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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT MERCURY

STATUS REPORT NO. 6

FOR

PERIOD ENDING APRIL 30, 1960

By Langley Space Task Group

WORD ONE/KEYSEARCH

INTRODUCTION

This report is the sixth in a series of reports on the status of the NASA manned-satellite project, PROJECT MERCURY. Earlier Status Reports covered the progress made through January 31, 1960.

The capsule construction is progressing. The first capsule was delivered to NASA Wallops Station on April 2, 1960 for use in an escape-system test. This test flight is scheduled for early May 1960 and is to be the first flight of McDonnell Aircraft Corp.-produced hardware.

The capsule for the first Atlas flight is undergoing instrumentation, preparation, and structural modification at the NASA Langley Research Center.

The static firing of a Redstone booster and capsule combination, previously scheduled to occur at the NASA Marshall Space Flight Center, Huntsville, Alabama, has been replaced by a more stringent noise-and-vibration test of the capsule at the NASA Langley Research Center.

The MERCURY Astronaut training program has continued along the lines previously reported. Pilot-egress training has been accomplished in smooth water and in waves at the NASA Langley tank no. 1 and in rough seas at the U.S. Navy School of Aviation Medicine, Pensacola, Florida. Experience in controlling high-angular-rate motions was obtained by the Astronauts on the multiaxis gimbal facility at the NASA Lewis Research Center.

The Department of Defense (DOD) PROJECT MERCURY Planning Office has continued to function satisfactorily in planning the DOD support for launch, in-flight control, and recovery operations. Arrangements and personnel assignments have been made by the DOD for the medical monitoring aspects of the in-flight control. NASA has made personnel assignments for the technical monitoring of the in-flight control, and training of these personnel has begun.

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The preparation of the tracking and communication network is continuing satisfactorily, and construction has begun at many of the stations. All intergovernmental arrangements have reached the informal agreement stage and some formal agreements have been reached.

PRESENT STATUS - MAJOR SYSTEMS

The present status, schedules, and other plans for the various major systems of PROJECT MERCURY are given in the following sections.

Capsule

General.- Only relatively minor changes have been made in the MERCURY capsule and its internal systems during the past 3 months. As discussed in later sections of this report, the problems of strength of the outer heat-resistant shingles have been resolved unless the forthcoming flight of the first Atlas-boosted capsule (MA-1) discloses further problems.

Delivery schedule.- MERCURY capsule no. 1 was delivered to Wallops Island on April 2, 1960, and is expected to be launched off-the-beach during the first week of May 1960.

MERCURY capsule no. 4 (MA-1) was delivered to Langley Research Center on January 25, 1960, to undergo modification and instrumentation to make it suitable for substantiating the shingle structure. This capsule is scheduled to be delivered at Cape Canaveral, Florida during the fourth week of May 1960.

The latest delivery schedule of the remaining capsules is shown in figure 1. This schedule shows the preparation time and launch dates and also indicates that the checkout period at Huntsville, Alabama has been reduced to 15 days. There will be no booster-capsule static firing at Huntsville. Instead, MERCURY capsule no. 3 (Little Joe 5) to be launched at NASA Wallops Station, will be diverted to Langley Research Center prior to firing. Capsule no. 3 will be subjected to a simulated flight-noise environment produced by the exhaust from the Langley 9- by 6-foot thermal structures tunnel, and to a program of random mechanical excitation by electromechanical shakers.

Configuration.- The PROJECT MERCURY configuration is the same as that reported in Status Report No. 5. A general arrangement of the capsule in the three flight configurations is shown in figure 2.

Weight.- The current effective launch weight is 2,962 pounds, which is an increase of 90 pounds since Status Report No. 5. This launch weight still allows a high probability of achieving orbit with the current Atlas performance. Almost all of this weight increase is in the capsule itself. Some of the major design changes which have affected the weight are: shingle redesign (63 pounds); increase of insulation (3 pounds); landing-bag deployment mechanism (9 pounds); reinstatement of drogue parachute (19 pounds); and the addition of a super SARAH beacon (5 pounds). These changes, plus a number of small changes and updating of weights by actual weighing, have resulted in an increase of 124 pounds. A weight-saving program is being pursued concurrently and has accounted for a saving of 34 pounds in the last 3 months.

Escape system.- Analysis of the motions from the Little Joe flight tests has indicated a large reduction of the capsule's aerodynamic static stability during escape-rocket motor firing. The stability reduction is believed caused by escape-rocket exhaust flow field in the vicinity of the capsule afterbody. Because of the large reduction in static stability, the eccentricity of the escape-rocket thrust has been tentatively changed from a nominal of 1.07 inches (the value calculated to obtain a minimum Atlas capsule miss distance of 75 feet with no exhaust effects), to some value less than 0.5 inch. Studies are currently being conducted to determine a value of thrust eccentricity which will be compatible with both acceptable lateral loads and sufficient Atlas capsule miss distance. Qualification firing tests of the escape-rocket motors should be completed during May 1960.

Structure and heat shield.- Several important changes have been made to the capsule structure since the last report. For the most part, the changes have resulted from studies of external heating and airloads occurring during reentry and of parachute opening loads.

Conical section shingles have been increased in thickness from 0.010-inch thick L-605 cobalt alloy to 0.016-inch thick René 41 nickel alloy. They have also had the bead configuration more or less custom-fitted to stringer spacing so that less unstiffened portions exist. Shingle specimens incorporating these changes have been tested successfully under temperature time histories simulating severe reentry.

The light-gage shingles on the cylindrical portion of the capsule have been replaced by twelve 0.220-inch thick beryllium panels. These panels are retained in a manner that accommodates thermal expansion. External surfaces are painted black to increase emissivity.

The antenna fairing skin has been increased also to 0.031-inch thick nickel alloy and several minor changes in insulation have been made. The support structure for the antenna jettison mortar has been strengthened and proof-tested.

The combination of high pulloff angles of the drogue parachute and effect of reentry heating on the antenna fairing structure has required extensive structural "beef-up" in the antenna area. The cylindrical section structure was unable to support the antenna fairing and also required strengthening.

Recoil forces from the antenna fairing ejection mortar partially failed the upper capsule structure. The structure has since been strengthened and successfully resisted additional mortar firings.

Capsule structural tests are underway. Pressure and leak tests on various capsules do not indicate any structural inadequacy; impact tests with boiler-plate capsules but with production-type impact skirt are continuing; and vibration programs have been started.

Extensive investigation of the escape tower is underway. There are questions regarding tower strength during tumbling at maximum q aborts.

Retrograde rockets.- An ignition delay in the retrograde rocket motor occurred in the development program. A detailed investigation of the igniter showed that the squibs were rupturing the Fiberglas igniter tube, scattering the unignited boron pellets throughout the engine cavity. The igniter tube was changed to a 0.016-inch-wall Lamtex Porotube that would withstand the squib blast and be consumed by the burning of the boron pellets in the igniter. A test of the new igniter in a motor was successful. The qualification test program of 36 motors started the middle of April 1960.

Landing system (onboard).- The drogue parachute has been reinstated in the landing system as reported in Status Report No. 5. The time sequence for the off-the-pad abort case has been changed in a manner now to deploy the drogue parachute 2 seconds prior to the main parachute. Helicopter tests simulating off-the-pad aborts, deploying the parachutes in this manner, showed a marked improvement in the total time required for main parachute deployment.

A failure occurred in the qualification program in which the reserve parachute riser line was cut on the parachute disconnect. The riser line has been strengthened by 50 percent and covered with a heat- and abrasive-resistant Fiberglas sleeving at the parachute disconnect end, and the sharp edges of the parachute disconnect have been chamfered. Additional drop-tests are being planned to proof-test these modifications.

Due to the expected weight increase in the capsule, the values of the reefing parameters of the parachutes are being changed to keep the parachute shock loads below the structural design limit of 10,000 pounds. Tests are now in progress to validate these new values. The qualification test program will then be continued.

Environmental control system.- The environmental-control-system design and operation are basically the same as reported in Status Report No. 3 except for the following changes:

(a) The snorkel air inlet has been modified to bring air in from the conical side wall instead of through the cylindrical section. This change was necessitated by the installation of a beryllium heat sink on the cylindrical section which might have caused the snorkel air to become overheated following a severe reentry.

(b) The postlanding ventilation problem has been studied further. It has been determined that the temperature rise across the suit compressor is 10° - 12° F rather than 20° - 25° F as previously reported. This lower temperature rise, coupled with a maximum ambient temperature of 85° F and 85 percent relative humidity, provides ventilation air to the astronaut at a maximum temperature of 97° F with a 58 percent relative humidity. A series of human tolerance tests has been made under these conditions. The subjects were clothed in pressure suits and subjected to these postlanding conditions for 12 hours without serious physiological affect. Based on these tests, no modifications to the system have been made. The postlanding ventilation conditions will be further evaluated during the environmental-control-system tests and a decision will then be made on the requirements for system modification.

The current status of the environmental control system is as follows:

(a) The fabrication of the manned environmental-control-system training capsule has been essentially completed, and the test program at McDonnell was started during the week of April 18, 1960. This test will last approximately 4 weeks and the capsule will then be installed in an altitude chamber at the U.S. Navy Air Crew Equipment Laboratory, Philadelphia, Pennsylvania, for Astronaut training and additional system tests.

(b) Fabrication and qualification of the two 7,500-psi oxygen recharge carts have been completed.

(c) One unit of the Freon ground-cooling unit has been fabricated and qualified. The second unit is being fabricated.

(d) The fabrication, qualification, and delivery of capsule flight hardware is progressing satisfactorily. Approximately nine systems have been delivered to McDonnell, and with minor exceptions, the systems are complete.

(e) The subcontractor has experienced difficulty in fabricating the oxygen-bottle transducers and the high-pressure assemblies. Latest reports indicate that solutions to the problems are forthcoming.

