</i>	Scientific lunar probe, photographic, transmitted 7000 photos of moon	Atlas-Agena B (ETR)	S	S	S
Mar 18	<i>Voskhod II</i>	Continuation of study of manned spaceflight, conduct extravehicular activity	Unknown (Baikonur, U.S.S.R.)	S	S	S
Mar 21	<i>Ranger IX</i>	Scientific lunar probe, photographic, transmitted 5814 photos of moon's craters to earth before impacting	Atlas-Agena B (ETR)	S	S	S
Mar 23	<i>Gemini III</i>	Orbital manned Gemini flight, first U.S. 2-man spaceflight	Titan II	S	S	S

* The launches described in this table include only those related to the exploration of the moon: unmanned lunar probes, unmanned tests of spacecraft designed for later manned missions, and manned space flights. The table is not intended as a comprehensive summary of all American and Soviet space flights. The information used in this Appendix is taken primarily from *Astronautics and Aeronautics, 1964*, and *Astronautics and Aeronautics, 1965*, Appendixes A and B.

Legend:
 ETR—Eastern Test Range
 WSMR—White Sands Missile Range
 S—Successful
 P—Partially successful
 U—Unsuccessful

Date	Name	General Mission	Launch Vehicle (Site)	Performance		
				Vehicle	Payload	Mission Results
<i>1965—concluded</i>						
May 9	<i>Luna V</i>	Attempt soft landing on lunar surface	Unknown (U.S.S.R.)	S	Unknown	F
May 19	Apollo (BP-22)	Suborbital Apollo capsule test	Little Joe II (WSMR)	U	S	P
May 22	Fire II	37,000 fps reentry test	Atlas D (ETR)	S	S	S
June 3	<i>Gemini IV</i>	Orbital manned Gemini flight; first U.S. extra-vehicular space activity	Titan II (ETR)	S	S	S
June 8	<i>Luna VI</i>	Investigate the moon; develop techniques and technology for lunar investigation	Unknown (U.S.S.R.)	Unknown		
June 29	Apollo pad abort test (BP-23A)	Demonstrate the capability of the launch escape vehicle, equipped with a canard system and boost protective cover, to abort from the launch pad and recover	Escape rocket (WSMR)	S	S	S

Aug 21	<i>Gemini V</i>	Orbital manned Gemini flight	Titan II (ETR)	S	S	S
Oct 4	<i>Luna VII</i>	Soft-land on the moon; take measurements of lunar en- vironment	Unknown (U.S.S.R.)	Impacted on Moon 10/7/65		
Oct 25	Agena (GATV)	Agena stage target vehicle for <i>Gemini VI</i> flight, rendez- vous and docking	Atlas-GATV (ETR)	U		U
Dec 4	<i>Gemini VII</i>	Orbital manned Gemini flight, endurance	Titan II (ETR)	S	S	S
Dec 15	<i>Gemini VI-A</i>	Orbital manned Gemini flight, rendezvous	Titan II (ETR)	S	S	S
<i>1966</i>						
Jan 20	Apollo (A-004)	Final suborbital Apollo cap- sule test	Little Joe II (WSMR)	S	S	S

APPENDIX 5—APOLLO PROGRAM FLIGHT OBJECTIVES

Apollo Mission A-002 (December 8, 1964)

First Order Objectives:

- (1) Demonstrate satisfactorily launch escape vehicle performance utilizing the canard subsystem and boost protective cover and to verify the abort capability in the maximum-dynamic pressure region with conditions approximating emergency detection system limits.
- (2) Deliver the Apollo boilerplate spacecraft to the desired conditions for demonstration of the launch escape vehicle.

Second Order Objectives:

- (1) Determine the performance of the launch escape vehicle in the maximum-dynamic pressure region.
- (2) Demonstrate satisfactorily launch escape vehicle power-on stability for abort in the maximum-dynamic pressure region with conditions approximating emergency detection subsystem limits.
- (3) Demonstrates satisfactory canard deployment, launch escape vehicle turnaround dynamics, and main heatshield forward flight stability prior to launch escape subsystem jettison.
- (4) Demonstrate satisfactory separation of the launch escape system plus boost protective cover from the command module.
- (5) Demonstrate satisfactory operation and performance of the emergency landing system using reefed dual drogues.
- (6) Determine the command pressure loads, including possible plume impingement, in the maximum dynamic pressure system.

Apollo Mission A-003 (May 19, 1965)

First Order Objectives:

- (1) Demonstrate satisfactory launch escape vehicle performance at an altitude approximating the upper limit for the canard subsystem.
- (2) Demonstrate orientation of the launch escape vehicle to a main heatshield forward attitude.
- (3) Deliver the Apollo boilerplate spacecraft to the desired conditions for demonstration of the launch escape vehicle.

Second Order Objectives:

- (1) Determine the damping of the launch escape vehicle oscillations with the canard subsystem deployed.
- (2) Demonstrate jettison of the launch escape system plus boost protective cover after high-altitude entry.

Pad Abort Test 2 (June 29, 1965)

First Order Objective:

- (1) Demonstrate the capability of the launch escape vehicle, equipped with a canard subsystem and a boost protective cover, to abort from the launch pad and recover.

