PROJECT MERCURY ASTRONAUT TRAINING PROGRAM*

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Introduction

This paper presents a general outline of the NASA Project Mercury Astronaut training program. Basic considerations which entered into the development of the program are listed. Six primary training areas are described, together with the training equipment and facilities employed. Problem areas for future training programs are discussed.

Any training program must be based on three factors: (1) the nature of the job for which training is required, (2) the characteristics of the men to be trained, and (3) the facilities and time available in which to do the training. In Project Mercury the astronaut's job involves both flight and non-flight tasks. He is expected to contribute to systems design and to the development of operational procedures through his daily contact with the project engineers. It was considered that, by virtue of the selection process, the astronaut had the skills required to make these contributions; therefore, no training was attempted in connection with the non-flight tasks. The astronaut's in-flight activities can be broken down into six areas: (1) "programming" or monitoring the sequence of vehicle operations during launch, orbit, and re-entry; (2) systems management—the monitoring and operation of the on-board systems, such as the environmental control, the electrical systems, and the communications systems; (3) the vehicle-attitude control; (4) navigation; (5) communications; and (6) research and evaluation. In addition to these in-flight activities, the astronaut has a number of ground

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tasks connected with the flight operations. He has a role in the countdown and preparation of the vehicle; in communications from the ground to the vehicle; and in the recovery program following the flight. It is for these activities associated with the flight itself that a training program was undertaken. More detailed descriptions of the astronaut's tasks are available in papers by Slayton[1] and Jones[2]. It should be noted that the astronaut's job is only one of many jobs associated with space flight for which training is required. Brewer[3] has outlined the overall training requirements for Project Mercury.

The astronaut selection program was designed to select individuals who would require a minimum of training in order to fulfill the Mercury job requirements. Particularly desired were individuals who had sufficient experience in aircraft-development operations to make immediate contributions to the Project Mercury program. On this basis, the following criteria were adopted as the mininum requirements for qualification as a Project Mercury Astronaut:

1. Age - less than 40.
2. Height - less than five ft. 11 in.
3. Excellent physical condition.
4. Bachelor's degree (or equivalent).
5. Graduate of test-pilot school.
6. 1,500 hours flying time.
7. Qualified jet pilot.

Records of 508 Air Force, Navy, Marine, and Army pilots who had graduated from test-pilot school were reviewed and screened on the basis of these requirements. Of these, 110 met the seven basic requirements. Forty-one of these pilots were eliminated through further screening based on recommendations from instructors at the test-pilot schools. The remaining 69 pilots were interviewed and given an opportunity to volunteer for the Project Mercury program. Of these, 37 pilots either declined or were eliminated as a result of the initial job interviews. The remaining 32 who were considered to be qualified in education and experience were given detailed medical examinations and were exposed to the physical stresses expected in the space flight. The nature of these tests has been described in more detail in references 4 and 5. On the basis of the medical examination and the stress tests, the number of candidates was reduced to 18, from which were selected the seven who demonstrated the most outstanding professional background and knowledge in relation to the job requirements. Through this procedure, a group of experienced test pilots with extensive training in engineering, excellent health, and a high motivation in the Mercury Project were selected for the training program. The availability of such individuals makes it possible to utilize self-instruction,to a great extent and thus to minimize the amount of formal group training required.

At the outset, few, if any, facilities were available to support the training program. Both training devices and training manuals have become available in stages throughout the first 12 to 15 months of the training program. The more elaborate and complete training devices were not placed in operation until more than a year after the program was initiated. As a result, the early part of the training program depended upon review of design drawings in vehicle components and on travel to various Mercury production facilities to attend design briefings. Verbal presentations by scientists of the NASA Space Task Group and of the prime contractor were heavily relied upon. In addition, early in the program, extensive use was made of established Armed Forces Aeromedical facilities for familiarizing the astronauts with the conditions of space flight. Thus, the training methods and the order in which topics were presented were, to a great extent, dictated by the resources available at the time the program was initiated.

Since mature, intelligent trainees were selected and since little if any training equipment was available initially, it might have been argued that the astronauts should be allowed to work completely on their own without any group program. There are, however, a number of desirable benefits to be derived from such a program. A planned group program facilitates the scheduling of activities with other organizations. In addition, a structured program permits more efficient use of instructor and student time. It also makes possible progress from one aspect of the operation to the next in an appropriate sequence. Sequence in training activities is important, since learning is simplified if material is presented in a logical order. An organized program also insures completeness in that no major training requirement is overlooked. Finally, since this project represents a first effort of its kind, the use of a group program facilitates the collecting of records and the evaluation both of the astronauts' progress and of the various training activities.