(f) The 10 full-pressure suits received by NASA in November and December 1959 have been used extensively in Astronaut training and suit development. In general, the suits have been satisfactory except for decreased mobility due to the thick insulation layer and poor fitting and ballooning caused by stretching of suit fabrics. Human subjects dressed in uninsulated pressure suits have undergone numerous heat-chamber tests based on Big Joe reentry-heating data; responses of the subjects have indicated that the suit insulation layer is unnecessary. Investigations by The B. F. Goodrich Company, the suit manufacturer, indicate that the stretching problem can be solved by slightly undersizing suit patterns, modifying certain stitching allowances, and removing the insulation layer. Suit bulk will be further decreased by removing the spacer garment and attaching strips of the spacer material to the underwear. Two experimental suits were delivered in March 1960; three qualification suits were delivered on April 15, 1960. Evaluation of these suits indicates that mobility and suit-capsule compatibility have been greatly enhanced by removing insulation and spacer material and decreasing the stretching. Qualification testing will be performed in April and May 1960; production of Astronaut flight suits will commence in late May and should be completed in early July 1960.

(g) The principal items of pressure-suit support-equipment are suit-test consoles, portable ventilation units, and spare parts. The suit-test consoles will pressurize and ventilate a suit, measure leakage and flow-resistance, and provide a continuity check for the headset and microphones within the helmet; two such consoles will be delivered by the Firewel Company, Inc. early in May 1960. The portable ventilation units ventilate the astronaut between suit-donning and entrance into the capsule. These units are boxes roughly $\frac{1}{2}$-cubic foot in volume, weighing about 16 pounds, powered by silver-zinc batteries, cooled by ice cubes, and capable of providing cool air for about 45 minutes. One ventilator has been in use since December 1959; additional units will be procured from the A. J. Sawyer Company by July 1960. Complete sets of spare parts and repair materials are being obtained for both Langley and Cape Canaveral suit shops.

Attitude control system.- On the Automatic Stabilization and Control System (ASCS), all qualification testing has been completed and reports submitted by Minneapolis-Honeywell Regulator Company to McDonnell. On the Rate Stabilization and Control System (RSCS), the high and low temperature, acceleration, acoustic noise, altitude, salt spray, high potential, and voltage stability tests have been completed. The third ASCS has completed 660 hours of test, bringing the total hours of reliability testing on the two systems to 1,500 hours. Final reliability tests of 500 hours were started in the first week of April 1960. Eleven calibrators, together with supporting rate gyros and accelerometers, have been received by McDonnell. The vertical gyro acceptance rate has been slow; however, modifications to the design have been accomplished and delivery rate is expected to accelerate.

Heading reference tests have been conducted using the horizon scanner output with the attitude gyros. These tests give results consistent with the analog computer studies and Minneapolis-Honeywell error analysis.

The single-axis simulation tests on the ASCS have been successfully completed and tests are now underway on the RSCS. The reliability tests on the RSCS are in progress and will run for 1,000 hours.

Reaction control system.- Bell Aircraft Corporation has satisfactorily completed development tests of both the automatic and manual subsystems and approximately 80 percent of component qualification.

The main items yet to be qualified are the relief valves, the thrust chambers, and their associated solenoid, check, and throttling valves.

The original relief valve has been discarded as unreliable and a substitute has been developed.

Bell has completed a study of the normal system rate of decomposition, and McDonnell will install thermocouples on the propellant tanks to allow a more accurate determination of abnormal decomposition rates during prelaunch checkout.

The thrust chamber evaluation program at NASA Lewis Research Center has been completed. Indications are that the Bell chambers have satisfactory starting characteristics above 60° F. McDonnell heat transfer data indicate that the minimum chamber temperature during a 3-orbit mission will be 125° F.

Systems qualification and reliability testing is expected to start about the middle of May 1960 at Bell.

Pilot support and restraint.- The couches for the April training program on the centrifuge at the U.S. Navy Aviation Medical Acceleration Laboratory (AMAL), Johnsville, Pennsylvania, have been delivered together with a complete restraint harness. The Astronauts' experience with these couches will determine whether minor modifications will be needed for the final flight support and restraint system. Preliminary study indicates that a significant part of the headward movement resulting from tailward accelerations can be eliminated by pulling the lap strap down into the crotch with the inverted V strap.

Construction of the flight couches has been started.

Crew station layout, controls and displays (including egress and windows).- No major changes have occurred in the internal arrangement of the capsule display and layout during the past 3 months. Further operational qualification of the instruments for orientation and control of the capsule by the Astronaut has been continued. Experience to date indicates instruments are adequate.

The test program on egress has produced another aid for the Astronaut when leaving the capsule by the side hatch. The U.S. Navy School of Aviation Medicine has modified a standard 20-man raft in such a way that it can be placed around the base of the capsule and extended impact skirt. When the raft is then inflated, the capsule rides high enough to permit easy egress from the side hatch. Tests were done during the Astronaut training and although these results are preliminary, they appear to be of sufficient importance to continue the tests.

Communications (onboard).- The status of onboard communications is as follows:

Antennas -

S- and C-band antennas - Design approval tests have been completed.
VHF rescue antenna - Design approval tests have been completed.
HF rescue antenna system - With the exception of the rain test, all design approval tests have been completed.
HF balloon antenna - The balloon appears to be marginal and an alternate antenna-deployment system is under active study.

Telemetry - Design approval tests are about 70 percent complete. During these tests, troubles have arisen on voltage regulation, spurious radiation, the conduction of heat from the unit to the water tank, and noise generation during vibration. The voltage regulation and spurious radiation problems have been eliminated. Work is currently in progress on the temperature and vibration problems.

The overall telemetry system from the sensors through the ground range discriminators will be operated at McDonnell the first week in May 1960 to determine any discrepancies. The reliability report is scheduled for completion on June 15, 1960.

Command receivers - The design approval test report has been written for review by Collins Radio Company. The 1,000-hour test has been successfully completed. The reliability test report is expected to be completed on June 15, 1960.

HF orbital transmitter-receiver - The class C power amplifier tube with a 5-watt output could not meet the 1,500-hour mean time to failure with a transmit-receive duty cycle exceeding 1:9. The contractor has been requested to incorporate cooling provisions which will permit a transmit-receive duty cycle of approximately 60 percent during launch and insertion, and 30 percent during the balance of the mission. Since the present capsule instrumentation for the primate and unmanned shots does not provide the playback facilities for exercising the voice transmitters over all MERCURY range stations (command sites only), the contractor has been requested to provide this capability in capsules nos. 8, 9, 12, and 13 for all stations in accordance with the above duty cycle. These requirements do not apply to the recovery transmitter.

UHF voice transmitter-receiver - The above duty cycle and playback requirements also apply to the UHF voice transmitter.

HF/UHF rescue beacons - Design approval tests have been completed except for the radio interference tests referred to in Status Report No. 5. The design of a backup high-power UHF beacon has been completed. Design approval tests are now in process. Field tests are being conducted at Space Task Group (STG) to evaluate its effectiveness using various antenna systems which will be independent of the present descent antenna. This beacon is scheduled for break-in on capsules nos. 12, 13, 18, 19, and 20.

C- and S-band beacons - Design approval tests have been passed except for the acceleration and vibration. These tests are being rerun. The double-pulse coding circuitry failed the thermal tests and failed to meet the pulse tolerance requirements; delivery of beacons are being accepted without this circuit board, pending redesign of a coding board that can meet the requirements. Retrofit will be made on delivered units.

<u>Instrumentation</u>.- Blood-pressure instrumentation considered for use with the primate shots has been eliminated.

Special vibration instrumentation has now been deleted with the exception of capsule no. 8. This capsule will utilize all of the special vibration instrumentation as planned. The special vibration instrumentation package consists of a continuously-recording system into which is fed the output from one microphone (standard equipment on all capsules), one strain gage, and seven accelerometers. The accelerometers are to be located in various places on the structure, including the escape-rocket tower and the parachute compartment.

The O_2 supply and emergency pressure transducers were not qualifying due to the rupturing of the diaphragm within the transducer; however, the manufacturer is believed to have corrected the troubles now.

An integrating accelerometer has been incorporated to determine the capsule posigrade separation velocity and to establish the retrograde velocity. Environmental and reliability tests of this unit should start in June 1960.

Cameras - Radio interference tests for the instrument panel camera (Milliken DBM-7) have been completed and reported by McDonnell.

Some redesign of pilot and instrument cameras is required due to use of toxic materials in wiring and lacing. The Milliken Company (vendor) was notified of the discrepancy on March 15, 1960. All qualification tests have been successfully completed except the humidity tests. The earth-sky camera (Maurer 70-mm) has completed all qualification and reliability tests, has been accepted by McDonnell, and is now in stock.

Tape recorder (Consolidated Electrodynamics Corp.-C.E.C.) - High temperature and humidity test failures have resulted in some redesign of the unit. Six weeks will be required to redesign, rerun qualification tests and submit reports. Several retrofit items have been initiated including bias adjustment and takeup clutch. Functional test procedures for the tape recorder were received on February 2, 1960. The plastic brake on the takeup spool has been eliminated, and voltage regulators have been designed to maintain a voltage differential between two motors to provide proper tape tension. C.E.C. has designed retrofit kits to take care of this modification.

Time-delay relays (Wheaton Engineering Corp.) - Wheaton has completed qualification tests but McDonnell has not received any reports to date. No reliability tests are scheduled for these units. Some qualification tests were waived on a basis of similarity to the F4H test program.

Programer (Wheaton Engineering Corp.) - Qualification tests were made at Inland Testing Laboratories and were completed on approximately March 28, 1960. The acceleration test program is now in progress at McDonnell. The latest programer has had a major change in the escapement mechanism used in connection with the water-sponge squeezer. A stronger spring escapement should correct this trouble. McDonnell has now received five units.

Maximum altitude sensor (Donner Scientific Co.) - Capsules nos. 1, 2, and 3 will use an unqualified unit (7005). The qualified units, which will be a later model (7005B), will be available for capsules nos. 5 and up. Qualification testing is incomplete. McDonnell approval of qualification testing is dependent on resolving open relay coils which Donner claims are isolated cases.