Second Order Objectives:

- (1) Determine the performance and stability characteristics of the launch escape vehicle with boost protective cover and control weight command module.
- (2) Determine the turnaround dynamics of the launch escape vehicle following canard deployment.
- (3) Demonstrate satisfactory separation of the launch escape subsystem and boost protective cover from the command module.
- (4) Demonstrate proper event sequencing during abort from the launch pad and recovery.

Apollo Mission A-004 (January 20, 1966)

First Order Objectives:

- (1) Demonstrate satisfactory launch escape vehicle performance for an abort in the power-on tumbling boundary region.
- (2) Demonstrate the structural integrity of the launch escape vehicle airframe structure for an abort in the power-on tumbling boundary region.
- (3) Deliver the Apollo spacecraft to the desired conditions for demonstration of the launch escape vehicle.

Second Order Objectives:

- (1) Demonstrate the capability of the canard subsystem to satisfactorily reorient and stabilize the launch escape vehicle heatshield forward after a power-on tumbling abort.
- (2) Demonstrate the structural capability of the production boost protective cover to withstand the launch environment.
- (3) Demonstrate the capability of the command module forward heatshield thrusters to satisfactorily separate the forward heatshield after the tower has been jettisoned by the tower jettison motor.
- (4) Determine the static loads on the command module during launching and abort sequence.
- (5) Determine the dynamic loading on the command module inner structure.
- (6) Determine the dynamic loads and the structural response of the service module during launch.
- (7) Determine the static pressures imposed on the command module by free stream conditions and launch escape motor plumes during a power-on tumbling abort.

APPENDIX 6—FUNDING

Fiscal Year	Funding Breakdown (Dollars in Thousands)			
1965				
(Original budget request including Fiscal Year 1964 supplemental)	NASA:	\$4 523 000	CSM:	\$577 834
	Apollo:	2 818 500	LEM:	242 600
			Guid. & Nav.:	81 038
			Integ., reliab. & checkout:	24 763
			Spacecraft support:	83 663
(Fiscal budget appropriation with Fiscal Year 1964 supplemental)	NASA:	4 270 695	Saturn I:	40 265
	Apollo:	2 614 619	Saturn IB:	262 690
			Saturn V:	964 924
			Engine Development:	166 300
			Apollo mission support:	170 542
1966				
(Original budget request—No supplemental for prior Fiscal Year)	NASA:	\$4 575 900	CSM:	\$615 000
	Apollo:	2 997 385	LEM:	310 800
			Guid. & Nav.:	115 000
			Integration, reliab. & checkout:	34 400
(Fiscal budget appropriation—No supplemental for prior Fiscal Year)	NASA:	4 511 644	Spacecraft support:	95 400
	Apollo:	2 967 385	Saturn I:	800
			Saturn IB:	274 185
			Saturn V:	1 177 320
			Engine Development:	134 095
		Apollo mission support:	210 385	

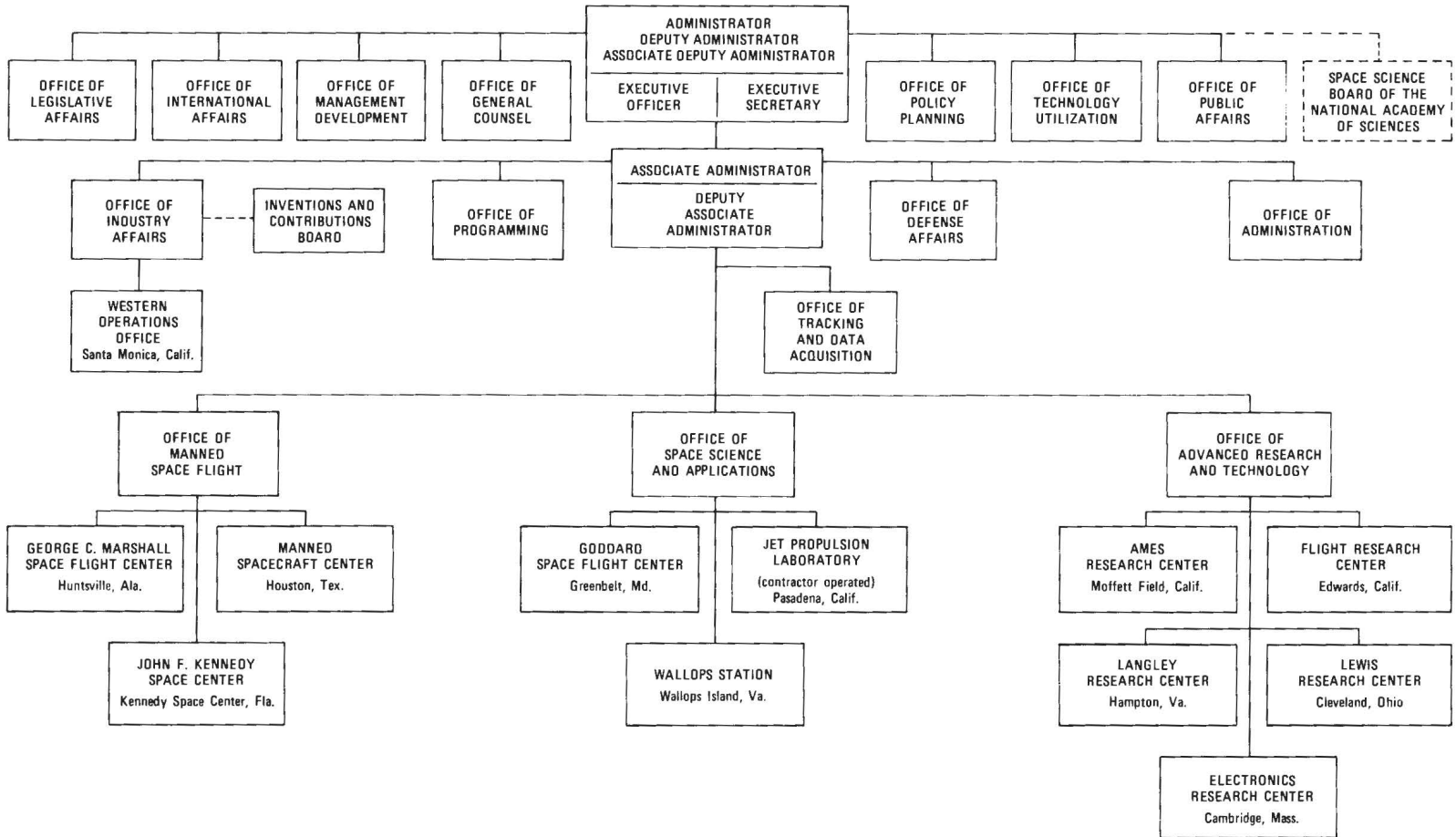
Compiled by F. B. Hopson, Administration and Program Support Directorate.



