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HUMAN FACTORS LITERATURE RELEVANT TO CIVIL AVIATION: A GUIDE FOR MANAGEMENT AND DESIGN ENGINEERS

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INTRODUCTION

PURPOSE AND SCOPE OF THE BIBLIOGRAPHY

The importance of considering "human factors" in the design of man-machine systems, underscored by demands for effective and safe manned weapon systems in World War II, becomes more important daily with advances in industrial, military, and space technology. Premium is placed upon such factors as system reliability, safety, speed, and efficiency, all of which, once the machine part of the system is fixed, can become a function of its "man" aspect. Today, human factors has become a broad, interdisciplinary science cutting across traditional fields of experimental psychology, applied physiology, physical anthropology, industrial design, and engineering. But communication proglems exist between scientists representing these fields and engineers, R & D managers, and operations personnel who typically are responsible for systems design, development, operation, and analysis. Engineers, for example, are rarely exposed to biology, anthropometry, and sensory psychology during their undergraduate college study, only in the last year or two have educators reached general consensus on the need for human factors courses in engineering curricula. Consequently, few engineers have any great familiarity with the human factors body of knowledge.

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Bibliography, FAA Office of Aviation Medicine Report AM 64-20, October 1964; The National Airspace System: A Bibliography of Selected References, FAA Systems Research & Development Service, July 1965; and Aviation Medicine Reports: An Annotated Catalog of Office of Aviation Medicine Reports: 1961 through 1965, FAA Office of Aviation Medicine Report AM 66-1, January 1966.

The user who desires access to the most recent human factors research should consult the major journals in the field. These include Human Factors, Ergonomics, and Aerospace Medicine. The latter two journals also include sections containing abstracts of current literature. Other relevant journals are IEEE's Transactions on Human Factors in Electronics, Journal of Engineering Psychology, and The Journal of Environmental Sciences. To find out "who's doing what" currently, one can also use the services of the Science Information Exchange of the Smithsonian Institution.

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I. GENERAL REFERENCES

Human Factors Design Engineering

1. McCormick, E. J. Human Factors Engineering (2nd Edition of Human Engineering). N. Y.: McGraw-Hill, 1964.

   This reorganized and updated textbook provides both a theoretical and practical orientation for the human factors design of man-machine systems and equipment. This new edition includes several new chapters on systems development.

   Among the topics presented are man-machine systems; the development and use of human factors information; human sensory and motor processes; human processes in man-machine systems (human information processes, speech communication, human motor activities, controls, displays, man-machine relationships); workspace and arrangements of elements; environmental factors (lighting, noise, vibration, atmospheric conditions); and systems development and simulation.

2. Morgan, C. T., Cook, J. S., III, Chapanis, A. & Lund, M. W. Human Engineering Guide to Equipment Design. N. Y.: McGraw-Hill, 1963.

   This comprehensive source of human engineering information compiled from the joint Army-Navy-Air Force human engineering handbook, will help the engineer to design equipment that is compatible with the abilities and performance characteristics of the human operator. This book is a guide in human engineering which the designer can use in the same manner as a handbook. It is specifically arranged and illustrated so that it can be most useful in helping to solve design problems of nearly any type of human operated equipment.

   Particular emphasis is given to man-machine system planning and evaluation; the visual and auditory display of information; the design of controls and workplaces; design for ease of maintenance; environmental effects on performance; and anthropometric data.

3. Woodson, W. E. and Conover, D. W. Human Engineering Guide for Equipment Designers, 2nd Edition. Berkeley: University of California Press, 1964.

   Written primarily for engineers, this book is regarded by many as a basic reference for human factors design recommendations. The second edition has been considerably expanded over the first, and utilizes results of much recent research. Organized as a guide, the book presents little discussion and no theory.

   Detailed recommendations are given for equipment and workspace design; controls and displays involving vision and audition; body

measurement; and other factors such as body sensitivity, movement, control and orientation. The design recommendations are incorporated into a large number of charts, tables and nomographs.