Thrust cutoff sensor (Donner Scientific Co.) - This item is completely qualified; no qualification test was required on a basis of similarity to Lockheed Aircraft Corporation functional-environmental evaluation tests of similar units used in the Polaris program.

Satellite clock (Waltham Precision Instrument Co.) - Waltham clock no. 1 is due at McDonnell on approximately May 20, 1960, a delay occurred due to mechanical friction problems. Clock no. 2 is scheduled for qualification testing and will be delivered to McDonnell about 2 weeks after the first clock is delivered. Estimated starting date of qualification testing is June 30, 1960, to be completed by July 30, 1960. The delay is due to a shortage of qualification test units. The Waltham Precision Instrument Company advises that qualification tests can be completed in 1 month due to McDonnell approval of elimination of certain tests.

The McDonnell interim clock (made by McDonnell) is to be used on the first seven capsules if necessary, but will be replaced by the Waltham satellite clock when the latter is available. The first interim clock is already installed in capsule no. 3.

Satellite periscope - Preliminary tests have been completed. The Perkin-Elmer Corporation (vendor) is now involved in qualification testing which should be completed early in May 1960. No reliability tests are to be performed.

Horizon scanner - The Barnes Engineering Company submitted its first qualification test report to McDonnell, who suggested slight circuit modifications (the changing of certain resistance values) to decrease the background noise. Six horizon scanners have been accepted by McDonnell. A report from Barnes brought up a question regarding the "pitting" of the germanium window when the escape rockets are fired. In a test, 25, 50, and 75 percent of the area of a germanium specimen was subjected to sand-blasting. Measurements revealed that the transmissibility of the specimen decreased in direct proportion to the area sand-blasted.

Power supplies.-

Batteries	3,000 WH) 1,500 WH)	Qualification and reliability testing 100 percent complete
Inverters	250VA	Qualification testing 90 percent complete; 1,000-hour reliability test 50 percent complete
	150VA	Qualification testing started April 18, 1960. Require approximately 2 weeks to complete. 1,000-hour reliability test not started as of the date of this report.

Boosters

General status - Atlas.- The MA-1 booster (50D) has received the final inspection at Convair/Astronautics (CV/A), San Diego, California, and was found to be satisfactory. Delivery of the booster to the Air Force Missile Test Center (AFMTC) at Cape Canaveral is expected early in May 1960. The Abort Sensing and Implementation System (ASIS) will be aboard the booster for the MA-1 mission, but it will be restricted from initiating an abort.

However, the function of the ASIS will be monitored via the Atlas telemeter system.

Abort sensing.- A study of 43 Atlas flights showed that 13 of these flights would have been aborted by the ASIS had it been aboard. The missile destroyed itself in seven of the 13 cases and only one would have been aborted which otherwise would have been a successful flight. An analysis of flights showed an overall reliability of 67 percent for all missiles. This reliability has steadily improved from only 38 percent for the A-series missiles to 75 percent for the D-series missiles. To further improve reliability, the engines for the MERCURY-Atlas boosters will be selected by evaluating various parameters as determined from the log and test history of each engine. These engines will be chosen on the basis of average performance rather than peak performance, since it is believed that peak-performance engines may be more prone to malfunctions. A study was made to determine the response that a normally-functioning ASIS would have given during the recent failure of Atlas missiles 48D and 51D had the ASIS been aboard. The study showed that the ASIS would have sensed the booster engine malfunctions in time to initiate capsule aborts.

Atlas guidance.- The MERCURY orbital guidance equations have been completed by Space Technology Laboratories, Inc. (STL), Los Angeles, California, and are being programed by Burroughs Corporation. Actual Burroughs guidance computer hardware implementation will begin about May 30, 1960. The MERCURY orbital guidance equations are planned to be used for the first time in the MA-2 mission.

Quality-assurance programs.- The suppliers of both the Atlas and Redstone boosters have instituted special quality-assurance programs in order to provide the most reliable boosters feasible for MERCURY. Included in these programs are such items as:

(a) Special marking of all parts to be used in MERCURY boosters

(b) Special selection of parts to be as near nominal performance as feasible

(c) Additional testing to cover environments expected in MERCURY operations

(d) Special factory roll-out inspection, more complete than for standard production boosters

In addition, NASA will conduct a Flight Safety Review of each booster and its associated test history, inspection records, and so forth, prior to each flight.

Operations

Control centers and flight monitoring.- The layout of the Operations Room at Cape Canaveral is basically as shown in Status Report No. 5. Building construction for the Control Centers at Cape Canaveral and Bermuda is on schedule and should be complete by May 1, 1960 with the exception of minor partition changes at Cape Canaveral. The special consoles have completed mechanical and electrical assembly, and all console work should be completed by the end of the first week in May 1960. Consoles and common equipment, recorders, plotboards, cables, and junction boxes should arrive at Cape Canaveral and Bermuda during May 1960. Check-out of both Cape Canaveral and Bermuda will be conducted simultaneously and should commence near the beginning of June 1960.

Work has continued on further refinement of details of operations staff functions, responsibilities, procedures, and so forth, as a basis for ultimate operations plans and procedures. In most instances, concurrence of the DOD has been obtained. Contractural monitoring of Western Electric Company, Bell Telephone Laboratories, Stromberg-Carlson Division for Control Centers at Cape Canaveral and Bermuda, Bendix Radio Division of Bendix Aviation Corporation, and so forth, continues as the Control Center facilities proceed in design and implementation.

Training of flight-control personnel.- The training program for the Remote-Site Flight Controllers and for Cape Canaveral and Bermuda Flight Controllers has been inaugurated by a series of Space Task Group lectures accompanied by special study material on all capsule systems. The lecture series will continue for complete coverage of facilities, network systems operations, simulator equipment, and so forth. In addition, a program has been established for familiarization, orientation, and specialized instruction of the DOD group of aeromedical staff personnel who have been designated as members of Flight Controller teams.

The Cape Canaveral Control Center Simulator and the Remote-Site Simulator being procured for integrated training of Flight Controllers are in full contractural activity by Western Electric Company.

The site training program for Flight Controllers is under discussion with Western Electric Company for appropriate integration with the site operations personnel.

Specifications for the equipment and systems to be used for the training of the Remote-Site Flight Controllers and of the Control Center Operations personnel were submitted to Western Electric Company team in January 1960. Since that time, documents have been published which fully describe the areas of responsibility of the team members and details of the equipment each is to manufacture.

Target dates for completion of installation of the equipment are early August 1960 for the remote-site simulator and September 1960 for the Control Center simulation equipment.

Control Center Training Simulation

The specification issued in January 1960 was used by Western Electric Company as the basis of a proposal to the NASA. Western Electric has now been authorized to proceed with design engineering and procurement, and discussions between NASA and Western Electric and its subcontractors have led to the publication of a system design plan. Dated March 31, 1960, this document contains a detailed work statement which has been informally accepted by both NASA and Western Electric. However, formal acceptance of the plan and revised cost estimates have not yet been received from the contractor.

The plan calls for an interim open-loop capability by September 1, 1960. This open-loop operation will be used primarily for system familiarization, and depending upon launch schedules, orientation towards either MA-2 or MA-3. The simulation will utilize the capsule procedures trainer to supply the bulk of the data normally received via telemetry. Ultimately, provisions will be made to feed command functions exercised by the trainees back into the simulation so that realistic effects are achieved. Flight trajectory data, supplied by STL, will be prerecorded on tape and played back over the operational data link to the Communications Center at Goddard Space Flight Center for generation of display quantities. These will be retransmitted to Cape Canaveral, again using the operational data link. Voice communication circuits will be activated, with instructors representing all nontrainees with whom communications are required. All instructors and simulation equipment, including the procedures trainer, will be housed in a room in the Control Center building set aside for this purpose.

The contractor will also provide data tapes suitable for playback into the Bermuda IBM 709 computer so that the Flight Dynamics Officer's displays may be activated. This simulation will be open-loop only.

Work has now commenced on the program of simulated missions to be used for training the Control Center personnel.

Launch Operations

Range safety agreements.- During the past several months, a number of important agreements have been reached between the Range Safety Office at AFMTC and the NASA. These agreements have removed all of the major areas of conflict between the responsibilities of protecting the land areas and at the same time providing for optimum pilot safety. Some of the operating procedures remain to be written and agreed upon, but the ground rules for these procedures have been established. The following is a summarization of the more important range safety aspects:

(a) The Range Safety Office has no objections to the concept of the automatic abort system to be used in MERCURY missiles.

(b) Should a capsule abort occur, it will result in a cutoff signal to the booster. This signal will not be effective until 30 seconds after lift-off in an effort to avoid unnecessary missile impact on the launch site.

(c) A 3-second delay between fuel cutoff and enabling of the missile destruct package is to be built into the booster system.

(d) Should range safety limits be exceeded, the Range Safety Officer (RSO) will send a booster cutoff signal until a verification of the reception of this signal has been received, but in no case will this signal be transmitted for a period greater than 10 seconds in order to avoid unnecessary conflict with capsule commands originated from the AN/FRW-2 transmitter.

(e) On the MERCURY mission, utilizing the northeast launching azimuth and the 32.5° inclination angle, the RSO will relinquish control of the missile flight to the NASA when the predicted impact point has passed the island of Bermuda.

(f) At any time during the powered portion of the flight, the NASA will have the prerogative of terminating the mission by means of commands to the capsule within the ground rules established in (d) above.

(g) The NASA will be allowed the use of certain RSO command channels to generate a manual fuel cutoff to prevent an overspeed condition at orbital insertion.