APPENDIX 7—ORGANIZATION CHARTS

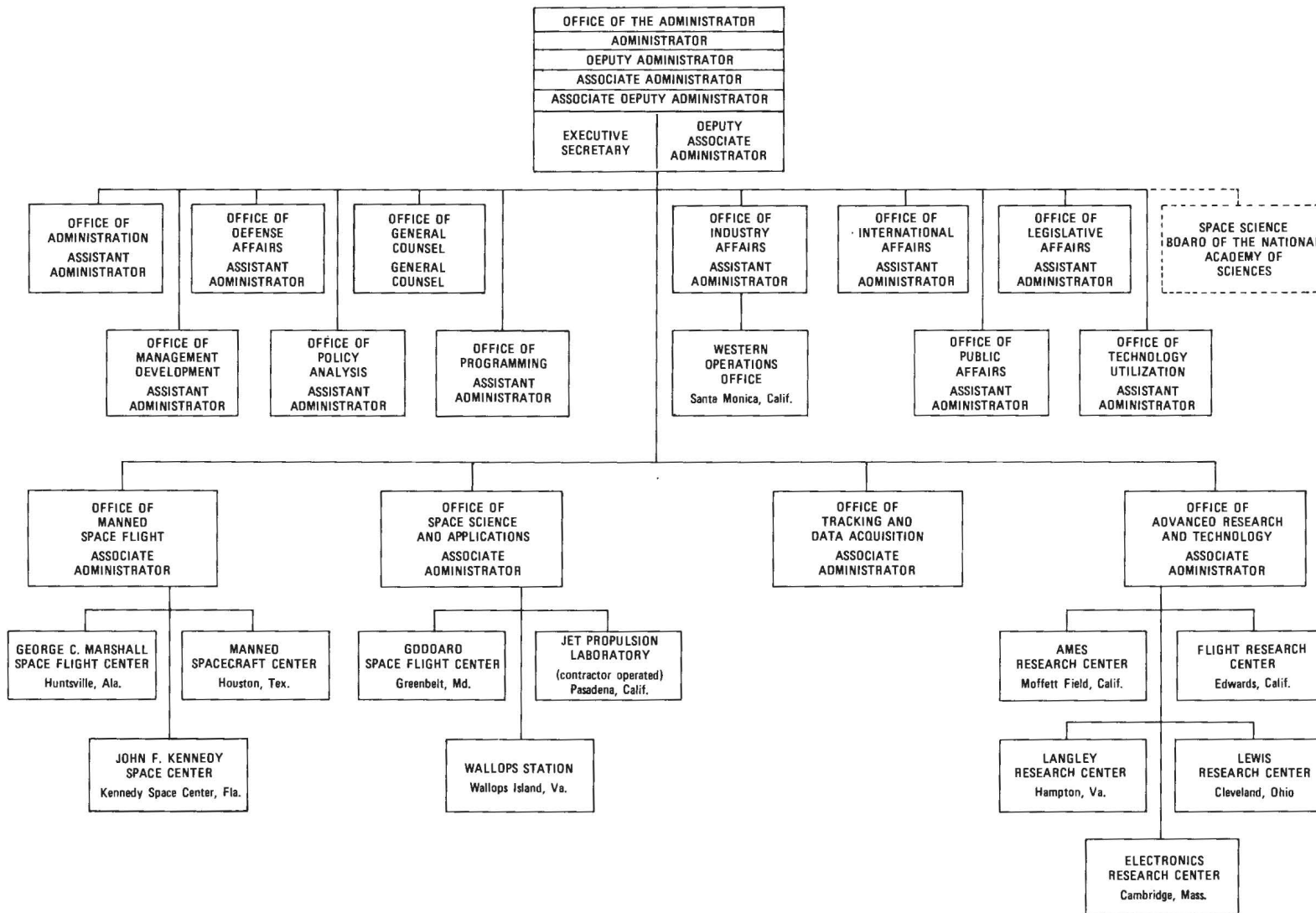
October 1, 1964, through January 20, 1966