About one-half of the program which has resulted from these considerations is allotted to group activities, and the other half to individually planned activities in each astronaut's area of specialization. A review of the Astronauts' travel records reveals the relative division of their time between group training and other duties associated with the development of the Mercury vehicle. During the 6-month period from July 1 to December 31, 1959, the Astronauts were on travel status almost two months, or one out of every three days. Half of this travel time (28 days) was spent on four group-training activities: a centrifuge program; a trip to Air Force Flight Test Center, Air Force Ballistic Missile Division, and Convair; a weightless flying program; and trips to fly high-performance aircraft during a period when the local field was closed. The other half of their travel time (27 days) was devoted to individual trips to attend project-coordination meetings at McDonnell and the Atlantic Missile Range, or for pressure-suit fittings, couch moldings, and viewing of qualification tests at McDonnell, B. F. Goodrich Company, and their subcontractors' plants. These individual activities, while providing important training benefits, are primarily dictated by the Project Mercury development program requirements and are not considered part of the group training program.

The extent to which the Mercury crew-space area is "customized" to the seven astronauts, and the time required to fit the man to the vehicle, should be noted. Each man has had to travel to B. F. Goodrich Company for a pressure-suit fitting and to a subcontractor for helmet fittings; then to the Air Crew Equipment Laboratory for tests in the suit under heat and lowered pressure; then to McDonnell for couch molding. Usually, he has been required to return to the suit manufacturer for a second fitting, and to McDonnell for final fittings of the couch and studies of his ability to reach the required instruments and controls in the capsule. While the Mercury vehicle is more limited in size than future spacecraft, the cost of space flight and the limited personnel involved will probably always dictate a certain amount of customizing of the crew space. The time required for this activity should not be underestimated.

Training Program

The astronaut training program can be divided into six major topic areas. The primary requirement, of course, is to train the astronaut to operate the vehicle. In addition, it is desirable that he have a good background knowledge of such scientific areas related to space flight as propulsion, trajectories, astronomy, and astrophysics. He must be exposed to and familiarized with the conditions of space flight such as acceleration, weightlessness, heat, vibration, noise, and disorientation. He must prepare himself physically for the stresses he will encounter in space flight. Training is also required for his duties at ground stations before and after his own flight and during the flight of other members of the astronaut team. An aspect of the training which might be overlooked is the maintenance of the flying skill which was an important factor in his original selection for the Mercury program.

Training in Vehicle Operation

Seven training procedures or facilities were used in developing skills in the operation of the Mercury capsule. These included lectures on the Mercury systems and operations; field trips to organizations engaged in the Mercury Project; training manuals; specialty study programs for the individual astronaut; mockup inspections; and training devices. To provide the astronaut with a basic understanding of the Mercury system, its components, and its functions, a lecture program was set up. A short trip was made to McDonnell for a series of lectures on the capsule systems. These systems lectures were then augmented by lectures on operations areas by Space Task Group scientists. This initial series of lectures provided a basis for later self-study, in which use was made of written descriptive material as it became available. Individual lectures have been repeated as required by the developments within Project Mercury. A series of lectures on capsule systems by both Space Task Group and McDonnell personnel have been scheduled to coincide with the delivery and initial operation of the fixed-base Mercury trainer. In these lectures, the same areas are reviewed in an attempt to bring the astronauts up-to-date on each of the systems as they begin their primary procedures training program.

In addition to this lecture program, indoctrination trips have been made to the major facilities concerned with the Project Mercury operations. Two days were spent at each of the following facilities: McDonnell, Cape Canaveral, Marshall Space Flight Center, Edwards Flight Test Center, and Space Technology Laboratories and Air Force Ballistic Missile Division. One day was spent at Rocketdyne Division, North American Aviation, and five days were spent at Convair/Astronautics. At each site there was a tour of the general facilities, together with a viewing of Mercury capsule or booster hardware and lectures by top-level personnel covering their respective aspects of the Mercury operation. The astronauts also had an opportunity to hear of related research vehicles such as the X-15 and Discoverer, and of the technical problems arising in these programs and their significance for Project Mercury.

Obtaining current and comprehensive study materials on a rapidly developing program such as Project Mercury is a major problem. McDonnell has been providing manuals covering Project Mercury systems. The first of these, the Indoctrination Manual, was delivered at the time of an early astronaut visit in May 1959. No attempt was made to keep this manual current, and a first edition of a full systems manual (Familiarization Manual) was issued in September 1959. It quickly became out of date, however, and a new manual, a second edition of the Familiarization Manual, was issued in December of the same year. A first copy of the Capsule Operations Manual (Astronauts' Handbook) was delivered in June 1960. During initial phases of the program, the astronauts have had to depend primarily on capsule specifications and specification control drawings for written information on capsule systems. Copies of these, however, were not always available and they were too large to compile into a single manual.

Valuable aids to the astronauts in keeping abreast of the status of the development program are the regularly issued reports of the Capsule Coordination Group Meetings. At these meetings, the status of each of the capsule systems is reported and any changes are discussed. Miscellaneous reports on boosters and on progress have also been provided to the astronauts by cooperating agencies. Maintaining an up-to-date flow of accurate information on vehicle-development status is a critical problem not only for the Mercury training program, but also, in all probability, for most near-future space-flight applications, since training must proceed during the vehicle-development phase.