Department of Defense Operations Support

General.- During March 1960, the Secretary of Defense and the Joint Chiefs of Staff approved the "Overall Plan for Department of Defense Support for Project Mercury Operations" submitted by Major General Donald N. Yates. Space Task Group is preparing for the DOD a series of documents which are the formal means of establishing the required operations support. The first is an "Operations Prospectus" which sets forth the management techniques by which NASA plans to discharge its overall program responsibilities in the operations area. The second is the "Program Requirements Document," a loose-leaf collection of program information necessary for effective continuing operational support. The first pages of this document were distributed in March 1960. The remainder of the formal documents to the DOD are the "Operations Requirements" for each test. These will be distributed at the time of commencement of launch preparations about 6 weeks prior to the launch date. A Mission Directive is also being prepared for each flight. This document provides an overall picture of the flight test but does not present detailed requirements.

Medical.- The DOD support for PROJECT MERCURY as outlined in the DOD Overall Plan, Support for PROJECT MERCURY Operations, has been approved by the Space Task Group. Approximately 30 physicians have been designated by the DOD as medical monitors for the flight program. These monitors will take part in a 2-week indoctrination training class starting in May 1960. The first week will be spent at Cape Canaveral in a briefing on the medical aspects of missile operations. The second week will be spent at STG for a series of lectures and demonstrations on capsule systems, astronaut medical histories and the monitoring stations. This training period will be followed by practice training sessions with the monitoring consoles and other station personnel.

Flight-Test Support

Further examination of the work schedule for capsule preparation has led to some changes. The first Redstone capsule is scheduled to be at Huntsville, Alabama for 15 days, where work will proceed on a 10-hour shift, 7-day week basis. The scheduled checkout period at Cape Canaveral is $6\text{-}\frac{1}{2}$ weeks. The necessity for the Huntsville checkout of future capsules will be reexamined later.

There has been no change in capsule preparation plans for MERCURY-Atlas flight tests.

The Launch Operations Branch of the Operations Division has prepared a Manual for Launch Operation which gives details of all procedures associated with capsule preparation and launch, including the participation of McDonnell personnel.

Ground-support equipment.- The installation of fixed base ground-support equipment has begun at Building S at Cape Canaveral, beginning with the weight and balance, and rocket alinement fixtures. The first set of trailer-mounted checkout equipment is being tested at McDonnell and will be shipped to the use site at the beginning of June 1960. Other ground-support equipment is in manufacture and present schedules are compatible with the launch requirements.

The flight-monitoring trailer will be shipped to Cape Canaveral at the beginning of June 1960 for installation of communications and command systems. An additional cable has been added to connect to an auxiliary trailer which will house the Missile Operations Intercommunication System (MOPIS) amplifiers and command-system tone generators.

Manufacture is proceeding on the mobile pad egress tower (cherry picker) and will be completed by the middle of July 1960. It has been decided to use this tower at the Atlas complex only.

Installation of the altitude chamber has begun and the majority of the work will be completed early in May 1960. Checkout and acceptance testing will follow, and it is expected that the chamber will be available for use by the end of May 1960.

Building facilities at AFMTC.- Progress on refurbishing the first floor of Building 575 at Patrick Air Force Base, Florida, is progressing and it should be ready for occupancy on July 1, 1960. This building will be used for launch, network, and data coordination activities by Space Task Group personnel. Modifications to Hangar S, including partitioning of existing office areas and construction or remodeling of structures on the hangar floor, are near completion. A proposal has been submitted for an additional building to be constructed adjacent to Hangar S. This building will provide for overflow of launch-preparation personnel from Hangar S and for flight-operation personnel. Approximately 20,000 square feet of additional area have been proposed as a minimum to meet near-future requirements.

Capsule Recovery

Recovery planning.- Organizational arrangements for DOD support of recovery operations have been formalized in an overall plan for support of PROJECT MERCURY operations. The Navy Deputy for Recovery coordinates planning for recovery operations with the Commander-in-Chief, Atlantic, and with the NASA. The Commander-in-Chief, Atlantic, has designated Task Force 40 as the PROJECT MERCURY recovery force and has assigned responsibility for this Task Force to the Commander of Destroyer Flotilla FOUR. This Destroyer Flotilla Command has been planning and conducting recovery operations for all PROJECT MERCURY operations to date.

During the past 3 months, planning has continued for support in the designated water landing areas in the North Atlantic Ocean for the 3-orbit flight mission. In addition, some progress has been made in preliminary planning in the following three areas:

(a) Launch-site recovery - Requirements have been discussed with DOD support forces, and one preliminary field exercise has been held. AFMTC operations personnel are currently preparing a detailed Launch-Site Recovery plan for submittal to ComDesFlot 4.

(b) Contingency recovery - Requirements to support recovery outside the designated landing areas have been discussed with DOD support forces. Work in this area is still in the preliminary information-gathering phase.

(c) Medical aspects of recovery - The U.S. Navy School of Aviation Medicine has been requested to develop a medical support plan for the MERCURY recovery operation. A preliminary plan has been presented to STG and is currently being reviewed. The plan details the numbers and location of medical recovery personnel, outlines the support equipments required, and defines the general modes of pickup, medical treatment, and astronaut debriefing. The medical recovery plan will cover both manned and animal flights and where possible, they will be identical.

Recovery operations.- Field tests have continued in evaluating pickup techniques, capsule water stability, and location-aid performance.

Pickup techniques.- Procedures have been evaluated for use in shipboard recovery during heavy seas. Some work has been done by both ships and helicopters in evaluating recovery feasibility with the extended-skirt heat shield. However, rough-water tests which are critical have not been made to date.

Capsule water stability.- Full-scale water stability tests using the egress training capsule have been made. The effects of extending the heat shield were studied and the tests were made in the Langley Research Center tank, thus providing for some limited study of the effects of waves. Capsule stability appears adequate for astronaut egress providing proper techniques are used. These tests all started with the capsule stabilized in the water. The transition phase following parachute landing remains to be tested.

Location-aid performance.- Electronic (HF and UHF) location-aid systems were evaluated in field tests. These tests have been directed mainly toward determining the performance capabilities of the present systems and evaluating means of improving this operational capability.

Tracking and Ground Instrumentation System

Schedules.- Construction is proceeding on schedule at Cape Canaveral, Bermuda, Grand Canary Island, the two Australian sites, and the Demonstration Site at Wallops Island.

Agreements have been signed with two Spanish firms to provide communications at Grand Canary Island.

Equipment is in the process of installation at the Wallops Station Demonstration Site with the first subsystem demonstration to start May 1, 1960, and the full-scale demonstration to start July 1, 1960. Installation of equipment at Bermuda was started April 29, 1960.

Siting.- With the completion of the Guaymas, Mexico survey, all siting surveys are now complete.

Government-to-government agreements for establishing Canary Island and Guaymas, Mexico have been signed.

Agreements covering Kano and Zanzibar are in process.

Guaymas, Mexico site design has been approved.

Detailed requirements for incorporating applicable portions of White Sands Missile Range and Pacific Missile Range have been completed.

Detailed requirements for the simulation systems to train flight controllers have been established and implementation is proceeding.

Western Electric Company has stated that the total contract is 24-percent complete, engineering design studies 67-percent complete, detailed engineering 55-percent complete, major equipment procurement 23-percent complete, subsystem manufacturing 13-percent complete, programing 55-percent complete, site preparation 10-percent complete, operator training 16-percent complete, installation 5-percent complete, spare parts 12-percent complete, and transportation and warehousing 7-percent complete. Three Active Acquisition Aids have now been shipped and the remainder are on schedule. The AN/FRW-2 command transmitters previously shown behind schedule are being expedited and the units designated for Bermuda, Pacific Missile Range, and Hawaii will be delivered with approximately 2 weeks delay in schedule.

Teletype network.- A recent traffic-load study on the teletype network shows that for the currently anticipated message traffic, the network is adequate and retains some reserve capacity for additional traffic. This reserve is a variable of mission time and is at a minimum during the launch and insertion phase.

Voice network.- This is limited to fewer stations than the teletype network but will be available to the following sites: Cape Canaveral, Bermuda, Muchea, Woomera, Hawaii, and all the sites on the North American continent. The requirement for voice access to the Canary Islands has now been removed.

Goddard Space Flight Center.- The Goddard Space Flight Center Communications Center has been coordinated into the network implementation and the automatic teletype switching system has met with their approval and is now being engineered. The complete automatic switching facility will become operational by January 1, 1961. The automatic system, less the automatic broadcast facility, will be operational by October 1960.

AFMTC coordination.- The DOD has been made cognizant of the MERCURY communications facilities, and some revision of terminal equipment at Cape Canaveral is being made to allow AFMTC/DOD operational use of the network.

Intercommunications facilities.- NASA presented their basic intercom requirements to the Western Electric Company and Bell Telephone Laboratories in January 1960.

Western's interim system proposal of February 1960 met with NASA approval, and final detail system approval is anticipated soon.

Cape Canaveral intercommunication.- The Cape Canaveral intercommunication system is a basic 15-loop system with specific personnel designation. The arrangements of loop designations within Tel 3 building have been completed. The interconnections between Tel 3 and the MOPIS facilities of AFMTC should be completed by the first of May 1960.

Remote-site intercommunications.- The remote-site intercommunications systems will have a basic 5-loop system (6 for Bermuda) with specific personnel designations.

The loop designations for the Flight Monitors have been completed, and the loop arrangements for the support personnel should be completed in the near future.

Communications procedures.- While basic procedures were developed to establish the basic needs for a communications facility, they are now being revised and extended to accommodate actual mission procedural requirements. These developments include but are not limited to:

(a) DOD participation in a basic network traffic exercise to establish the suitability of specific message formats, operator ability and probable network error.

(b) Technical support information programing to the Flight Controllers will be developed through simulated exercising of the positions of Maintenance and Operations Supervisor, Support Control Coordinator, and Communications Coordinator.

Computing systems.- The Goddard Space Flight Center IBM 7090 launch and orbit programs are presently being coded by the IBM Space Computing Center. The programs will be operational on approximately July 15, 1960. The work done on the Bermuda launch program indicated that an IBM 709 computer, having 8,000-word storage, would be very marginal. Therefore, the decision was made to obtain 32,000-word storage for the Bermuda computer. The Bermuda computer will be operational about May 15, 1960, and the complete Bermuda site will be operational about July 15, 1960.