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
 [October 1, 1965]



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

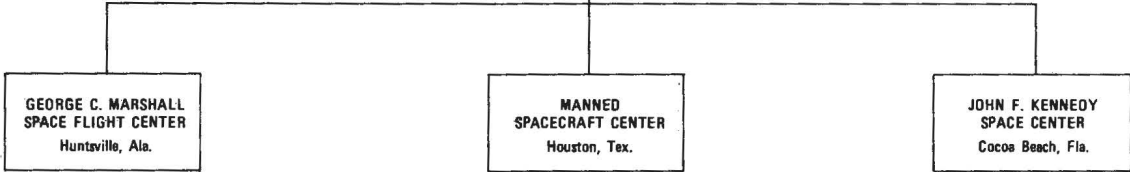
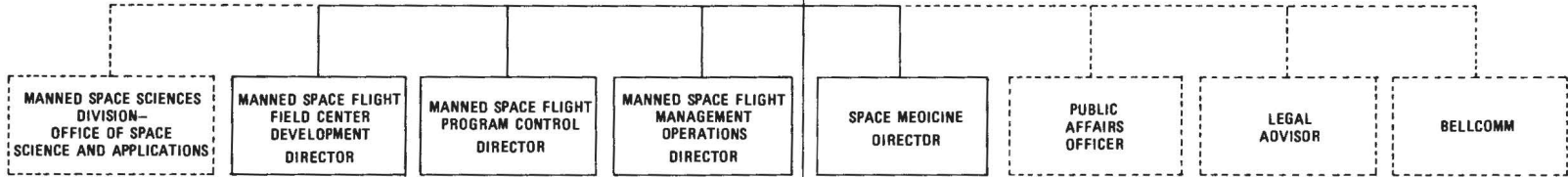
[January 2, 1966]



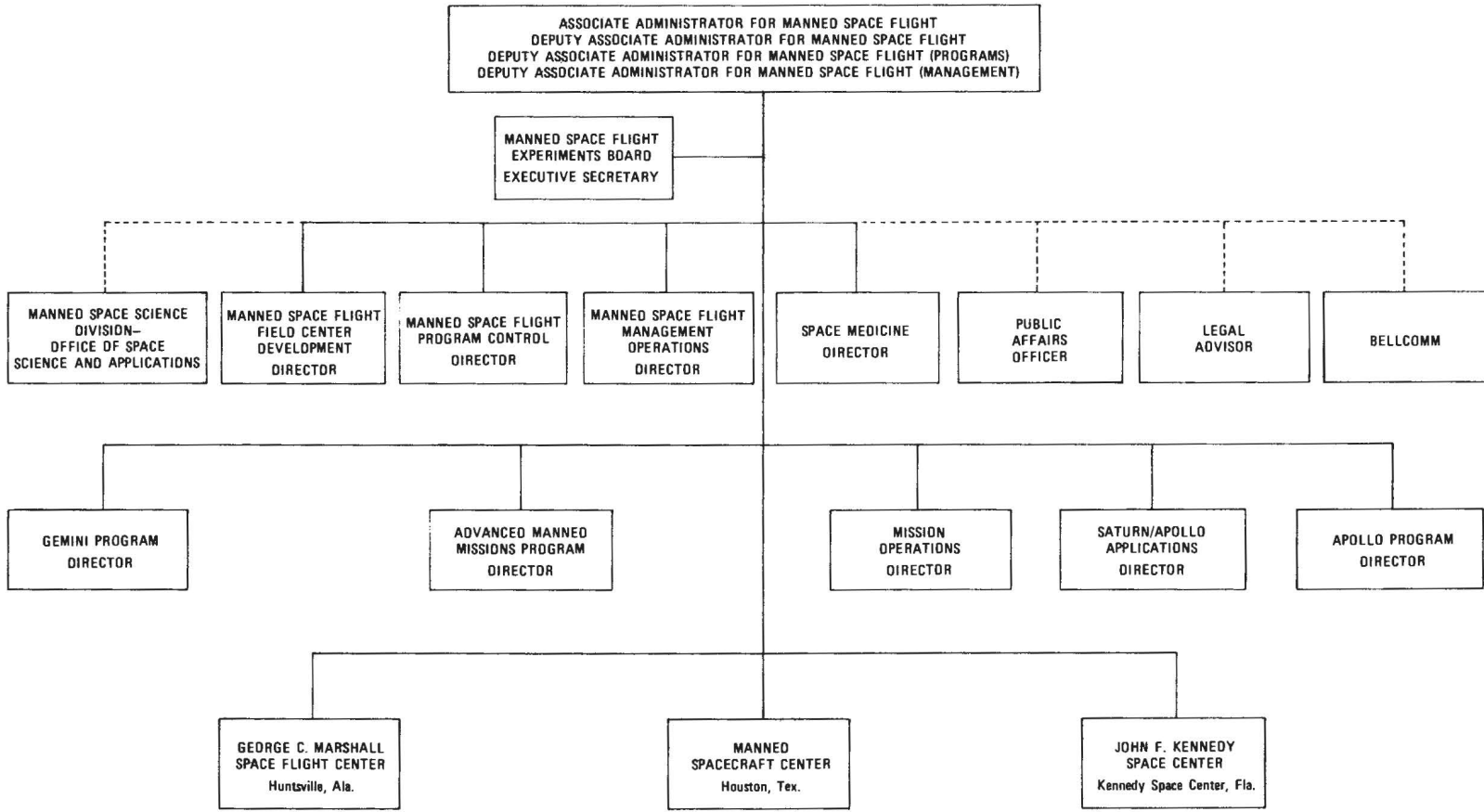
OFFICE OF MANNED SPACE FLIGHT
 [December 7, 1964]