Another method employed in the dissemination of information was assignment of a specialty area to each astronaut. These assignments were as follows: M. Scott Carpenter, navigation and navigational aids; Leroy G. Cooper, Redstone booster; John H. Glenn, crew-space layout; Virgil I. Grissom, automatic and manual attitude-control system; Walter M. Schirre, life-support system; Alan B. Shepard, range, tracking, and recovery operations; and Donald K. Slayton, Atlas booster. In connection with his specialty area, each man attends meetings and study groups at which current information on capsule systems is presented. Regular periods are set aside for all the men to meet and report to the group. Another important source of information about the vehicle, particularly in the absence of any elaborate fixed-base trainers, has been the manufacturer's mockup. Each of the men has had an opportunity to familiarize himself with the mockup during visits to McDonnell.

Following the initial familiarization with the Mercury system, the primary training in vehicle operation is being achieved through special training devices developed for the Mercury program. Early training in attitude control was accomplished on the Langley Electronics Associates Computer (Figure 1) which was combined with a

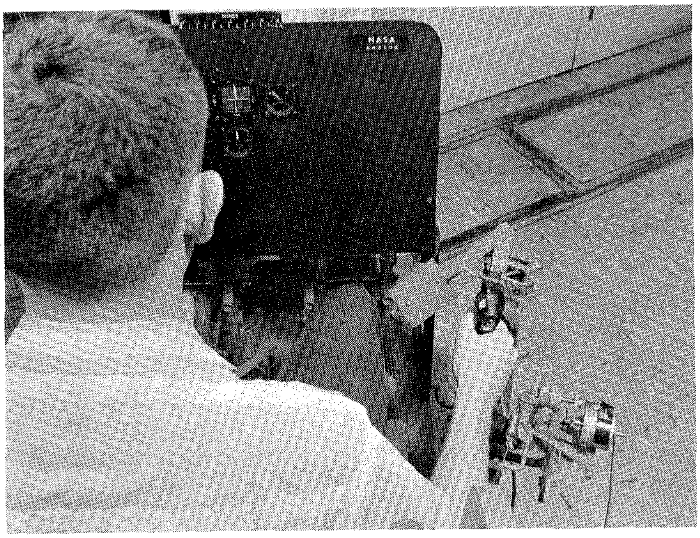

Figure 1. LEAC simulator: a simulator making use of an analog computer on which astronauts were given initial training in attitude control problems.

simulated Mercury attitude display and hand controller. This device was available during the summer of 1959. Later, another analog computer was "cannibalized" from an F-100F simulator and combined with actual Mercury hardware to provide more realistic displays and controls. This MB-3 trainer (Figure 2) also included provision for the Mercury couch and the pressure suit.

In addition to these two fixed-base simulators, three dynamic simulators were used to develop skill in Mercury attitude control. The first of these, the ALFA (Air Lubricated Free Attitude) Simulator (Figure 3) permits the practice of orbit and retrofire attitude-control problems by using external reference through simulated periscope and window displays. A simulated ground track is projected on a large screen which is viewed through a reducing lens to provide the periscope display. This simulator also permits training in the use of earth reference for navigation. The Johnsville Centrifuge (Figure 4) was used as a dynamic trainer for the re-entry

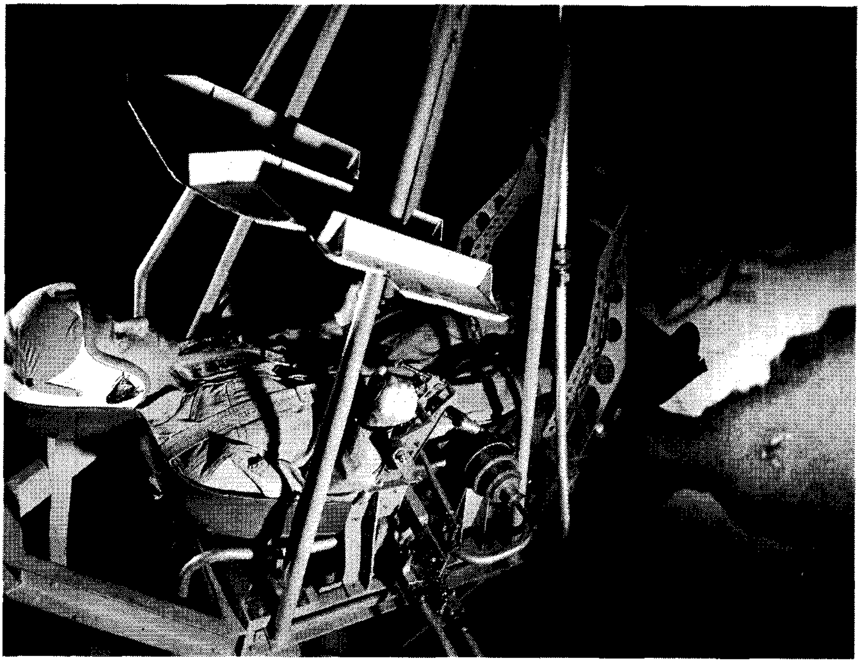

Figure 2. MB-3 simulator: a second stage of fixed-base attitude control simulation which incorporated the astronaut's couch, pressure suit, and Mercury hand controller.