Crew Training

The multiple-axis space test inertia facility located at the NASA Lewis Research Center was utilized in February 1960 to train the Astronauts not only to recognize and overcome the physiological and psychological effects of tumbling, but also to control such motion if it should occur during the actual capsule flight. A slow buildup of axes and rates was used in this confidence training. The final runs were made at 30 rpm in all 3 axes. In all cases, the Astronauts were able to bring the device to a stop in a short period, using the MERCURY-type rate indicator and hand controller.

Studies in star recognition.- The training program in star recognition and in yaw determination using apparent star drift was conducted during February 1960. Each Astronaut was given 2 days of personal instruction on the elements of celestial navigation and on star recognition by Dr. James Batten at the Moorehead Planetarium in Chapel Hill, North Carolina. Some practice in correcting yaw drifts was also achieved at the planetarium in a motorized trainer. This trainer simulated the view of the celestial sphere through the capsule window. Refresher training has been tentatively planned for later in the program.

C-131 weightless flying program.- During the week of March 7 to 10, 1960, an indoctrination program in free-floating during weightless flight was conducted for the Astronauts, using the facilities of the Air Force Wright Air Development Division (WADD), Dayton, Ohio. The rear end of a C-131B aircraft was cleared and padded to permit the Astronauts to float free within a 7-foot diameter, 15-foot long cylinder. From 12 to 15 seconds of weightlessness were achieved on each parabola. In all, 90 parabolas were flown during the six flights. During these weightless periods, the Astronauts had an opportunity to familiarize themselves with the orientation problems of floating in space with eyes open and closed. They also attempted to use tools and to move weights while suspended in space.

Egress training in the Langley tank no. 1.- Upon receipt of the McDonnell egress trainer in January 1960, the capsule was placed in the Langley tank no. 1. The Astronauts made egresses first in flight suits and later in the full-pressure suits. During this initial training, the basic techniques of leaving the capsule were developed. The final training runs were made with the wave motion simulator operating.

Open water egress training.- During the period of March 28 to April 1, 1960, open water egress training was conducted in the Gulf of Mexico, off Pensacola, Florida, in cooperation with the U.S. Navy School of Aviation Medicine. The McDonnell egress capsule was taken out to the Gulf in a Navy YSD. Each Astronaut made at least 2 egresses through the upper hatch in open water. State 3-4 seas (up to 10-foot swells) were experienced. No major problems were encountered during this program. The average of the best times made by each Astronaut was approximately 4 minutes from the completely restrained condition in the capsule to being in the raft in the water. Training was also provided in the use of the PK-2 life raft and other survival gear in a swimming pool and in open water. Plans are now being made to conduct an investigation into the possibilities of egress from the capsule through the entrance hatch. These tests are expected to be conducted at Langley tank no. 1 in the immediate future.

Johnsville centrifuge program.- The present (April 18 to May 7, 1960) Johnsville program incorporates a number of new aspects pertaining to simulation of the MERCURY flight. In addition to the dynamic simulation of the g profile and the effects of Astronaut control responses, which were part of the August 1959 program, the present simulation will include incorporation of the actual McDonnell seat and hand controller, a more complete simulation of the instrument panel, use of the full-pressure suit in both the ventilation and pressurization modes, depressurization of the gondola, and exposure to the noise associated with launch and reentry. These new facilities will permit the evaluation of a number of problems significant to the MERCURY mission, in addition to providing fuller, more complete training. Among the goals of the present program are the following eight items:

(a) To test the retention by the Astronaut of the straining technique and other skills developed in the August 1959 program

(b) To familiarize the Astronauts with the problems of straining under reduced pressure

(c) To familiarize the Astronauts with the problems of performing at high g levels with an inflated pressure suit

(d) To evaluate the couch manufactured by McDonnell

(e) To evaluate the hand controller developed by McDonnell

(f) To test proposed voice procedures under acceleration and reduced pressure

(g) To rehearse and evaluate the feasibility of a 2-hour countdown period following Astronaut insertion

(h) To provide initial experience with Redstone acceleration patterns.

Training Aids

MB-3 Static MERCURY trainer.- This static simulator is continuing to provide a manual-control training facility in the orbital mode, during retrograde for different retrorocket sequences and during reentry. The task display is a MERCURY-type rate and attitude indicator. Modifications to this trainer are presently underway in order to integrate it with the Procedures Trainer No. 1. The MB-3 computer setup will be ready to tie in to the Procedures Trainer when it arrives at Langley.

Orbital trainer (air-bearing).- This trainer is presently active in providing manual capsule manipulation training in the orbital mode. Several modifications to the basic trainer are now underway in order to extend its training capabilities to the retrograde mode and also to the use of the 1-pound thrust fly-by-wire reaction control system. These modifications should be completed by June 1, 1960. Further modifications call for the addition of an active rate and attitude display system.

MERCURY Procedures Trainers.- Construction of Procedures Trainer No. 1 is now complete and McDonnell is currently involved in checkout tests of the various systems. Delivery and installation at Langley is expected in early May 1960. This trainer will be used for Astronaut training in the management of capsule systems and, upon connection with a simulated remote-site tracking station, will enable down-range monitor personnel training.

Procedures Trainer No. 2, to be located at Cape Canaveral, has a current delivery date of July 1960. This trainer will also be used for Astronaut training and will be integrated with the displays in the Control Center Operations room to assist in training of the Operations staff who will direct the MERCURY flight operation.

Environmental Systems Trainer.- The Environmental Systems Trainer is scheduled for qualification demonstration by McDonnell for June 1, 1960. The Astronauts' training program is scheduled to begin in early July 1960 at the U.S. Navy Air Crew Equipment Laboratory, and continue through July. As presently conceived, it is expected that each Astronaut will receive approximately 20 hours in the environmental trainer, simulating various mission profiles.

Animal Program

The animal program has continued to progress satisfactorily. Current status of the program is as follows:

(a) A new supply of young animals has arrived at the Air Force Aeromedical Field Laboratory (AMFL), Holloman Air Force Base, Texas, and will be used as a source for further subjects if the need arises.

(b) Training - In addition to the training to simple shock-avoidance tests, the animals are now being taught to discriminate displays of symbols required for the advanced psychomotor test. Good progress is being made in this final task.

Feeding with special flavored pellets suitable for an automatic dispenser has led to adoption of a satisfactory design of pellets which move freely, will not crumble, and are palatable. Special packaging by the Ciba Company will obviate jamming in the dispenser.

(c) Training Support - The light sequence that will be found in the MERCURY capsule during flight has been received by AMFL and the training mockups will shortly be fitted with it. The panels will also be colored to simulate the flight item more closely.

It has been necessary to reengineer the pivots of the handles used by the animals due to the heavy wear and loads imposed during prolonged training use. A slight redesign of the couch has been necessary to clear obstructions during placement on the pallet. This has led to movement of the water bottle to a location between the animal's legs previously designed for the blood-pressure apparatus.

(d) Instrumentation - A very thin probe designed by the Yellow Springs Instrument Company, Inc. for small animals has proven satisfactory for rectal temperature measurements. The electrocardiographic electrodes are currently undergoing test. A working model of the respiratory sensor has not yet been received.

(e) Flight conditioning - Arrangements are being made to run the animals on the centrifuge at WADD and simultaneously impose the acceleration, sound, and vibration pattern that will be encountered during takeoff and recovery. The object is to determine if there is a performance decrement and if so, to precondition the animals so that they will not be distracted from their tasks during the flight of the vehicle. It is also desired to predetermine the response of the young chimpanzee to the physiological stresses of the flight. The tentative date for the first such tests is the week of May 23, 1960. Similar studies are planned using the environmental control system to determine the compatibility of the animal and system.

(f) Operational procedures - The six animal trailer vans have been accepted and were delivered by the contractor to the Space Task Group. Certain modifications are being carried out in accordance with suggestions of a visiting inspection group from AMFL. It is planned to make a first trial of the equipment during the centrifuge runs at WADD.

(g) Preliminary operational plans for Redstone animal flights have been drawn up, and at a conference at AMFL with Dr. Dietrich E. Beischer of Captain Ashton Graybiel's group from Pensacola, Florida, the training requirement and operational procedures for the animal recovery teams to be placed on board ship have been determined.

(h) Fabrication of the flight-pressurized couches is currently underway at McDonnell with deliveries scheduled to start in May 1960.

PRESENT STATUS - RESEARCH AND DEVELOPMENT PROGRAM

The NASA research and development program discussed in previous Status Reports is nearing completion. The following sections present a discussion of this research and development program.

Pilot Support System

Experiments will be conducted at the Holloman Air Force Base Aeromedical Field Laboratory to determine whether, without head restraint, interference may occur between the pressure-suit helmet and the occupant's face and head when accelerations force the occupant to nod. The subjects will be exposed to accelerations starting at 2g and increasing to 10g in 2g steps. The subjects will be dressed in a full-pressure suit. These experiments are scheduled for the first part of May 1960.

Tests of structural components of the couch at McDonnell show that the couch structure should pass the final qualification tests. The final qualification tests will be conducted as soon as the results of full-scale capsule drops being done by McDonnell are available.

Full-scale drop tests of the skirt-type impact bag at McDonnell are proceeding. The instrumentation has been checked out, however, and preliminary tests indicate that the orifices in the impact skirt are now correctly sized.

Wind-Tunnel Tests

As previously reported, the wind-tunnel program, which was initiated in February 1959, is complete. The results of these tests continue to be used in dynamic trajectory calculations of capsule motions and preflight trajectory studies for the MERCURY-Atlas, MERCURY-Redstone, and MERCURY-Little Joe flights.

Additional wind-tunnel tests to investigate further the effect on lift, drag, and static stability of the capsule-tower combination with the modified clamp which is described in the Configuration section of Status Report No. 5 have been completed.

