FOREWORD

This bibliography was prepared in the Operator Training Section of the Training Research Branch, Behavioral Sciences Laboratory, under Project 1710, "Training, Personnel, and Psychological Stress Aspects of Bioastronautics," Task 171003, "Human Factors in the Design of Systems for Operator Training and Evaluation." Dr. Ross L. Morgan was the Project Scientist and Dr. Theodore E. Cotterman was the Task Scientist. This bibliography was started in January 1961 and covers reports up through December 1961.

ABSTRACT

In this bibliography a list of reports is compiled from a number of disciplines which bear on the problem of motion and its effects on human performance. Psychophysiological reports in the area of spatial orientation, perception, and receptor mechanisms provide background on the human organism in relation to motion stimuli. The effects of aerospace vehicle motion are represented by a compilation of studies of performance under acceleration, vibration and buffeting, tumbling, and weightlessness. Finally reports on training and motion simulation, equipment and methodology, and general analyses of the whole problem area are presented.

PUBLICATION REVIEW

This technical documentary report has been reviewed and is approved.

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INTRODUCTION

Would the simulation of aerospace vehicle motion in an aircrew mission simulator contribute to its training value? With certain exceptions pilots have been trained for years on fixed base flight simulators which provide no motion cues or sensations. The training value of these devices has been generally recognized. The few simulators which did have some limited motion capability were accepted on the rationale that motion contributed to training "realism." In addition, the opportunities for relatively safe, on-the-job training experience in conventional missions were sufficient to downgrade the importance of the limited motion simulation possible in ground training devices. However, current emphasis on high-speed, low-altitude bombing missions and space vehicle missions with their obvious hazards and high costs increases the likelihood that the major portion of aerospace vehicle crew training will be concentrated in ground training devices. These unique mission environments interact with the system dynamics of particular vehicles and operator controls to produce motions which may impose unusual demands upon the skill of a pilot or astronaut.

The high-speed, low-altitude mission is an operational necessity, permitting manned bomber vehicles to fly "under" hostile radar detection systems. The pilot's attention to his primary flying task is heightened by the need to fly close to terrain obstacles which could destroy the aircraft, and to keep from penetrating some upper altitude limit. The need for increased maneuvering causes the pilot to experience a variety of motion cues. The vibrations and buffeting caused by winds, turbulence, terrain, or sloppy aircraft configuration result in a highly stressful situation, tending to degrade operator performance over extended periods of time.

The requirements for launching a vehicle with present fuels dictate that relatively high accelerations be sustained by the astronaut over relatively short periods of time. During the orbital phase, the astronaut will experience weightlessness. The long-term effects of weightlessness on the human body, on performance, and on the perception of motion cues are virtually unknown. Re-entry into the atmosphere is accompanied by vibrations (also encountered in the launch phase), accelerations, and sometimes tumbling.

Since these missions may subject crew members to a variety of accelerations, buffeting, tumbling, vibrations, etc., both singly and in combination, ground-based training systems will have to simulate these phenomena to the degree required for effective training. Any ground-based system can only approximate the full range of aerospace vehicle motions possible. But, since even limited simulation can be very expensive, we must determine what motion characteristics are required for training and how best to simulate them.

We have a training problem, but we have little in the form of experience or data on which to solve the problem. In this bibliography we have compiled a list of reports from a number of disciplines (i.e., aviation medicine, physiology, medicine, aerodynamics, engineering, etc.) which have been valuable in studying the effects of motion on performance, in the absence of a systematic assemblage of empirical data applicable to the motion problem. As

a whole, the bibliography should prove useful to the researcher who wishes a more complete understanding of a very complex problem area. The various subsections may aid the systems designer or training specialist seeking what little data does exist in these more circumscribed areas.

The bibliography covers a broad range of topics because of the complexity of even partially simulating the spectrum of motion stimuli encountered in aerospace flight. The first section (Motion Stimuli and the Human Organism) consists of reports on spatial orientation, vertigo, the perception of motion stimuli, nystagmus, and the physiology of vestibular receptor mechanisms. In Section II (Research on the Effects of Aerospace Vehicle Motion) are listed reports on acceleration, vibration and buffeting, tumbling, and weightlessness research. Acceleration physiology studies and reports on weightlessness are only partially listed, since both areas have been so well reviewed previously, and only a limited number of the reports have some relationship to training. The studies most directly related to training and motion simulation research are listed in Section III. Reports on motion simulation equipment and methodology are listed in Section IV. In Section V literature surveys, analyses, and general reports on space science and aviation medicine are listed. An AD or ATI (Astia Document) number is listed in many of the bibliographic entries. These may be ordered from Armed Services Technical Information Agency, Arlington Hall Station, Arlington 12, Virginia. A PB number indicates that the report may be purchased for a nominal fee from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

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