Aviation Medicine

1. Armstrong, H. G. (Ed.) Aerospace Medicine. Baltimore: Williams and Wilkins, 1961.

   This book with 21 contributing authors examines in detail the medical problems of both civil and military aviation and astronautics, and is based to a large extent on USAF studies. It is written for the student and practitioner of aviation medicine and for the designer and operator of aerospace equipment.

   Among the variety of topics included are the following: historical introduction to aerospace medicine; medical and psychological examination and selection of air crew personnel; atmospheric conditions and altitude physiology; effects of the various types of acceleration; effects of temperature and noise; escape, survival and rescue; toxicology; aircrew maintenance; aeromedical evacuation; hygiene and sanitation; aircraft accidents; and space medicine.

2. Gillies, J. A. (Ed.) A Textbook of Aviation Physiology. Oxford: Pergamon Press, 1965.

   An excellent and comprehensive textbook written primarily for the physician involved in aviation physiology, this work is a useful guide to the effects of the aviation environment on man.

   The 46 chapters are organized into 9 sections with these titles: 1) physical environment of flight; 2) general effects of reduced atmospheric pressure; 3) oxygen deprivation at reduced barometric pressure; 4) thermal stress and survival; 5) accelerations; 6) noise and vibration; 7) visual factors in aviation; 8) aircrew performance; and 9) aircraft accidents.

3. Sells, S. B. & Berry, C. A. (Eds.) Human Factors in Jet and Space Travel. N. Y.: Ronald, 1961.

   A collection of articles written to provide needed up-to-date information on human problems in high performance flight, this book presents a comprehensive view of the role of human factors in aviation.

   Among the topics discussed are: preventive medicine in jet flight; environment of flight; human qualifications and requirements for jet and space travel; performance under non-normal environment conditions; radiobiology; human engineering aspects of jet and space vehicles; and aircraft accidents and flight safety.

Protection and Survival

1. Burns, N. M., Chambers, R. M. & Hendler, E. (Eds.) Unusual Environments and Human Behavior, London: Free Press of Glencoe, 1963.

   This book is concerned with the general problems man encounters in the unusual environments of marine submergence, air travel and aerospace explorations. The first half of the book considers the general physiological and psychological effects of these while the second half examines the specific problems of isolation, acceleration, temperature, weightlessness, vibration and radiation.

2. McFarland, R. A. Human Factors in Air Transportation, N. Y.: McGraw-Hill, 1953.

   This book is concerned primarily with the health and safety of passengers, flight crew and ground personnel.

   Now somewhat dated, this is the only book that is strictly concerned with civil aviation and its special problems.

   The topics of the volume are: 1) nature and extent of air line operations, 2) selection and training of flight personnel, 3) maintenance of health and efficiency of flight personnel, 4) selection, placement, and health of ground personnel, 5) safety on the ground and in flight, 6) sanitation and health in airline operations, 7) passenger and service problems, and 8) health and medical services in air transportation.

3. Webb, P. (Ed.) Bioastronautics Data Book. NASA SP-3006, 1964 (Available from Superintendent of Documents, Washington, D. C., 20402 for $2.25).

   An outgrowth of the NASA Life Sciences Data Book, this volume has been expanded, revised and updated to provide engineers with quantitative and qualitative human data for developing design criteria for aerospace vehicles and equipment.

   Physiological data obtained from 20 areas of experimental study are presented in the text, much of it displayed in readable tables, charts, and graphs. This volume contains useful data relevant to such topics as: atmosphere, toxicology, acceleration, vibration, radiation, temperature, food, vision, and hearing. Many references are included for each topic.

II. HUMAN FACTORS METHODS
Systems Design
Maintainability
Use of Simulators and Computers in Man-Machine Studies

1. Alexander, L. T. Schematic Simulation: A Technique for the Design and Development of a Complex System. System Development Corp., September 1963 (AD 422 676).

   The schematic simulation technique was developed in response to the expressed need of the designers of the terminal air traffic control laboratory system. It provides a method for determining, in advance of system development, many of the specifications for subsystem design.

2. Altman, J. W. Some Procedures in Design for Maintainability, MRL-TDR-62-9, February 1962.

   Suggested procedures for including maintenance design considerations in advanced system analysis and conceptual design are presented. The chapter headings are: 1) conceptual design requirements and development of specifications; 2) analysis of maintenance functions; 3) maintenance concepts; 4) maintainability planning; 5) development of maintenance supports; and 6) evaluation and testing of maintenance design.