Tests on the Atlas booster alone to obtain the necessary characteristics to allow studies of relative capsule and booster motion after separation during an abort have been scheduled, and will be conducted as soon as model construction is completed.

Little Joe Flights

Program.- The research and development flight-test program of five flights utilizing the Little Joe booster has been completed. The Little Joe booster is a fin-stabilized cluster of four large rocket motors, either Pollux or Castor types, and four auxiliary Recruit rocket motors.

Details of the five flights were given in previous Status Reports, but further analytical information is now available for flight no. 5 and is given below:

Flight No. 5.- Flight No. 5 was the final maximum dynamic-pressure abort test which was made on January 21, 1960.

Further analysis of the data indicates that maximum longitudinal acceleration at launch was 9.3g. Just prior to escape-motor firing, the longitudinal g was -1.4, and this changed to +11.3g at peak thrust of the escape motor and then reversed to -6.5g at escape-motor burnout. No significant change in longitudinal acceleration occurred at drogue parachute deployment, and when the main parachute was deployed, the g peaked at roughly 5.0.

Present records indicate that there was a capsule-tower oscillation in pitch of some $\pm 15^{\circ}$ at escape-motor burnout, and this damped down to $\pm 8^{\circ}$ approximately 11 seconds after abort initiation. The magnitude of the oscillation is considerably more than that obtained from theoretical estimates. Further analysis continues in this area.

Preliminary results of the physiological experiment indicate that the primate stopped performing the psychomotor task roughly 2 seconds after the escape-rocket motor fired, and despite shock stimulus, did not resume work until some 30 seconds later, i.e., after the drogue parachute was deployed. In addition, the animal suffered nystagmus (involuntary eyeball oscillations) just after the escape rocket fired, and also just after capsule impact with the sea.

Big Joe Flight

The thermal data obtained from the Big Joe research and development flight has been used to establish the thermal protection for the MERCURY capsule afterbody. Excessively high local heating has been found to occur on the cylinder which necessitated modifications to the capsule. The 0.010-inch L-605 cobalt shingles have been replaced by thicker 0.22-inch beryllium shingles which will now function as a heat sink. Material changes were also indicated for the shingles on both the conical section and the antenna canister. The current design calls for 0.016-inch René 41 shingles on the conical section and 0.031-inch René 41 shingles on the antenna canister. The Big Joe heat shield and afterbody heating data are presently being prepared for publication as NASA Research Memorandums.

PRESENT STATUS - QUALIFICATION PROGRAM

As previously reported, the operation concept for PROJECT MERCURY includes a qualification program of ground and flight tests so planned that as many hardware items as possible will be exposed to, and their operation proven in, those environments to which they will be subject in both normal and emergency conditions for orbital flights. The following sections contain discussions of the various parts of this qualification program in some detail.

McDonnell Qualification Program

General.- Visits to McDonnell are made by STG engineers to monitor tests by McDonnell and their subcontractors primarily at systems level. At component level, monitoring by STG engineers is limited to those components which evidence problems during environmental and functional tests.

Primary systems test status.- The testing status of most of the primary and integrated assemblies is listed in the discussions of each system in the section entitled PRESENT STATUS - MAJOR SYSTEMS. The status of other items is listed in the following paragraphs.

(a) Posigrade rocket - Qualification tests were begun on April 15, 1960. Delay is due to lack of qualified squibs and shortage of igniters.

(b) Pylon jettison rocket - Qualification tests started in March 1960. Delay is due to lack of qualified squibs and shortage of igniters.

(c) Horizon scanner - Qualification tests are complete; reliability tests are scheduled for completion about June 20, 1960.

(d) Explosive egress hatch - Exploratory auto-ignition tests on detonators prior to initiating qualification tests are being conducted. Qualification tests are scheduled for completion about the middle of May 1960.

(e) Explosive bolts - One explosive bolt tested at Langley seems to have detonated, the shield being destroyed and the bolt disintegrating into large fragments. It appears that other bolts may be on the verge of detonation indicated by occasional fragmentation. McDonnell has been notified of these deficiencies. Qualification and supplementary tests by Olin Mathieson Chemical Corporation on the retrograde release bolts are complete. Tests on the clamp-ring percussion bolts are continuing.

Material review records.- As in the past, these discrepancy reports of the capsule and associated equipment are being reviewed. It has been suggested that McDonnell prepare charts to determine whether the number of discrepancy reports are decreasing as production becomes more efficient.

Reliability program status.- McDonnell has submitted their reliability program status report 7007-7 for the period ending March 31, 1960. The number of failures reported during March was 176; the revised total is 837 to date. Accompanying the McDonnell report is the failure summary report which is an IBM listing.

Failure-mode analysis.- The failure-mode analysis is 90 percent complete; the preliminary orbital phase data has been submitted. A meeting at McDonnell on April 27, 1960 covered McDonnell's intentions for reducing the document into a useful tool suitable for astronaut and ground-training procedures, and maintenance manual.

Static Noise and Vibration Test

Flight-test results of the Little Joe program have indicated a higher aerodynamic noise environment than expected. In order to experimentally evaluate the effect of a sound pressure level of 150 to 155 decibels on the capsule with tower, McDonnell capsule no. 3 will be placed in the noise field of the Langley 9- by 6-foot thermal structures tunnel.

Before delivery of this capsule, McDonnell will perform a low-level dynamic response test on their 5,000-pound shaker. Various components and brackets will be instrumented during this test.

Before and after the capsule is subjected to the noise levels described, the capsule systems will be checked. Limited monitoring of the capsule will be made during the test. The capsule telemetry and onboard recorders will provide capsule systems performance data. Limited internal noise and vibration instrumentation will make it possible to determine the decibel attenuation through the capsule wall and vibratory effects. The Atlas-booster simulator will be used in checking the capsule sequencing system.

After completion of the noise test, the capsule will be subjected to mechanical "white" vibrations at the Langley Research Center Instrument Research Division. This work will be done on a 7,500-pound shaker. The capsule tower will not be on for this test in order that a higher g level may be reached.

Altitude Tunnel Tests

The escape-rocket motor tests on the Little Joe boiler-plate capsule at NASA Lewis Research Center have been reported in Status Report No. 5. Three additional escape-motor firings will be made during these tests at altitude as part of the rocket-motor qualification program. These tests started in April 1960.

A three-component balance to measure the torques due to posigrade and retrorocket misalinement on the capsule has been built by the NASA Lewis Research Center. The stand supports the heat shield with the retropackage which includes the retrorockets and posigrade rockets. The stand will measure the torques in the pitch, roll, and yaw planes to determine if the forces are within the tolerances of the reaction control system. The rockets will be fired at the maximum altitude of the tunnel of approximately 95,000 feet. Photographs of the rocket exhaust plumes will be made. Temperature and pressure measurements will be made on the retropackage and the retrorocket chamber pressure will be recorded. Six sets of posigrade and retrorockets are scheduled to be fired.

The retrorockets will be alined at Cape Canaveral to check out the procedures and alinement equipment, and thus serve to check the torques resulting from misalinement. These tests are scheduled in May 1960.

Two sets of posigrade rockets have been fired on the test stand and preliminary data analysis indicates that the resulting torques due to misalinement are well within the specified tolerances. Additional posigrade tests will be made with live retrorockets in the retropackage in May 1960.

Little Joe No. 5 Flight

Objectives.- One qualification flight test of a MERCURY capsule using a Little Joe booster is planned to take place during the summer of 1960.

This test, which utilizes McDonnell capsule no. 3, will be made to qualify the capsule and escape system at the combination of dynamic pressure, Mach number, and flight-path angle that represents the most severe conditions anticipated for an escape from a MERCURY-Atlas orbital mission launch. This flight will also be made with a medium-sized primate (chimpanzee) aboard. The flight will provide a performance test of the following: (a) escape system, (b) landing parachute system, (c) capsule water stability, and (d) location and recovery equipment.

Flight plan.- The Little Joe booster with the McDonnell capsule will be launched at a nominal elevation of 80° to the horizontal. In the booster, two empty Pollux rocket motors with dummy nozzles will be ballasted before flight so that the maximum dynamic pressure encountered during booster flight will not exceed 1,325 psf (a capsule design limit). Two Pollux and four Recruit rocket motors will be ignited simultaneously at lift-off. After 25 seconds of flight, the abort-initiation system will be armed, and at approximately 28 seconds, the system will sense a total-head pressure which corresponds to a dynamic pressure of 1,000 lb/sq ft. At this point, the capsule abort sequence will be initiated. Other conditions of flight will be: Mach No., 1.26; altitude, 22,000 feet; and horizontal range, 2.3 nautical miles. The escape and landing sequence will then operate as in a prestaging abort on an orbital MERCURY-Atlas flight.

Schedule.- Capsule No. 3 is now undergoing final systems testing at McDonnell. It is expected that the capsule will be delivered to the NASA at Langley Field during June 1960 where it will then be subjected to a program of acoustical and vibration tests. At the completion of these tests, the capsule will be transferred to Wallops Station and prepared for the Little Joe flight scheduled for the end of August 1960.

Ground operations.- The outline of the countdown for Little Joe No. 5 has been submitted by McDonnell and approved by the NASA. The detailed countdown and the capsule preparation plan are now being prepared.

Plans are being considered to relocate the Little Joe launch pad from the present area to the northern section of Wallops Island.

The trailers for the animal complex have been delivered to the NASA and are being checked out at Langley Field. The McDonnell checkout trailer and the Air Force telemetry trailer are now at Wallops Station for the beach-abort test of capsule no. 1. The checkout trailer will be returned to McDonnell for additional equipment required for the Little Joe No. 5 test.

All hardware required for the test has been manufactured. These items include ground cables, terminal boxes, junction boxes, the umbilical support tower, and the hardware for the abort-initiation system. The pressure switches which will sense the abort condition have completed qualification testing.