ASSOCIATE ADMINISTRATOR FOR MANNED SPACE FLIGHT
 DEPUTY ASSOCIATE ADMINISTRATOR FOR MANNED SPACE FLIGHT (MANAGEMENT)
 DEPUTY ASSOCIATE ADMINISTRATOR FOR MANNED SPACE FLIGHT (PROGRAMS)

MANNED SPACE FLIGHT
 EXPERIMENTS BOARD
 EXECUTIVE SECRETARY



OFFICE OF MANNED SPACE FLIGHT
 [August 6, 1965]

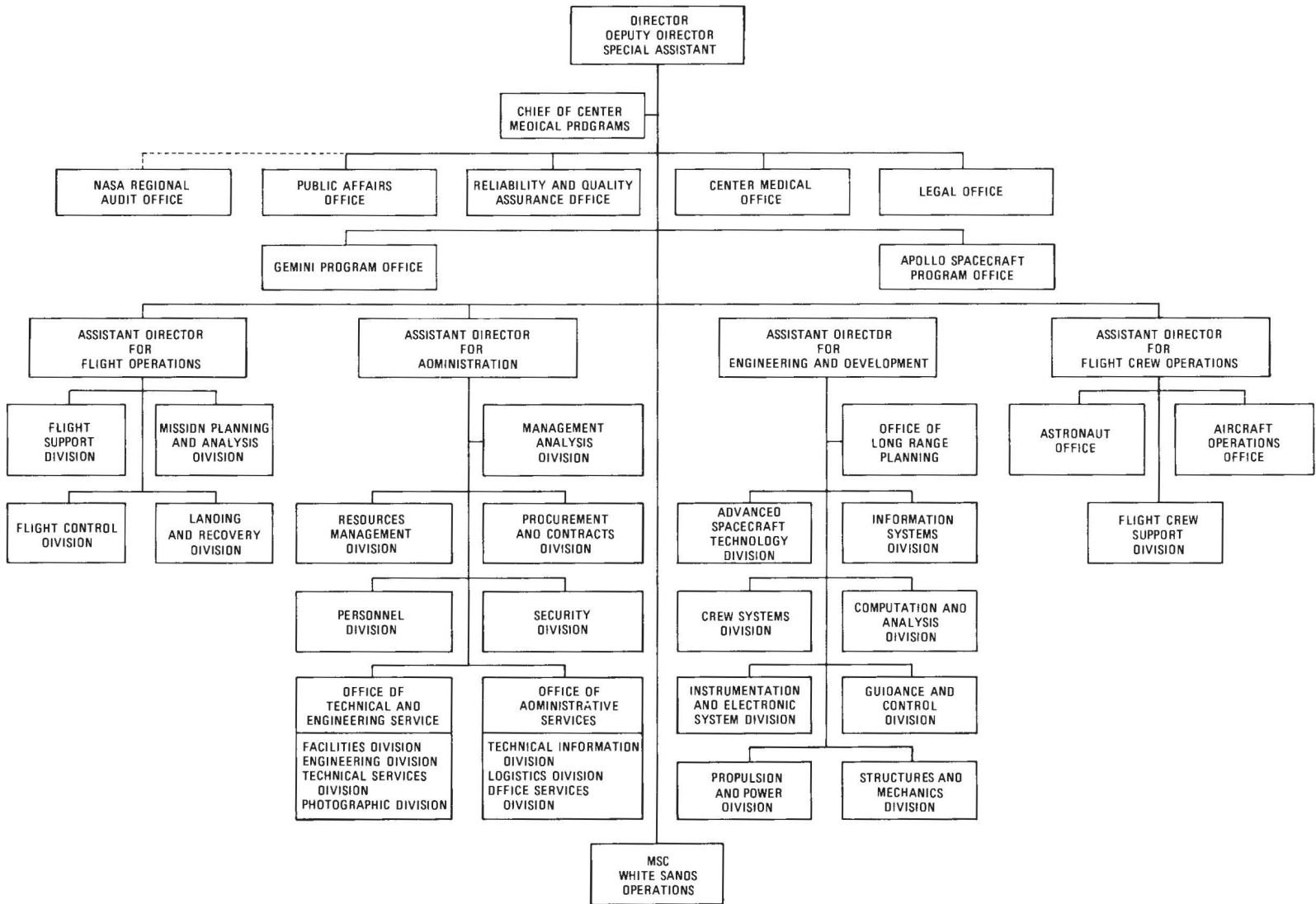


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APPENDIX 7

MANNED SPACECRAFT CENTER

[December 7, 1964]