3. Altman, J. W., Marchese, A. C. & Marchiando, B. W. Guide to Design of Mechanical Equipment for Maintainability. ASD TR 61-381, August 1961.

   Written for design engineers, this guide presents human factors recommendations to increase efficiency and ease of maintainability of mechanical equipment associated with aircraft, ground and support systems.

4. ASTIA. Maintenance and Maintainability. AD 247 300, November 15, 1960.

   This report abstracts ASTIA documents published between 1953 and 1960 on maintenance and maintainability. The abstracts pertain to: 1) general concepts, principles and related aspects of maintenance engineering; and 2) studies on maintenance and maintainability of equipment of all types.

5. Chapanis, A. Research Techniques in Human Engineering. Baltimore, Md.: Johns Hopkins Press, 1959.

   This book describes methods, principles and guidelines for selecting data on man, machine and their interaction. Topics covered are: methods of direct observations; methods for study of accidents and

near accidents; statistical methods; experimental methods; special problems in human experimentation; psychophysical methods; and articulation testing methods.

6. Cooper, J. I., Rigby, L. V. & Spickard, W. A. Guide to Integrated System Design for Maintainability. ASD TR 61-424, October 1961.

   This guide outlines major concepts and procedures commonly used, and indicates the steps to be followed, throughout system design, and data to ensure maintainability. Useful design data for ease of maintenance are provided in this report.

7. Cooperband, A. S., Alexander, L. T. & Schmitz, H. S. Test Results of the Terminal Air Traffic Control Laboratory System. Systems Development Corp., Report No. TM 639 04000, September 23, 1963 (AD 422 853).

   The terminal air traffic control laboratory system, which simulates the complex environment of man-machine information-processing systems, is described. Some test results of the system are reported.

8. Flagle, C. D., Huggins, W. H. & Roy, R. H. (Eds.) Operations Research and Systems Engineering, Baltimore, Md.: Johns Hopkins Press, 1960.

   This book presents the basic concepts and principles of operations research and of systems engineering, and explains the use of a variety of mathematical techniques for the analysis, design and control of systems. Included are applications of the principles and methods to actual case studies. Of particualr interest is an article by A. Chapanis in Chapter 19, which examines the role of human factors in systems design. Various examples of human factors contributions to systems engineering are cited.

9. Folley, J. D. (Ed.) Human Factors Methods for System Design, The American Institute for Research, Contract No. NONR-2700(00), 1960.

   This volume examines the human engineering task from a system-oriented viewpoint. The areas covered in the three parts of this volume are: systems analysis for human factors, human engineering in equipment design, and development of the personnel subsystem.

10. Folley, J. D. Research Problems in the Design of Performance Aids, ASD TR 61-548, October 1961, (AD 270 866).

    Written primarily for the researcher in human factors system design, this report presents the problems and issues involved in designing performance aids to facilitate on-the-job performance.

11. Folley, J. D. and Altman, J. W. Guide to Design of Electronic Equipment for Maintainability, WADC TR 56-218, April 1956, (AD 101 729).

    Written for designers of electronic equipment for the Air Force, the purpose of this guide is to provide principles for design of electronic equipment so that maintainability will be more efficient and cost of maintainability will be less.

12. Gagne, R. M. (Ed.) Psychological Principles in System Development. N. Y.: Holt, Rinehart and Winston, 1962.

This book presents the development of the man-machine system from the human operator's point of view. The technology for each stage of system development is described. Individual chapters discuss: human functions in systems; human capabilities and limitations; equipment design; task analysis; aids to job performance; training approaches and devices; simulation and system evaluation. The book is an excellent introduction to psychological research for the engineer.

13. Hannah, L. D. & Reed, L. E. Basic Human Factors Task Data Relationships in Aerospace System Design and Development. AMRL-TR-65-231, December 1965.

The application of human factors data to system development is described. Data flow diagrams illustrate the dynamic input and output relationships between human factors data and system planning, specifications, reliability, maintainability, task analysis, human engineering, personnel requirements information, training equipment information and maintenance manuals.