Redstone Flights

<u>Flight plans</u>.- Capsule No. 2, planned for flight testing on MR-1, is presently undergoing capsule systems tests at McDonnell and is scheduled to have an abbreviated capsule-booster system checkout at Huntsville, Ala.

<u>Separation tests</u>.- Separation tests utilizing a mockup capsule and Redstone adapter have been conducted at the Lewis Research Center altitude wind tunnel. These tests show that a favorable "pop-gun" effect approximately doubles the specification separation velocity when the posigrade rockets are fired. This increased separation velocity affords approximately 1,000 feet greater separation distance.

<u>Clamp-ring retention tests</u>.- Clamp-ring retention tests are presently being conducted at the Marshall Space Flight Center. It has been considered desirable to retain the segments of the clamp-ring at the separation to avoid unnecessary litter during an early abort in the Cape Canaveral area, and protect the Redstone booster from possible collision with the segments.

<u>Booster-television camera</u>.- It has been considered desirable to include a booster-television camera on MR-2 with the possibility that it be included on MR-3 flight. Preliminary preparation work concerning this camera installation is presently going on at the Marshall Space Flight Center. This camera would permit a view of separation and possibly an evaluation of the separation distance.

<u>Coordination panels</u>.- Working panels affecting the various problem areas of the MERCURY-Redstone flight-test program have been reduced in number; the areas of interest of the remaining panels are as follows:

Panel I (Chairman, J. B. Hammack, STG): Design coordination, supporting ground tests, fabrication, systems checkout, scheduling and shipping, and prelaunch activity.

Panel II (Chairman, Dr. K. H. Debus, MSFC): Range safety, pilot safety, pad safety, emergency procedures, communications, and recovery.

Panel III (Chairman, J. P. Mayer, STG): Trajectories, aerodynamics, and flight loads.

<u>Engines and airframes</u>.- All of the A-7 engines have been delivered by Rocketdyne Division of North American Aviation, Inc. MR-1 and MR-2 engines have been static fired and flight accepted. Fabrication of the

booster airframes has been completed on all boosters. Structural tests on the MERCURY-Redstone aft section have been completed.

Pad Abort Flight

A test is to be conducted at the NASA Wallops Station to demonstrate the overall capability of the escape system, the landing system, and the postlanding equipment during an off-the-pad abort. The test is scheduled to be conducted in early May 1960.

The test article will consist of a McDonnell-production capsule and escape tower (capsule no. 1) with the additional instrumentation necessary to evaluate the test. The capsule will be mounted on an Atlas D-series adapter, having a production-type capsule-to-adapter clamp-ring installation. The adapter will be rigidly mounted on a support fixture which will provide positioning of the launch angle and flight azimuth. A launch angle of 90° will be used, the main parachute will have 4 seconds reefing time and be 12 percent reefed, and the escape-rocket thrust eccentricity will be set at 0.5 inch.

MERCURY-Atlas Flights

Flight plans and objectives.- The MA-1 (capsule no. 4) is scheduled to be launched down the Atlantic Missile Range the week of July 4, 1960. The capsule will essentially consist of a MERCURY capsule structure and heat protection, parts of the landing and recovery system, all of which will be supplied by McDonnell and a sequencing and instrumentation system supplied by the NASA.

The test objectives for this mission are:

Capsule

(a) Determine the integrity of the MERCURY capsule structure and afterbody shingles for a reentry associated with a critical abort.

(b) Determine MERCURY-capsule afterbody heating rates during reentry.

(c) Determine the flight dynamic characteristics of the MERCURY capsule during reentry.

(d) Establish the adequacy of the capsule recovery system and recovery procedures.

(e) Familiarize MERCURY-Atlas operating personnel with launch and recovery operations.

Atlas-booster -

(a) Determine the ability of the Atlas booster to release the NASA capsule at the conditions of position, attitude and velocity defined by the guidance equations.

(b) Evaluate the open-loop performance of the ASIS.

(c) Obtain data on the repeatability of the performance of all Atlas missile and ground systems.

The MA-2 (capsule no. 6) is scheduled to be flown down the Atlantic Missile Range the week of September 12, 1960. The MA-2 capsule will include the following systems: Escape, Communications, Automatic Stabilization and Control, Automatic Reaction Control, a part of the Environmental Control, Electrical Power, and Landing and Recovery.

In general, the objectives of the MA-2 mission are to evaluate the capsule systems and determine the integrity of the capsule during a simulated normal reentry from orbit, and to establish operational procedures from prelaunch through recovery.

MERCURY-Atlas panel reorganization.- The new organization will include a permanent Coordination Panel with three subgroups reporting to it for guidance and coordination. The panels and functions thereof are as follows:

(a) Coordination Panel (Chairman, C. W. Mathews, NASA-STG) -

This panel will determine the broad aspects of integrating the Atlas and capsule into an operating system. In addition, it will be the main source of interchange of information on flight-test results between all agencies involved in the MERCURY-Atlas program.

(b) Flight Test Working Group (Chairman, B. P. Brown, NASA-STG) -

This is a subgroup which will have the general responsibility for coordinating launch activities at the Air Force Missile Test Center.

(c) Trajectory Analysis Group (Chairman, B. A. Hohmann, STL) -

This subgroup will have the responsibility for performance, trajectory, aerodynamics, loads, impact and dispersion studies, booster-capsule separation studies, real-time trajectory displays, and so forth.

(d) Change Control Group (Chairman, a member of the Coordination Panel) -

This subgroup will have changing membership, appointed by the Coordination Panel, to resolve technical details of changes to the Atlas capsule system and to assess the effect of changes on delivery schedules, and so forth. The membership of the group would depend on the nature of the particular problem. The group would cease to exist upon solution of the problem.

Each panel is composed of at least one representative from NASA (STG), McDonnell, Air Force Ballistic Missile Division, Space Technology Laboratories, Inc., and Convair/Astronautics. An additional representative from the Department of Defense will be included in the Flight Test Working Group.

PUBLICATIONS

The following papers relative to PROJECT MERCURY have been received during the last 3 months:

1. Pritts, O. R., and Mallard, S. R.: Pressure and Heat Transfer Distribution on a One-Tenth Scale Mercury Capsule at Mach Number 8. AEDC-TN-59-164 (Contract No. AF40(600)-800), Arnold Eng. Dev. Center, Jan. 1960.

2. Wallace, A. R., and Swain, W. N.: Static Stability, Heat Transfer, and Pressure Distribution Tests of NASA-McDonnell Mercury Models at Mach Numbers 17 to 21. AEDC-TN-59-157 (Contract No. AF40(600)-800), Arnold Eng. Dev. Center, Jan. 1960.

3. Robinson, Ross B., and Harris, Roy V., Jr.: Static Longitudinal Stability Characteristics at a Mach Number of 1.98 of a Nonlifting-Space-Capsule Model with Finned-Adapter Escape System. NASA TM X-261, 1960.

4. Johnson, Joseph L., Jr.: Wind-Tunnel Investigation at Low Subsonic Speeds of the Static and Oscillatory Stability Characteristics of Models of Several Space Capsule Configurations. NASA TM X-285, 1960.

5. Windham, John O.: Static Longitudinal Stability Characteristics of the Mercury Redstone Booster. Rep. No. DA-TM-10-60, Army Ballistic Missile Agency (Redstone Arsenal, Ala.), Feb. 1960.

6. Pearson, Albin O.: Wind-Tunnel Investigation at Mach Numbers from 0.50 to 1.14 of the Static Aerodynamic Characteristics of a Model of a Project Mercury Capsule. Proposed NASA TM X-292.

7. Rollins, R. H. II, and Domal, A. F.: Simulated High Altitude Tests of the Thiokol TE-316 Solid Propellant Retro-Rocket for Project Mercury. AEDC-TN-60-49 (Contract No. AF40(600)-800), Arnold Eng. Dev. Center, Feb. 1960.

8. Domal, A. F., and Rollins, R. H. II: Testing of the GCR 1KS-53,000 Solid Propellant Motor for the Mercury Model 133 Capsule Escape System at a High Simulated Pressure Altitude. AEDC-TN-60-48 (Contract No. AF40(600)-800), Arnold Eng. Dev. Center, Mar. 1960.

9. Shaw, David S., and Turner, Kenneth L.: Wind-Tunnel Investigation of Static Aerodynamic Characteristics of a 1/9-Scale Model of a Project Mercury Capsule at Mach Numbers from 1.60 to 4.65. Proposed NASA TM X-291.

10. Clark, Carl C., and Gray, R. Flanagan: A Discussion of Restraint and Protection of the Human Experiencing the Smooth and Oscillating Accelerations of Proposed Space Vehicles. NADC-MA-5914. Aviation Med. Acceleration Lab., U.S. Naval Air Dev. Center (Johnsville, Pa.) Dec. 29, 1959.

11. Rittenhouse, Lewis E., and Kaupp, Harry, Jr.: The Effect of Several External Modifications on the Static Stability Characteristics of the NASA Project Mercury Escape Configuration at Transonic Speeds. AEDC-TN-60-50 (Contract No. AF40(600)-800), Arnold Eng. Dev. Center, Mar. 1960.

12. Mercury Project Office: General Aspects of the Pilot Safety Program for Project Mercury Atlas Boosters. Rep. No. STL-TR-60-0000-69047, Space Tech. Labs., Inc., Feb. 8, 1960.

13. Collins, C. C., Crosbie, R. J., and Gray, R. F.: Pilot Performance and Tolerance Studies of Orbital Re-entry Acceleration; MA-8, Bur. Aero. TED ADC AE-1412, Aviation Med. Acceleration Lab., U.S. Naval Air Dev. Center (Johnsville, Pa.) Sept. 19, 1958.

14. Bell, Monty L.: Summary of the Aerodynamic Characteristics and Control Factors for Mercury Redstone. Rep. No. DA-TM-22-60, Army Ballistic Missile Agency (Redstone Arsenal, Ala.), Mar. 1960.