rate-damping task because it adds the acceleration cues to the instruments available in the fixed-base trainers. It also provides some opportunity to practice sequence monitoring and emergency procedures during launch and re-entry. Another dynamic simulation device, used to provide training in recovery from tumbling, was the three-gimbaled MASTIF (Multi-Axis Spin Test Inertia Facility) device at the NASA Lewis Laboratory (Figure 5). In this device, tumbling rates up to 30 rpm in all three axes were simulated, and the astronaut was given experience with damping these rates and bringing the vehicle to a stationary position by using the Mercury rate-indicators and the Mercury-type hand controller.

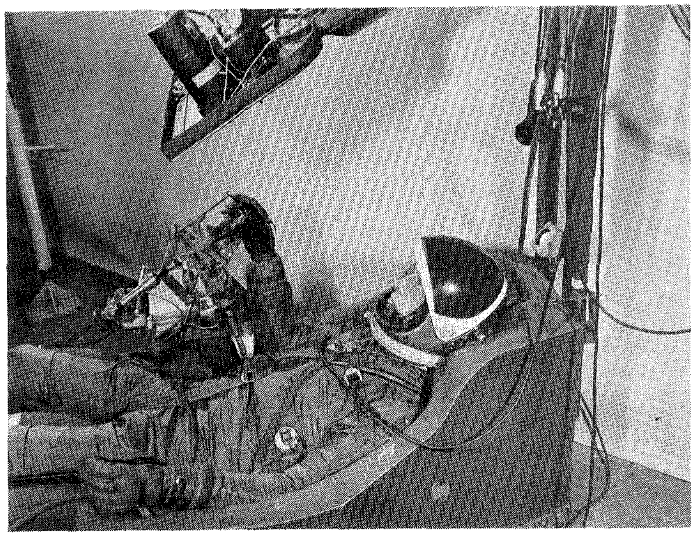

Figure 3. ALFA simulator: a dynamic simulator making use of an air bearing which provides practice in attitude control during orbit and retrofire phases of mission. External reference is simulated by use of a picture of earth from orbital altitude projected onto circular screen (seen behind trainer). Astronaut views screen through a set of mirrors and a lens which simulates periscope.

Two more elaborate trainers became available in the summer of 1960. These trainers provide practice in sequence monitoring and systems management. The McDonnell Procedures Trainer (Figure 6) is similar to the fixed-base trainers which have become standard in aviation operations. The computer used on the MB-3 has been integrated with this device to provide simulation of the attitude-control problem. External reference through the periscope is simulated by using a cathode-ray tube with a circle to represent the earth. Provision has been made for pressurizing the suit and for some simulation of heat and noise effects. The environmental-control simulator (Figure 7) consists of the actual-flight environmental-control hardware in the capsule mockup. The whole unit can be placed in a decompression chamber in order to simulate the flight pressure levels. This device provides realistic simulation of the environmental-control-system functions and failures. Effective use of these two simulators is predicated upon adequate knowledge of the types of vehicle-systems malfunctions which can occur. A failure-mode analysis by the manufacturer has provided a basis for determining the types of possible malfunction and the

