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Selection and Training of Personnel for Space Flight

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THE ACCOMPLISHMENT of powered flight into space will depend not only on the development of suitable cabins, propellants and engines, but also on the equally important issues of selection and training of space crews. It is the purpose of this report to formulate, in the light of presently available information and opinion, a tentative outline of crew requirements for spaceships and then to interpret these requirements as a rational basis for guiding needed research on selection and training.

The discussion is premised on an orbital space flight to a circular satellite orbit from 500 to 600 miles above the earth's surface. The period of rotation of a spaceship at this altitude, in equilibrium with the force of gravity, is approximately two hours.[3] The first manned flight very likely will remain in a near circular orbit for weeks or months if no severe technical difficulties are encountered. From present concepts of the size of the cabin and its crew stations, it is estimated that the crew will consist of one to five members. Each will be required to be cross-trained for every crew duty and as a group they must operate in a co-ordinated fashion. Their missions will involve close physical proximity and co-operative activity for prolonged periods. As far as can be anticipated, the engineering of the cabin will provide sufficient protection so that no physiologic or medical qualifications, other than those currently in force for pilots, will be required. However, it is apparent that the mission will involve extremes of potential hazard of both physiologic and physical dangers, and will be capable of arousing intense fears of circumstances and possibilities unknown. At the same time this task is most enticing in prospects for glory and

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distinction in pioneering a new frontier—today's frontier of interplanetary space.

With these requirements and prospects, the two problems of selection and training will be considered. It is unlikely that the first crew will be "selected" in the conventional sense in which the term aircrew selection is understood. They will be men who have displayed genuine interest and competency for this job through association with the projects of designing, building, and testing prototypes and the actual vehicle in early flights. Nevertheless, these men must be qualified adequately in the attributes which will be required in subsequent selection of space crews.

SELECTION

In analyzing the personnel requirements for any situation it is necessary to consider the following aspects of the problem: (1) the aptitude and skill requirements essential for performance of the task; (2) the biologic and physical requirements related to the environment, the machine and the mission; and (3) the psychologic stresses which may be anticipated and the tolerances they imply.

Aptitude and skill requirements.—Because all crew members must be cross-trained and the pilot will have the pivotal responsibility, this analysis is based on the position of pilot.

Present concepts of the space craft suggest that its operating characteristics will not be radically new. It is expected to be very much like a conventional rocket ship. Once launched into orbital flight, mainly by automatic controls, the ship will have to be monitored to a certain degree during the time it is in orbital flight and then brought down through the atmosphere to a landing. Once within the atmosphere a conventional landing will be made by the use of wings and a tricycle gear, after an extended glide, quite like the landing of a large jet aircraft. Descent and landing will require essentially the same skills as those used in the pilotage of medium and large jet aircraft. Training and experience in piloting jet and rocket aircraft will be most useful for transition to the space craft.

Using trained jet and rocket pilots as a source of personnel, the critical aptitude and skill requirements for space crew members tentatively appear as follows, when considered in relation to the requirements set forth earlier: (1) expert knowledge and proficiency in piloting high-performance aircraft (minimum experience and proficiency requirements could be used effectively to screen in this area); (2) a high level of general intelligence; (3) high mathematical and numerical ability; (4) knowledge and proficiency in aeronautical and electronics' engineering, demonstrated by a formal training prerequisite and/or performance on an examination; and (5) knowledge and proficiency in navigation and astronomy sufficient to learn the fundamentals of astronavigation as well as high speed, high level aeronavigation. These proposals may be regarded as hypotheses subject to empirical validation.

The selection of pioneer crews for initial flights will doubtless follow the same pattern as that which has of

necessity prevailed in selection of outstanding present test pilots—such as Yeager, Bridgeman, Smith, Everest and Murray—who are recognized for their pre-eminent ability and interest in meeting new challenges.