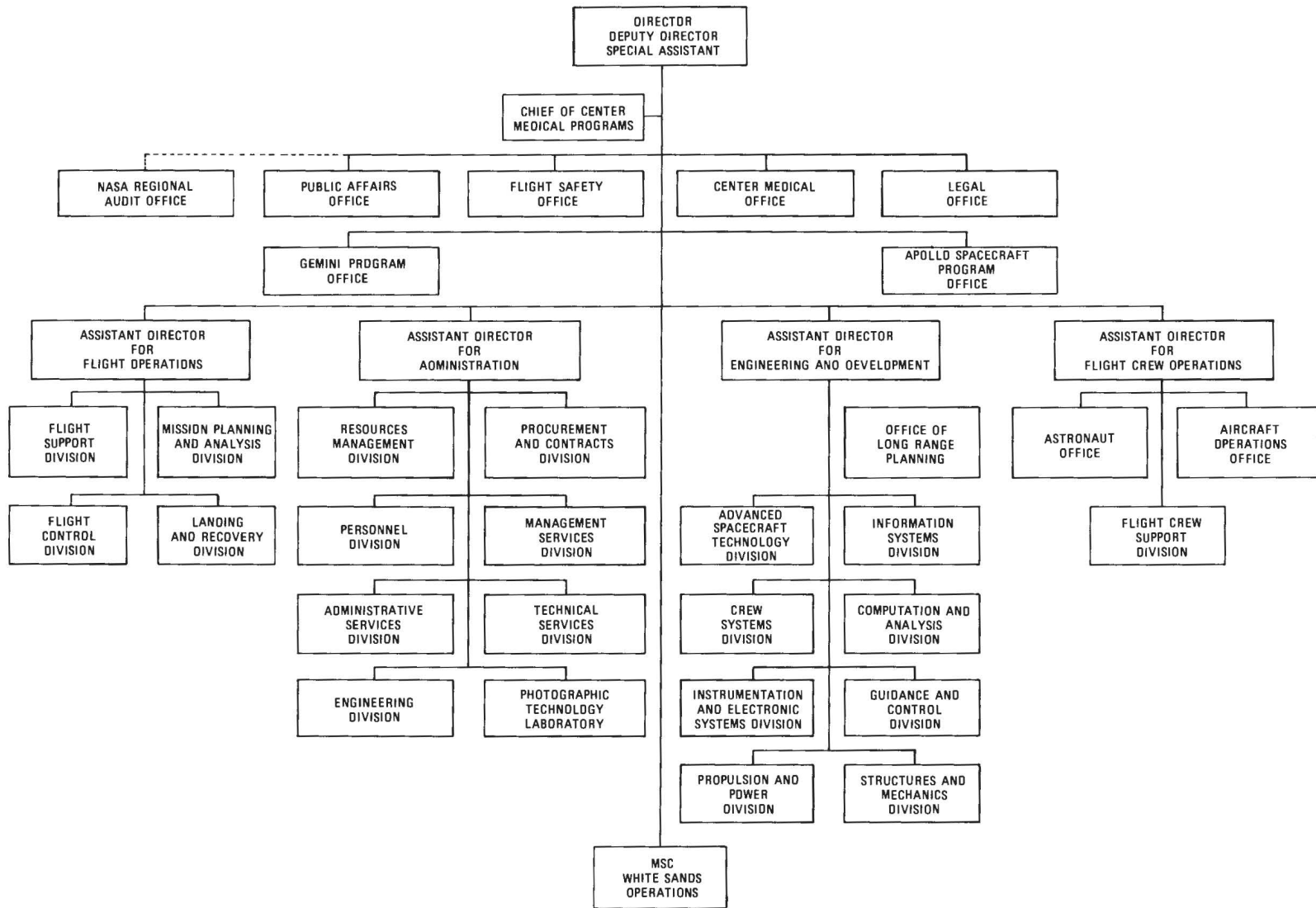


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[March 11, 1965]