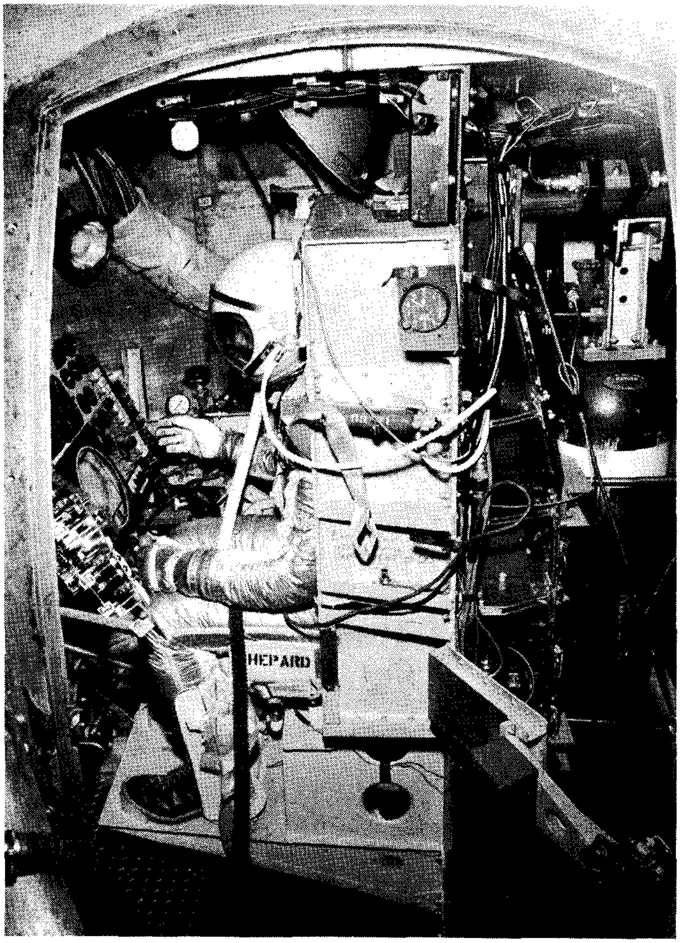

Figure 4. Johnsville centrifuge: centrifuge on which Astronauts were given experience with launch and re-entry acceleration profiles. Note that provisions have been made for use of full-pressure suit and for de-compression of the gondola. Astronauts are also provided with simulation of Mercury instrument panel and hand controller.

requirements for simulating them.[2] A record system on which possible malfunctions are listed on cards, together with methods of simulating them has been set up. On the back of these cards there is space for noting when and under what conditions a failure has been simulated and what action the Astronaut took to correct it. In this way, it is hoped that the experience in the detection and correction of systems-malfunctions can be documented.

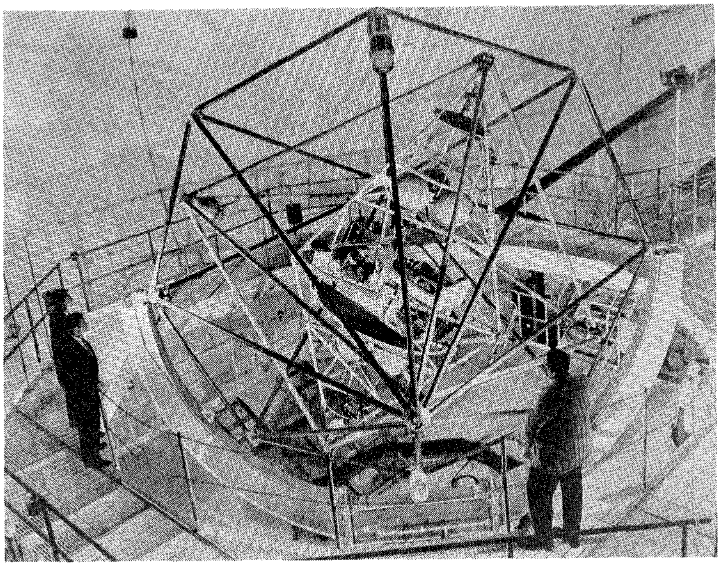

Figure 5. MASTIF simulator: a tumbling device on which astronauts experienced rotational rates up to 30 rpm in three axes. Once a steady rotational rate is achieved, astronaut assumes control and brings trainer to a stop by using instruments and controls similar to those available in Mercury vehicle.

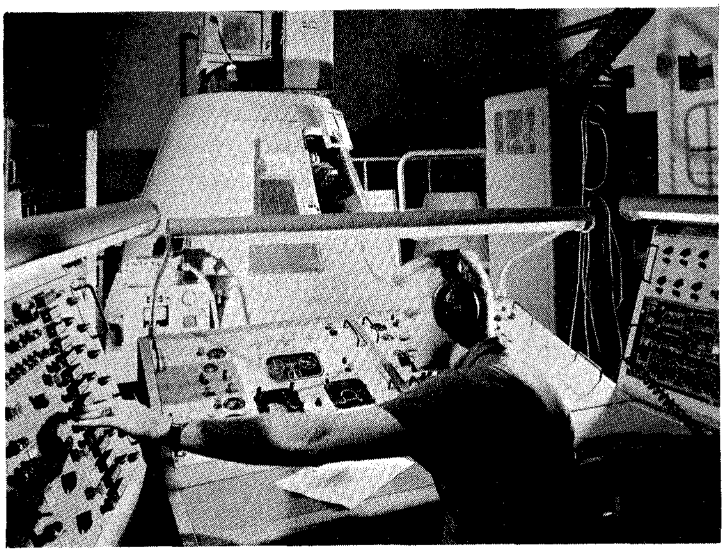

Figure 6. Mercury procedures simulator: a fixed-base trainer which permits practice in management of Mercury systems and attitude control. From instructor's console in foreground, faults can be inserted into any of the Mercury indicators. Astronaut's corrective action is signaled by lights on panel.