14. Haythron, W. W. System Simulation as a Technique in Systems Research. Chapter 35 in Bennett, E., Degan, J. & Spiegel, J. (Eds.) Human Factors in Technology. N. Y.: McGraw-Hill, 1963.

The purpose of this chapter is to illustrate techniques for examining human factors problems in system performance. System simulation is discussed in relation to task analysis, decision analysis, estimation of manpower requirements, and definition of training requirements. The use of system simulation as a means of providing design information feedback to engineers is emphasized.

15. Kearns, J. H. & Ritchie, M. L. Cockpit Control-Display Subsystem Engineering. ASD TR 61-345, October 1961 (AD 269 715).

This report presents the control-display schedule as a sequence of design activities. The relationships between activities within control-display design and the design of other parts of the system are shown. Step by step sequences are presented for design schedule, function allocation, mission profile, and mockups. Diagrams and flow charts, as well as illustrations of instruments, clarify the points of discussion.

16. Meister, D. & Rabideau, G. F. Human Factors Evaluation in System Development. N. Y.: John Wiley & Sons, 1965.

This book is concerned with how human factors evaluation is performed during system development. It is written for engineers, psychologists, physiologists and physicians.

The first part of the book discusses the system and system development, analysis and evaluation, and human engineering evaluation of system products. Part 2 is concerned with the variables of the evaluation, its planning and procedures of data collection and analysis, and evaluation of the production processes.

17. Morrow, L. C. (Ed.) Maintenance Engineering Handbook (1st Edition). N. Y.: McGraw-Hill, 1957.

The handbook is a well rounded source of instructions for the upkeep of machines no matter what the industry. Organized as a guide to the selection, installation and upkeep of the kinds of equipment that every plant must deal with, it includes sections on: buildings, electrical equipment, mechanical equipment, service equipment, transportation equipment, maintenance stores, lubricants and lubrication, instruments, sanitation, welding, and corrosion control. Maintenance of production equipment is discussed in terms of such components as bearings, clutches, chains, drives, gears, valves, and instruments.

18. Olinger, M. E., Carter, C. B. et al. Whole Panel Control-Display Study Vol. I. Methodology for Control-Display System Development, ASD TR 61-91, July 1960 (AD 266 340).

This report contains results of a study of the feasibility and advantages of establishing a systematic method for control-display systems development. The final version of the procedure is explained step-by-step, showing the logical interrelation of the various processes in the development of the system.

19. Sadoff, M. & Harper, C. W. Piloted Flight-Simulator Research: A Critical Review. Aerospace Engineering. Vol. 21, No. 9, 1962, 50-63.

Results of piloted flight simulator studies are examined in order to assess utility of simulators for defining and solving pilot-vehicle integration and control problems. Comparative appraisals indicate the degree of simulator sophistication required on conventional and advanced vehicles.

20. Sinaiko, H. W. (Ed.) Selected Papers on Human Factors in the Design and Use of Control Systems, N. Y.: Dover Publications, Inc., 1961.

Chapter 4 by J. A. Adams discusses principles that can be used in design and use of flight simulators. Sinaiko and Buckley, in Chapter 1, discuss system evaluation techniques in terms of the influence of human characteristics in system design. A check list of human factors considerations in the design and evaluation of systems is presented.

21. Training Psychology Branch, Behavioral Sciences Laboratory. Uses of Task Analysis in Deriving Training and Training Equipment Requirements. WADD TR 60-593, December 1960.

Seven papers by human factors subcontractors discuss the application of task information in developing requirements for training equipment. The topics include: the purposes and methods of task analysis; the determination of task analysis content; methods of recording and reporting task analysis information; methods for establishing training requirements; methods and procedures for selecting training equipment and job aids; proficiency measurement; and the use of task analysis in deriving requirements for a specific system.

22. The UDOFT Flight Simulation System. AMRL-TDR-63-133, December 1963.

This report summarizes and evaluates the program of the Universal Digital Operational Flight Trainer, the first full scale application of a digital computer to flight simulation problems. The computer hardware and programming are discussed. Recommendations are given for future simulators of this type.