CAPSULE NO.	USE	MISSION
1	BEACH ABORT	SYSTEM QUAL. TEST ESCAPE - LANDING-POST LANDING
4	MA-1	UNMANNED - MAX G MAX HEAT ON AFTERBODY
3	LITTLE JOE-5	PRIMATE - MERCURY MAX Q ABORT
2	MR-1	UNMANNED BALLISTIC
6	MA-2	UNMANNED BALLISTIC ORBITAL - REENTRY MATCH
5	MR-2	PRIMATE BALLISTIC
8	MA-3	UNMANNED ABORT IMMEDIATELY FOLLOWING ORBITAL INSERTION
7	MR-3	MANNED BALLISTIC
9	MA-4	PRIMATE ABORT IMMEDIATELY FOLLOWING ORBITAL INSERTION
10	MR-4	MANNED BALLISTIC
13	MA-5	UNMANNED ORBITAL
11	MR-5	MANNED BALLISTIC
12	MA-6	PRIMATE ORBITAL
15	MR-6	MANNED BALLISTIC
18	MA-7	MANNED ORBITAL
16	MR-7	MANNED BALLISTIC
19	MA-8	MANNED ORBITAL
17	MR-8	MANNED BALLISTIC
14		UNASSIGNED
20		UNASSIGNED

COMMUNICATIONS NETWORK

MA-3 CANAVERAL - BERMUDA - CANARY ISLAND STATIONS MUST BE IN OPERATION TO MAKE TEST OBJECTIVE.

MA-5 MUST HAVE AT LEAST THE COMMAND STATIONS IN WORKING ORDER FOR THIS FIRING.

MA-6 ALL RANGE STATIONS MUST BE WORKING FOR THIS FIRING.

GSE USAGE

TENTATIVE PLANS CALL FOR GSE USAGE --

AT LANGLEY AND WALLOPS — MAC BLUE COT; AIR FORCE TEL TR

AT AMR — COT 1

AT CAPE
- MA-1 - MAC SUPPLEMENT TO EXISTING CAPE EQUIPMENT
- MA-2 THRU 8 — COT 3; TEL 2
- MR-1 - COT 2; TEL TR; FLT.MON.TR.
- MR-2 THRU 8 — COT 1 OR 2; TEL TR. 1; FLT.MON.TR.

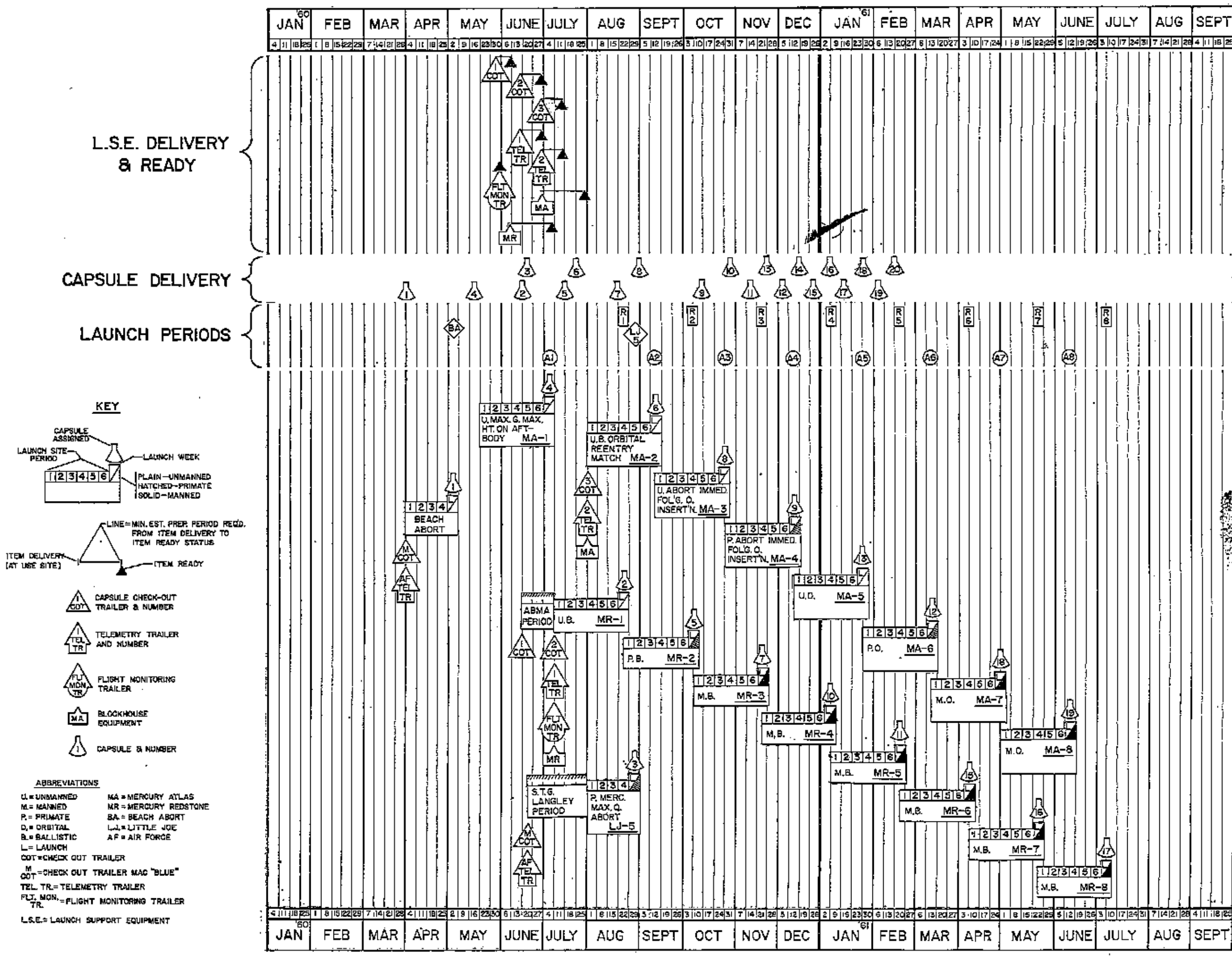

Figure 1.- PROJECT MERCURY master planning schedule.

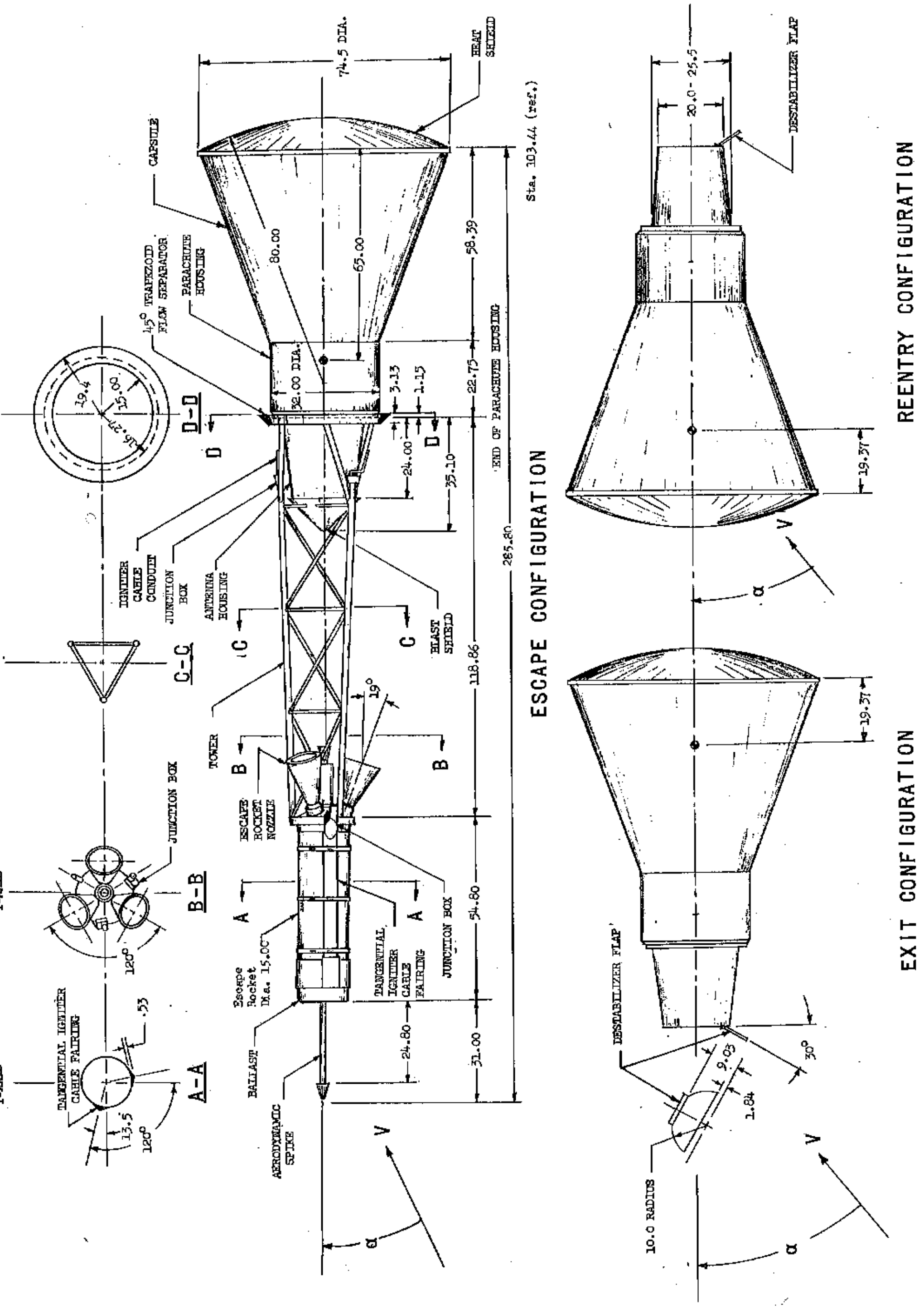

Figure 2.- General dimensions of the MERCURY configurations.

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