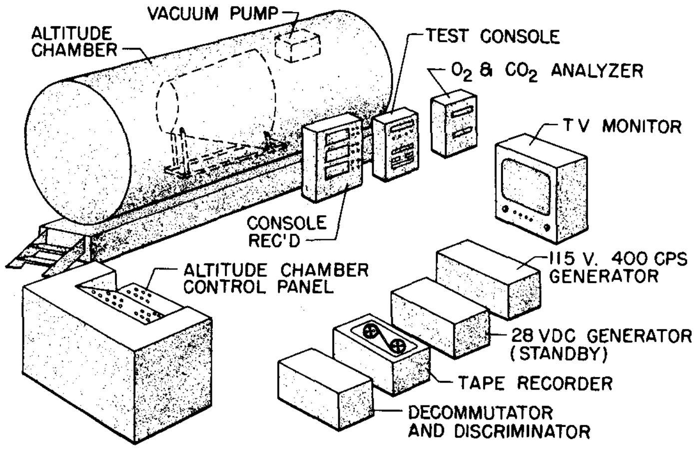

Figure 7. Environmental control system simulator: a device consisting of a mock capsule with a flight-type environmental control system which can be placed within a decompression chamber to simulate the operation of the environmental control system during the Mercury flight.

Training in Space Sciences

In addition to being able to operate the Mercury vehicle, the astronaut will be required to have a good general knowledge of astronomy, astrophysics, meteorology, geophysics, rocket engines, trajectories, and so forth. This basic scientific knowledge will enable him to act as a more acute observer of new phenomena with which he will come in contact during flight. It will also provide a basis for better understanding of the detailed information he must acquire about the Mercury vehicle itself. In order to provide this broad background in sciences related to astronautics, the Training Section of the Langley Research Center set up a lecture program which included the following topics: Elementary Mechanics and Aerodynamics (10 hours); Principles of Guidance and Control (4 hours); Navigation in Space (6 hours); Elements of Communication (2 hours); Space Physics (12 hours). In addition, Dr. W. K. Douglas, Flight Surgeon on the Space Task Group staff presented lectures on physiology totalling eight hours.

Following this initial lecture program, training in specific observational techniques is provided. The first activity of this program was training in the recognition of the primary constellations of the zodiac at the Morehead Planetarium in Chapel Hill, North Carolina. A Link trainer body was modified with a window and headrest to simulate the capsule's external viewing conditions. Using this device, the Astronauts were able to practice the recognition of constellations while the Planetarium was programmed to simulate orbital flight. Future plans call for further training in star recognition, together with methods of observing solar and meteorological events, earth and lunar terrain, and psychological and physiological reactions. These activities will be in support of a primary objective of the Project Mercury program, which is to determine man's capability in a space environment. The training program contributes to this objective in three ways:

1. By establishing base lines, both for the astronaut's performance and his physiological reactions. These base lines can then be compared with psychological and physiological factors in the space-environments.

2. Through the program in basic sciences described above, the Astronaut is given sufficient background with which to appreciate the importance of the observations he can make in the space-environment.

3. Specific training in observational techniques and the use of scientific equipment arms him with the skills with which to collect data of value to sciences.

Thus, the training program attempts to lay the groundwork for the scientific activities of the astronauts, as well as to provide the specific skills which are required to fly the Mercury vehicle.

Familiarization With Conditions of Space Flight

An essential requirement of the training program is to familiarize the astronaut with the novel conditions which man will encounter in space flight. An important part of the program, therefore, has been to provide the trainees with an opportunity to experience eight types of conditions associated with Mercury flights: high acceleration,weightlessness, reduced atmospheric pressure, heat, disorientation, tumbling, high concentration of CO_2, and noise and vibration.

The astronauts experienced acceleration patterns similar to those associated with the launch and re-entry of the Mercury, first at the Wright Air Development Division (WADD) in Dayton, Ohio, and later at the Aviation Medical Acceleration Laboratory at Johnsville, Pennsylvania. During this training, they were able to develop straining techniques which reduced the problem of blackout and chest pain. It was generally the opinion of the astronauts that the centrifuge activity was one of the most valuable parts of the training program.

The astronauts were given an opportunity to experience weightless flying both in a free-floating condition in C-131 and C-135 aircraft and strapped down in the rear cockpit of an F-100F fighter. While the latter is more similar to the Mercury operation, the astronauts, being experienced pilots, felt that there was little or no difference between this experience and their normal flying activities. They also felt, however, that the free-floating state was a novel and enjoyable experience. Since the longer period of weightlessness available in the F-100F aircraft is valuable for collecting medical data, while the C-131 aircraft appears to give the most interesting experiential training, both types of operations appear to be desirable in a training program. The fact that the pilots experienced no unusual sensations during weightlessness when fully restrained was an encouraging finding for the Mercury operation, and supports the desirability of selecting flying personnel for this type of operation.

The astronauts experienced reduced atmospheric pressure while wearing full pressure suits, first at WADD and later at Air Crew Equipment Laboratory (ACEL); in addition to reduced pressure, they also experienced thermal conditions similar to those expected during the Mercury re-entry while wearing a full pressure suit. At the Naval Medical Research Institute (NMRI), they were given an opportunity to become familiar with the body's thermal response, and the effect of moderate heat loads on the body's regulatory mechanisms was demonstrated. At the end of March 1960, the astronauts experienced disorientation in the U. S. Naval School of Aviation Medicine Slowly Revolving Room. As already mentioned, they have also experienced angular rotation up to 30 rpm in all three axes on a gimbaled device with three degrees of freedom at the NASA Lewis Laboratory.