Biological and physical selection requirements.—The general configuration of the orbital space craft is the first concern. Because of the necessity of the return of this craft to the earth and its aerodynamic landing, it will have a configuration generally conforming to present medium and large jet bombers and transports, with certain modifications. For example, von Braun stated in "The Mars Project" that the length of the third stage of the ferry vessel will be 15 meters, its aft diameter 9.8 meters, its wing span 52 meters, and its wing area 368 spare meters.[6]

The cabin of the inhabited space craft will be sealed and the temperature and atmosphere will be automatically controlled. Instruments will be numerous and complex, and every effort will have been made to engineer mechanical and interpretative errors out of them. Working and living facilities will be reasonably habitable and utilitarian. Adequate space will be provided for rest, limited exercise and recreation.[2] Von Braun predicted that an upper limit of 9 *g* would be imposed during take-off and a much lesser deceleration than this on landing.[6] Very recently Preston-Thomas and his associates published similar estimates.[4]

Some tentative biologic and medical selection standards can be proposed for crew members of this type of spaceship. In the first place, persons of ordinary dimensions are indicated and no unusual muscular strength appears necessary. Present day physical standards for jet pilots appear to be appropriate, at least as a minimal qualification. Tests of individual tolerances to special stresses, such as prolonged high *g* force,[1] zero gravity conditions, and prolonged wearing of pressure suits, should be investigated for inclusion in the physical selection procedure. Eventually the entire examination should be validated against appropriate criteria in the same manner as the other selection tests.

Psychiatric and psychologic adaptability requirements.—The final consideration in selection is concerned with the psychologic stresses of the mission on the crew members. It is essential to eliminate candidates who may be considered unlikely to maintain efficient performance while experiencing the actual and perceived hazards, threats and deprivations of space flight. This area of selection is difficult and complex, and the one in which there is perhaps the least complete information today. Nevertheless, it is recognized that further assessment is required of the individuals qualified on the first two sets of standards to determine their fitness to adapt to the peculiar stresses of this type of mission. The personnel to be assessed will be experienced pilots of high performance aircraft and may be assumed to have already accepted the usual stresses and dangers of flight. These factors could probably be best considered by reviewing critically the experience and the history of hazard exposure of the candidates.

Additional stresses over and above those of jet and rocket flight must be considered. In our opinion, by far the greatest problem involves the implications of a seemingly complete break from the earth and the protective societal matrix in a small, isolated, closely confined container with a few companions. Little is known today about the effects of confinement and social isolation on individual and group behavior, particularly under the hazardous and threatening conditions of space flight. We believe that research on these problems may indicate important possibilities of improving the habitability of the space craft and of achieving an optimal group structure for efficient operation under the assumed conditions. Based on current scientific knowledge, we can only speculate on the characteristics of the person most likely to enter such a situation with confidence, equanimity and the least likelihood of psychologic breakdown or interpersonal conflict.

The following proposals might serve as hypotheses for selection research in this area. They are formulated in terms of presumed favorable and unfavorable characteristics in relation to the situational demands.[5]

1. MOTIVATION. The successful applicant is expected to manifest intense motivation for this project. This may be revealed through an enduring interest in this general field, supported by tangible evidence, such as special readings, courses or studies of subjects related to space flight (e.g., astronavigation, rocket fuels and satellite construction), participation in test flight, engineering or other aspects of research or development projects, or other activities expressing interest as manifested in studies, occupational and recreational choices. Although this selection program will be confined to volunteers, the assessment should ascertain that desire to participate is *thus* consistent with an expectation of adequate need satisfactions rather than expressions of neurotic problem solution, such as viewing the project as a substitute for other supports catering to immature dependencies or as a means of therapy for their neurotic strivings.

2. COOPERATION. Because it is expected the job will demand co-operation as well as skill, importance is attached to ability to relate well with associates and assume responsibilities in a co-operative situation. This implies the capacity freely to place trust and confidence in associates as well as to win their trust and confidence. Underlying this capacity are positive interpersonal attitudes, mature character integration and emotional stability, involving an inner sense of duty, responsibility, self-control and restraint.[5]

3. ADVENTUROUSNESS. Characteristics indicative of willingness and ability to take calculated risks appear also to be essential. In effect, these describe persons who are characteristically daring but not foolhardy. To a large extent these characteristics may be reflected in the man's flying experience and military history, but systematic methods of assessment need to be devised and validated.