23. U. S. Air Force. Handbook of Instructions for Aerospace Personnel Subsystems Design (HIAPSD). AFSCM 80-3, Basic Issue, July 1, 1961, Reprinted July 15, 1962.

This handbook, which is revised every 3 to 6 months, gives information applicable to the management, design and development of aerospace equipment. It provides guidance for human engineering and for personnel and training requirements. A current bibliography on human engineering problems is included.

24. Williams, A. C., Jr., Adelson, M. & Ritchie, M. L. A Program of Human Engineering Research on the Design of Aircraft Instrument Displays and Controls. WADC-TR-56-526, December 1956 (AD 110 424).

Now somewhat dated, this report nevertheless serves as a model for developing a research program in support of equipment design requirements.

III. ACCIDENT INVESTIGATION
Incident Analysis

1. Aviation Crash Injury Research. United States Army Aviation Crash Injury Research. TREC TR 62-13, September 1961 (AD 275 184). (See also TREC 63-23, December 1962 for summary of 1962 work).

   This report describes a program of research on the following topics: crash injury investigations of military and civilian aircraft accidents; data collection in crash safety; design criteria for crash safety; crash safety equipment and procedures; and the development of procedures for investigating causes of crash and post-crash fires.

2. Barnes, A. C., Jr., Carroll, J. J. & Gregg, L. W. Handbook for Aircraft Accident Investigators Cooperating in Crash Injury Research. Aviation Crash Injury Research, Flight Safety Foundation, Phoenix, Ariz., April 1962.

   This handbook provides procedures for the accident investigator to follow so that evidence can be accumulated to decrease causes of injury through improved aircraft design.

3. Been, R. T. & Braunstein, M. L. Effect of Injury Information on Damage Estimates. Human Factors. Vol. 6, 1964, 475-477.

   This study suggests that information about injuries can bias investigators, in that they tend to make higher aircraft damage estimates when there are more injuries. This bias can distort true relation between crash dynamics, aircraft damage, and human survival and injury.

4. Bergeret, P. (Ed.) Aircraft Accident Investigation Manual for Air Surgeons. N. Y.: Pergamon Press, 1961.

   The purpose of this manual is to provide a common approach to aircraft accident investigation in the NATO countries. The manual includes methods of classification of accidents; the preparation, use and maintenance of records for accident investigation; etiological considerations; pathology; and medical prevention of accidents.

5. Chapanis, A. Research Techniques in Human Engineering, Baltimore, Md.: Johns Hopkins Press, 1959.

   Chapter 3 discusses methods and procedures in studying accidents and near accidents. Difficulties encountered in accident study are discussed.

6. Evrard, E., Bergeret, P. & van Wulfton Palthe, P. M. (Eds.) Medical Aspects of Flight (The Unexplained Aircraft Accident). N. Y.: Pergamon Press, AGARDOGRAH 30, 1959.

This book contains selected reports from two symposiums on flight safety held in 1956 and 1957. The reports are organized into five sections: 1) flight safety and aircraft accidents; 2) unexplained aircraft accidents; 3) use of pathology in crash injuries; 4) in-flight protection; and 5) some special problems. Some of the reports are written in French, with an English abstract.

7. Haddon, W., Jr., Suchman, E. A. & Klein, D. Accident Research: Methods and Approaches. N. Y.: Harper and Row, 1964.

The volume presents a methodology for accident research and evaluates the design of a number of published studies.

8. Jefferson, F. W. Transport Aircraft Cockpit Voice Recording. Atlantic City, N. J.: National Aviation Facilities Experimental Center, December 1960 (AD 258 320).

Tests were conducted, utilizing three different types of aircraft, to determine the most desirable method for recording crew conversations as an aid to accident investigation. Currently available area-microphones and individual pickup-microphones were employed.

9. Lederer, J. Methodology and Patterns of Research in Aircraft Accidents. Annals of the N. Y. Academy of Sciences. Vol. 107, 1963, 670-685.

The current method of civil aviation accident investigation is presented, with suggestions for improvement. The need for more thorough data collection and analysis is urged. A list of 51 references to accident investigation articles and studies is included.