In order to indicate the effects of the high concentration of CO_2 which might result from a failure of the environmental control system, the astronauts were given a three-hour indoctrination period in a sealed chamber at NMRI. In this chamber, they experienced a slow buildup of CO_2 similar to that which they would encounter in the event of failure of the environmental system. None of the men showed any adverse effects of symptoms from this training. As part of the selection program, the astronauts experienced high noise and vibration levels at WADD. During the second

Johnsville centrifuge program, noise recorded in the Mercury test flight was played back into the gondola. Further opportunities to adapt to the high noise levels associated with the Mercury launch will be provided by a sound system connected to the McDonnell Procedures Trainer at Langley Field.

Physical-Fitness Program

To insure that the astronaut's performance does not deteriorate significantly under the various types of stresses discussed in the previous section, it is important that he be in excellent physical condition. Since most of the trainees entered the Project Mercury program in good physical health, a group physical-fitness program, with one exception, has not been instituted. SCUBA training was undertaken because it appeared to have a number of potential benefits for the Project Mercury, in addition to providing physical conditioning. It provides training in breathing control and analysis of breathing habits, and in swimming skill (desirable in view of water landing planned in the Mercury program). Finally, there is, in the buoyancy of water, a partial simulation of weightlessness, particularly if vision is reduced. Aside from this one organized activity, each astronaut has been undertaking a voluntary fitness program tailored to his own needs. This program has included, for most of the astronauts, three basic items. First of all, as of December 1959, they have reduced or completely stopped smoking. This was an individual, voluntary decision; it was not a result of pressure by medical personnel, but of the individual's own assessment of the effect of smoking on tolerance to the stresses to be encountered in flight, particularly acceleration. Some of the members of the team who have a tendency to be overweight have initiated weight-control programs through diet. Nearly all members make it a habit to get some form of daily exercise.

Training in Ground Activities

The extent and the importance of the ground activities of the astronauts are frequently overlooked. Their knowledge of the vehicle and its operation makes them specially qualified for certain ground operations. The training in ground procedures has fallen into three main areas—countdown procedures, ground flight monitoring procedures, and recovery and survival. The astronauts are participating in the development of countdown procedures, and will be training themselves in their own part of the countdown through observation of countdown procedures for the initial unmanned shots, and finally, by participating in the preparation procedures for the actual manned flights.

An important aspect of the astronaut's activities when not actually flying the vehicle will be to aid in ground communications with the Mercury capsule. Since he is fully familiar with the capsule operation and intimately acquainted with the astronaut who will be in the capsule, he makes a particularly effective ground communicator. Procedures for ground monitoring and communicating personnel are presently being developed with the aid of the astronauts. At Langley Field, a ground monitoring station simulator will be tied in with the McDonnell procedures simulator. By using this device, ground-station activities can be practiced and coordinated with capsule-simulator training. The astronauts will also participate in training exercises at the Mercury Control Center at Cape Canaveral. Finally, just prior to manned flights, astronauts not involved in launch activities will be deployed to remote communications stations, where they will have an opportunity for on-site training.

A final area of ground training is in recovery and survival procedures. Study materials such as maps and terrain descriptions of the areas under the Mercury orbits are being obtained. They will be augmented by survival lectures and by field training in survival at sea and in desert areas. Finally, extensive training on egress from the capsule into the water has been given. This was accomplished in two stages, using the Mercury egress trainer (Figure 8). Phase One made use of a wave-motion simulation tank at Langley Field for initial training followed by a Phase-Two program in open water in the Gulf of Mexico.

<u>Maintenance</u> of flight skills. One of the continuing problems in training for space flight is the limited opportunity for actual flight practice and proficiency training. The total flight-time in the Mercury capsule will be no more than four to five hours over a period of three years for each astronaut. A question arises as to whether all the skills required in operating the Mercury vehicle can be maintained purely through ground simulation. One problem with ground simulation relates to its primary benefit. Flying a ground simulator never results in injury to the occupant or damage to the equipment. The penalty for failure is merely the requirement to repeat the exercise. In actual flight operations, failures are penalized far more severely. A major portion of the astronaut's tasks involves high-level decision making. It seems questionable whether skill in making such decisions can be maintained under radically altered motivational conditions. On the assumption that vigilant decision making is best maintained by experience in flight operations, the Mercury Astronauts have been given the opportunity to fly high-performance aircraft. The program in this area is a result of their own interest and initiative and is made possible by the loan and maintenance of two F-102 aircraft by the Air Force.