Established psychologic tests or psychiatric techniques are not yet available to assess these characteristics, although research in this school is developing useful instruments and approaches in this general area. The importance of these problems argues strongly for the continuation of long-term research focused on these problems.

TRAINING

Training and preparation of those selected as suitable for the job will

probably require several years prior to takeoff. This phase will involve the last major source of pre-mission attrition because of the high degree of selection which will already have been accomplished. It seems reasonable to expect that the training will involve three phases: (1) ground school or academics, (2) simulator training, and (3) transition flight training within the earth's atmosphere and at space equivalent levels.

The first space crews are expected to be pioneers who, in many respects, will have to be their own instructors. They will have the help and advice of many technical experts and will gradually go beyond the points where many of our present test pilots are now probing. Much of their work in the simulator and transition phases will proceed necessarily on a trial and error basis. However, everything indicates that their task will consist primarily of a gradual extension of contemporary flying techniques to the problems of the new altitudes, speeds and media which they will invade. These men and the procedures they develop, together with the correlated knowledge accumulated through their experience, will constitute the eventual basis on which more formal training programs will be constituted.

Present concepts of space flight suggest that academic training should consist of advanced studies in applied and theoretical mathematics, electronics, engineering, navigation, astronomy and astronavigation. Intensive courses on the design and construction of the spaceship, familiarization with the control of the ship under normal and emergency conditions and, finally, detailed instruction in basic spatial aviation medicine should be included.

The training sequence employing an appropriate simulator developed for this specific purpose will probably be conducted during and following the academic training phase. It is possible to envision this as a synthetic instrument training cabin in which the crew can learn and become familiar with procedures, the characteristics of the instruments, the cabin, and personal equipment as well as working with each other as a co-ordinated team.

Transition will complete the training and may necessarily involve using both a balloon gondola and an actual spaceship either towed or carried to altitude, or powered by more conventional means. In this phase the crew will gain experience in the characteristics and maneuvering of the ship within ranges of altitude where the atmosphere still has aerodynamic functions. Following this may come the final exercises of short, rocket-powered journeys into space equivalent areas and under gravity free conditions.

CONCLUSIONS

The problems of selection and training of space flight crews have been reviewed with tentative proposals based upon present concepts of the characteristics of the early space craft and its probable mission. Because these proposals must be both general and tentative until they are modified by mockups and actual experience supported by research, emphasis was placed on defining problems and presenting the broad outlines of a plan rather than a blueprint. One conclu-

sion which seems of particular interest as a consequence of this analysis is that space flight is not drastically different from most aspects of aviation which are now familiar. When engineers solve the remaining problems of development, it is expected that personnel will be available with the resources and capabilities to undertake the mission. Space flight may thus be approached as the addition of another dimension to the gradual unfolding of the sciences which have already made magnificent accomplishments in powered flight. However, it is necessary that research and interest in the human factors' aspects keep abreast of progress in engineering.

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Helicopter Ambulance Service

The value of the helicopter in war for evacuating the wounded was well demonstrated in the Korean campaign. In any future war helicopters are likely to be one of the main means of transport of serious casualties. Their peacetime use in medical emergencies is just being realized. Recently a helicopter brought medical aid promptly to the scene of an accident on board a Dutch vessel off Flamborough Head. A seaman was badly injured, and radio calls for medical assistance brought a medical officer of the Royal Air Force by helicopter, which landed on the deck of the vessel. A helicopter service is of greatest help in isolated districts many miles from expert medical assistance. In parts of Scotland districts are often cut off by snow in the winter so that roads are impassable for a period of time. Last winter in "Operation Snowdrop" supplies were landed in cut-off villages by naval helicopter, and some patients suffering from illness and exposure were rescued by their means. Anticipating that such conditions might arise again, the Scottish North Eastern Regional Hospital Board has now arranged to bear the cost of a helicopter ambulance service operated by naval helicopter from Lossiemouth, which, subject to prior claims by the Navy, will be available for the transport of civilian patients to a hospital in an emergency. A device is now available that enables the helicopter to "scoop" the casualty from the sea, or scene of accident, without landing.—Letter from England: *Journal of the American Medical Association,* Dec. 3, 1955.