10. Mason, J. K. Aviation Accident Pathology. A Study of Fatalities. London: Butterworths, 1962.

Written primarily for those involved in the medical aspects of aircraft accident investigation, this book is of broad interest to other workers in this field. In addition to analyzing many aircraft accidents, this volume treats the following topics: prevention of injury; effects of aircraft accidents; accident reconstruction; and reconstruction of the fatal ejection attempt.

11. McFarland, R. A. Human Factors in Air Transport Design. N. Y.: McGraw-Hill, 1946.

Chapter 12 covers methods of aircraft accident investigation, and the application of accident analysis to the prevention of future accidents. The importance of studying near accidents is stressed.

12. McFarland, R. A. & Moore, R. C. Accidents and Accident Prevention. Annual Review of Medicine. Vol. 13, 1962, 371-388.

An epidemiological approach is recommended in the investigation of causes of accidents. This paper reviews a number of accident research topics, including personality traits related to accidents; the use of alcohol by vehicle operators; and improved design for accident and injury protection.

13. Neely, S. E. Patterns of Interference with the Ability of Pilots to Control Their Aircraft. in Barbour, A. B. & Whittingham, H. E. Human Problem of Supersonic and Hypersonic Flight. London: Pergamon Press, 1962, 227-249.

By reviewing the aircraft accidents occurring in 1959, the author studies patterns of interference with the pilot's ability which result from vertigo, distraction, and loss of orientation. This type of accident investigation should be helpful in leading to methods of reducing accidents.

14. O'Connor, W. F. & Pearson, R. G. ATC System Error and Appraisal of Controller Proficiency. Oklahoma City, Okla.: CARI, Report AM 65-10, FAA, June 1965.

This report presents suggestions for the design of an air traffic control (ATC) incident-reporting system aimed at maximizing the amount of corrective feedback to the ATC system. The approach taken is system-oriented rather than controller-oriented. Included is a discussion of a philosophy of corrective and punitive action relative to controller involvement in an incident. Recommendations and examples of format are included for the design of incident-report forms and incident chronology and of a checklist to be used in periodic appraisal of controller performance. Emphasis is given in format design to use of systems and human function, rather than regulatory and procedural terminology. Implementation and data-analysis technique are also discussed.

15. Pearson, R. G. Human Factors Aspects of Lightplane Safety. Oklahoma City, Okla.: CARI Report 63-35, FAA, December 1963.

This paper represents an overview of the needs for human factors research to reduce accidents and prevent injury. It points especially to the need of relating accident investigation and aeromedical research in the areas of biomedicine, design safety and human engineering.

16. Sinaiko, H. W. (Ed.) Selected Papers on Human Factors in the Design and Use of Control Systems. N. Y.: Dover Publications, Inc., 1961.

Chapter 8 by P. M. Fitts and Chapter 9 by R. E. Jones present human factors design data based on the analysis of pilot errors in the

use of displays and controls. Recommendations are made for design changes that could decrease pilot error.

17. Special Issue on Accidents. Journal of Occupational Medicine. Vol. 4, No. 1, January 1962.

This issue presents articles on human-factors engineering and safety research related to: highway accidents; accidents at a missile center; industrial accidents; first aid; heart-lung resuscitation; and emergency care in industry.

18. Thorndike, R. L. The Human Factor in Accidents with Special Reference to Aircraft Accidents. A Report to the School of Aviation Medicine, U. S. Air Force (Project No. 21-30-001, Report No. 1), February 1951. Reprinted by U. S. Department of Health, Education, and Welfare, Public Health Service, Division of Accident Prevention, Washington, D. C., May 1965.

This report reviews the literature on human elements in aircraft, industrial and highway accidents which have problems common to aviation. Topics include: reporting of accidents; accident-proneness; accidents as related to temporary attributes of the individual, his training and experience; accidents as a function of operating procedures and situational factors.

19. Townsend, F. M. The Pathologic Investigation of Aircraft Accident Fatalities. Journal of Aviation Medicine. Vol. 28, No. 5, 1957, 461-468.