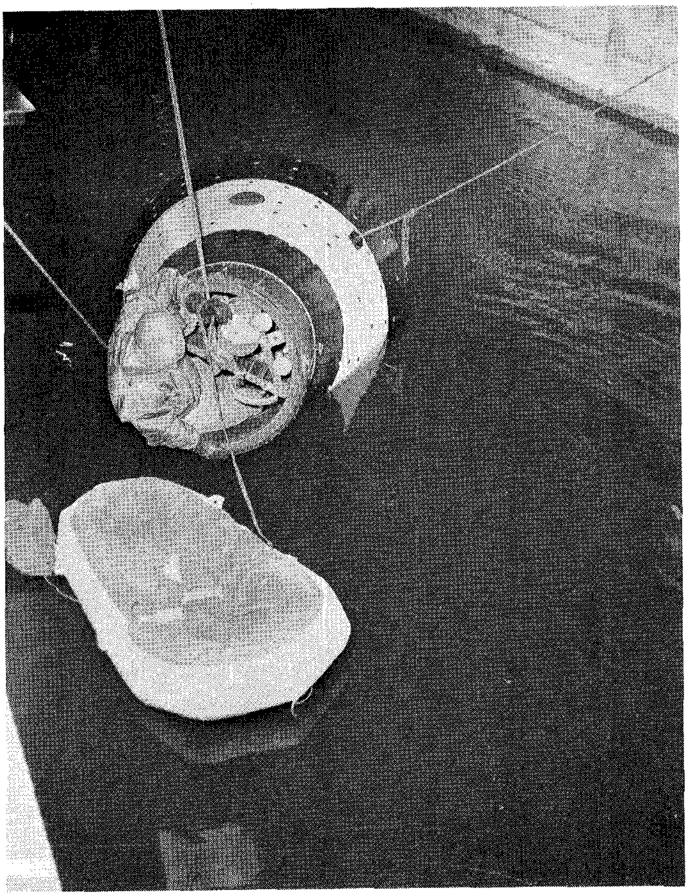

Figure 8. Environmental control system simulator: a device consisting of a mock capsule with a flight-type environmental control system which can be placed within a decompression chamber to simulate the operation of the environmental control system during the Mercury flight.

Implications for Future Programs

In conclusion, the problems relating to future space-flight projects which have been encountered in development of the Mercury program can be reviewed. In developing skills in operation of the vehicle, the difficulty of providing up-to-date information on the systems, when the training must progress concurrently with the development program, has been discussed. Concurrent training and development should tend to be a feature of future space-flight programs, since many of these will be experimental rather than operational.

All spacecraft have in common the problem of systems which must be kept functional for long periods without recourse to ground support. Even in the event of emergency termination of a mission with immediate return to earth, prolonged delay may occur before safe conditions within the atmosphere have been achieved. Thus, emphasis on "systems management" will increase in future space-operations programs. Recognition of malfunctions has always been a part of the pilot's task; usually, however, little in-flight maintenance is attempted. Since aborts are dangerous and, in any event, involve greater delay before return, the astronaut must make more detailed diagnoses of malfunctions and perform more in-flight maintenance. This will require extensive knowledge of the vehicle systems, and training in isolation and correction of malfunctions. In order to provide this training, as many as possible of the numerous malfunctions which can occur in even a relatively simple space vehicle must be identified and simulated. Considerable effort has been devoted to this area in the Mercury training and development program, and it should become an increasingly important feature of future programs.

The physical conditions (heat, acceleration, and so forth) associated with space flight are simulated to permit trainees to adapt to these stressors, in order to reduce the disturbing effects of such stimuli during actual flight. Present measures of the adaptation process are inadequate to provide criteria for training progress. A second purpose of the familiarization program was to give the trainees an opportunity to learn the specific skills required to minimize the effects of these factors on their performance. However, in many cases, the skills required have not been fully identified or validated. For example, in developing straining techniques for meeting increased acceleration, the efficacy of a straining technique has not been fully demonstrated, nor has the technique itself been adequately described. As yet, available data on the effects of combining physical stress factors are inadequate. Therefore, it is difficult to determine the extent to which the increased cost and difficulty of providing multiple-stress-simulation is warranted. In the present program, it has been possible to simulate both reduced atmospheric pressure and acceleration on the centrifuge. Initial experience seems to indicate that this is desirable but not critical. However, further data on the interacting effects of these stresses are required before any final conclusions can be developed.

A factor in space flight not yet adequately simulated for training purposes is weightlessness. Short periods of weightlessness have been included in the present program, as indicated previously. True weightlessness, however, cannot be achieved for periods long enough to be adequate for training purposes. On the other hand, ground simulation methods using water seem to be too cumbersome and unrealistic to be fully acceptable substitutes. At the present time, this lack of adequate simulation does not seem to be critical, since the effects of weightlessness on performance appear to be minor and transitory. Should early space flights uncover more significant problems, greater efforts will be justified in developing weightlessness-simulation methods.

Finally, it seems important to reiterate the requirements for reproducing adequate motivational conditions in the training program. The basic task of the astronaut is to make critical decisions under adverse conditions. The results of the decisions he makes involve not just minor discomforts or annoyances, but major loss of equipment and even survival. Performance of this task requires a vigilance and decision-making capability difficult to achieve under the artificial conditions of ground simulation. It appears probable that training in ground devices should be augmented with flight operations to provide realistic operational conditions.

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