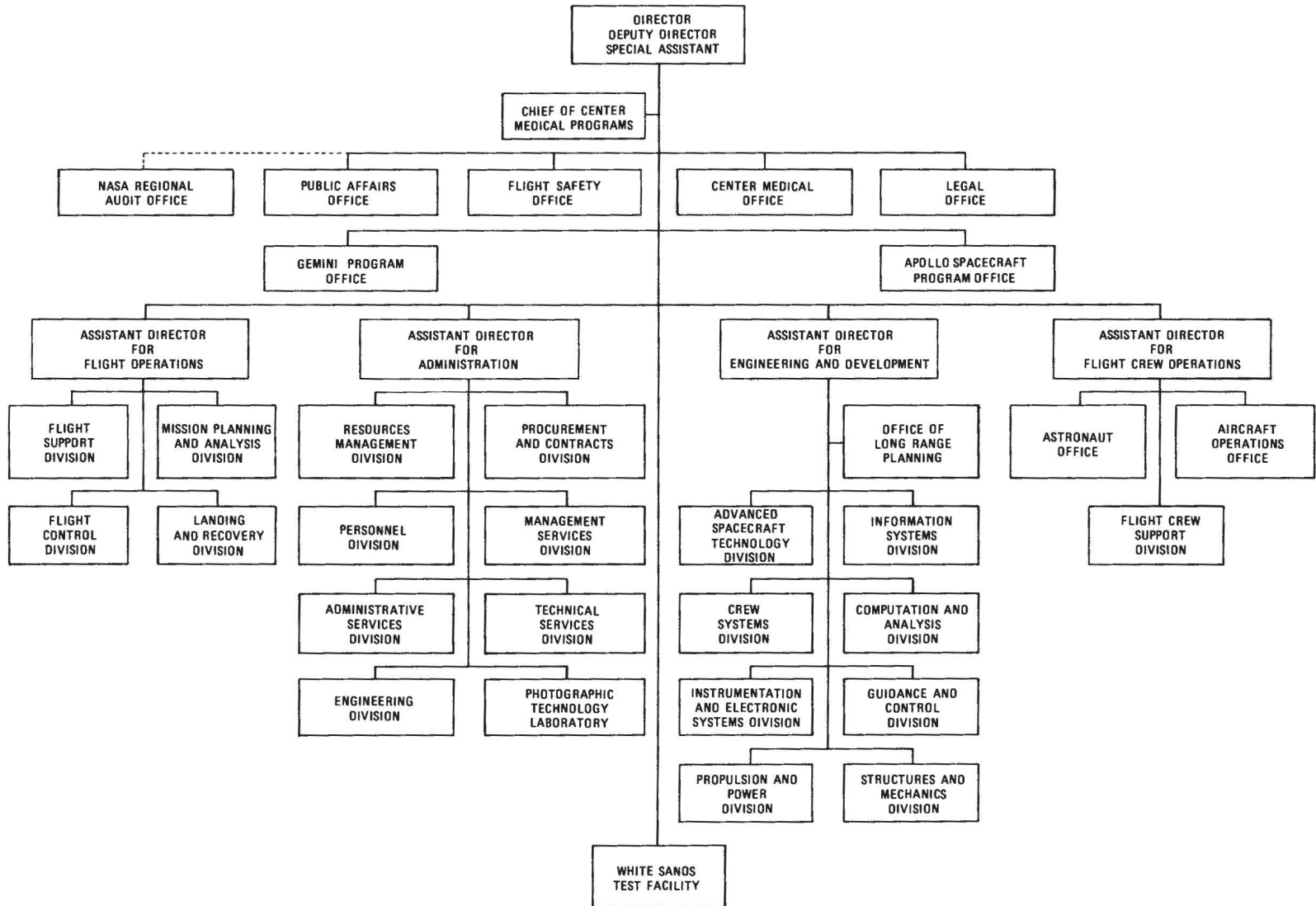


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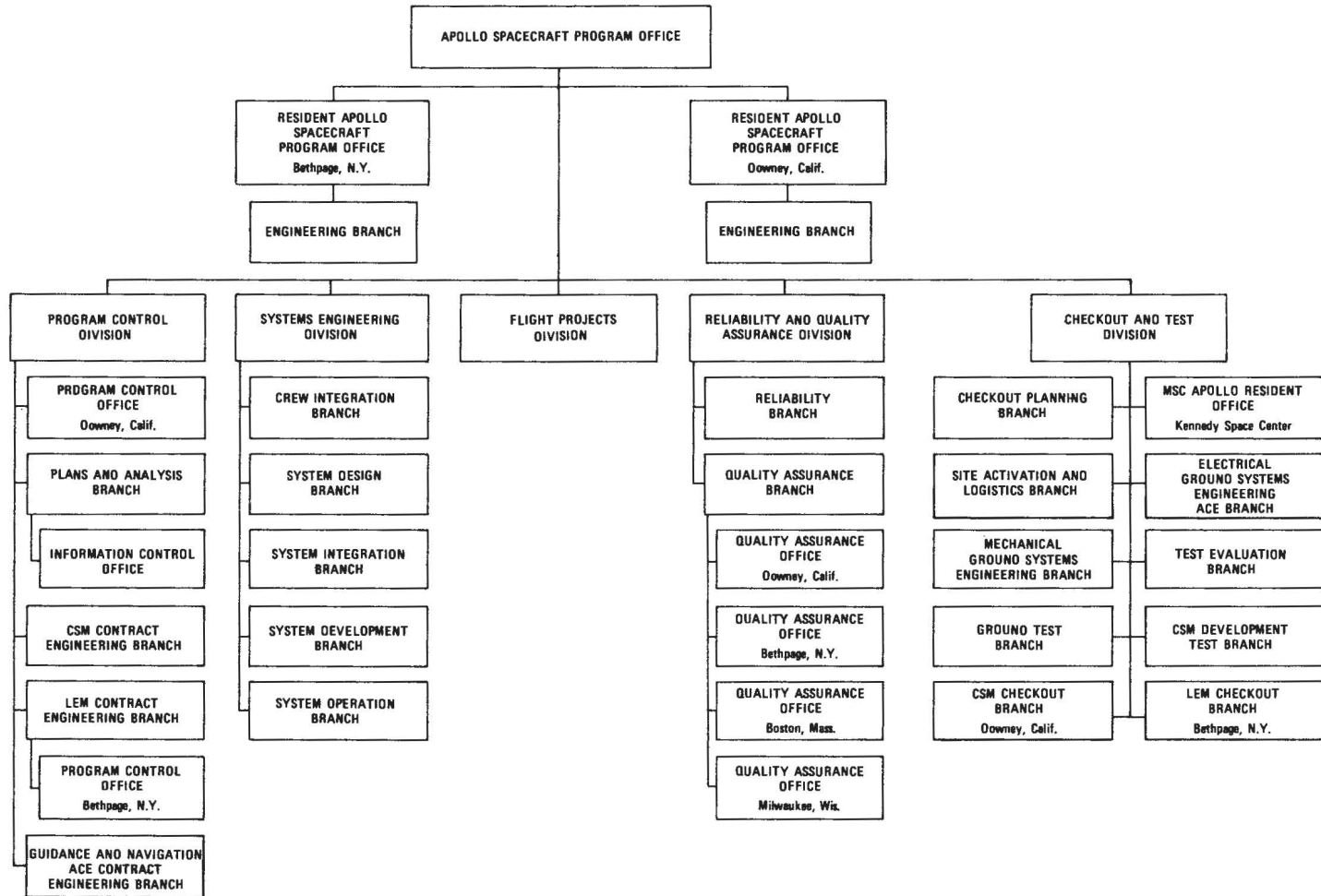
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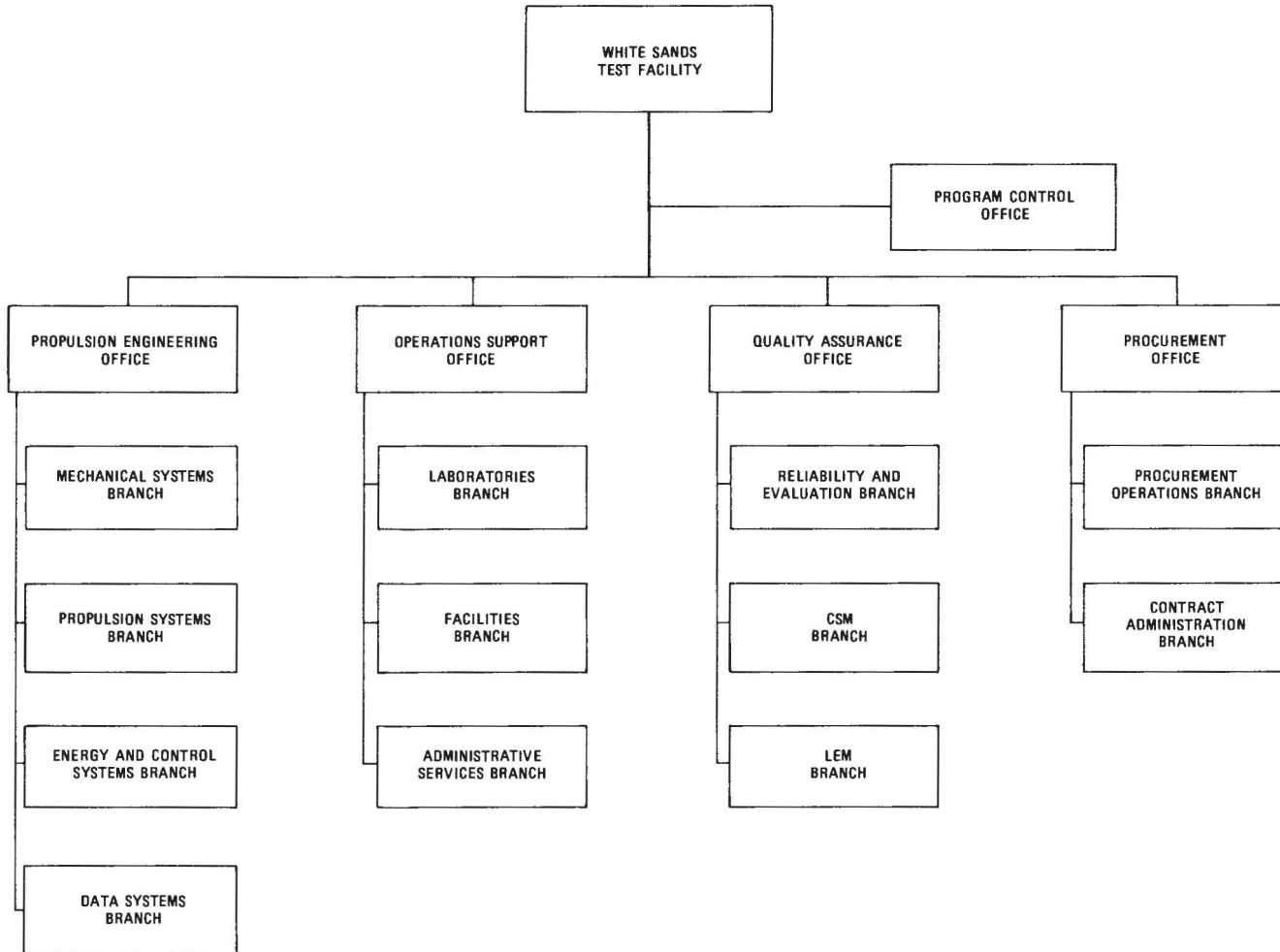
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