Written primarily for those who perform autopsies on aircraft accident fatalities, this article stresses the need for close cooperation between the doctor and accident investigator in determining the cause of an accident. Case studies and suggested procedures are presented.

20. U. S. Navy Diving Manual. Part I. Washington, D. C.: NAVSHIPS 250-538, Navy Dept., July 1963.

This manual presents the general principles of diving, and discusses water physics, physiology, basic diving procedures, diving tables and diving hazards, general safety precautions and training. The information is of some interest to the study of aircraft survival in overwater accidents.

21. Vasilas, J. N., Fitzpatrick, R., Dubois, P. H. & Youtz, R. P. Human Factors in Near Accidents. USAF School of Aviation Medicine, June 1953 (AD 14 889).

This document, a classic in the area, reviews methods of reporting on near-accidents and presents some new methods which are analyzed.

The use of near-accident reports in detecting and remedying hazardous situations is examined. Approaches to obtaining reliable reports on in-flight and ground incidents, and the problems associated with punitive action and anonymous reporting of incidents are discussed.

22. Zeller, A. F. Human Aspects of Mid-Air Collision Prevention. Aerospace Medicine, Vol. 30, No. 8, 1959, 551-560.

The factors involved in mid-air collisions are evaluated. These are seen to be primarily a combination of human limitations and situational factors. Protective measures considered are: multiple scanners in the aircraft; modification of aircraft to increase visibility; reduction of the complexity of the pilot's task; increasing the conspicuity of the aircraft; and improvements in traffic control.

IV. CRASH SAFETY
Evacuation
Survival
Restraint Systems

1. Anikeeff, A. M., King, B. G., Langston, J. H., Morris, A. D. & Phillips, C. R. Measures for the Improvement of Safety in Army Aviation. Silver Spring, Md.: Operations Research, Inc., TR-109, September 1960 (AD 629 642).

   The emphasis of this study is directed toward methodology which will be useful in accident prevention research. The problem is approached through introduction of task element analysis to accident analysis and airplane design; and through study of the broad civil aviation lightplane accident experience as a reference. (From DDC abstract)

2. Braunstein, M. L. & Been, R. T. (Eds.) Studies in Accident Injury Prevention. Flight Safety Foundation, AvSER Report 64-1, March 1964.

   A series of studies are presented with the aim of improving the quality of accident data. Methods are outlined for using these data in the modification of aircraft design and flight procedures so as to reduce the number and degree of injuries. Topics include the analysis of accident data; measuring degree of injury from severity of damage; reduction in injuries from improvement in safety design in agricultural aviation; the influence of report form instructions on damage estimates; improvement in accident data; comparison of data at the site and by photograph; the influence of training on damage ratings; and computer models of the accident and the investigator.

3. Bruggink, G. M. Impact Survival in Air Transport Accidents. Flight Safety Foundation, AvCIR-8-CSS-129, January 20, 1961.

   An analysis of three transport accidents reveals that the impact survival of the occupants of a relatively intact fuselage structure is governed primarily by the effectiveness of the restraint system and the injurious aspects of the environment. The results show that the current occupant protection criteria do not fully utilize the crash resistance of modern fuselage structure.

4. Bruggink, G. M. & Schneider, D. J. Limits of Seat-Belt Protections During Crash Decelerations. U. S. Army Transportation Research Command, TREC Technical Report 61-115, September 1961.

   The limitations of seat belts are discussed in reviewing case studies of aircraft accidents. Suggestions for increasing the dynamic strength of restraint systems are given.

5. Cambeis, L. Bibliography of Impact Acceleration Literature. TRECOM Tech. Rept. 63-31B, June, 1963. (See also Miller, C. D. Synthesis of Impact Acceleration Technology for Aviation Crash Injury Prevention (Project SIAT), TRECOM Tech. Rept. 63-31A, June 1963).

   These two reports of Project SIAT present a bibliography and a review of impact acceleration research. The major categories of the literature obtained for this project are: 1) hazard exposure; 2) crash loads; 3) human tolerance; 4) design; and 5) test and analysis methodology.

6. Eiband, A. M. Human Tolerance to Rapidly Applied Accelerations: A Summary of the Literature. NASA Memo 5-19-59E, June 1959.

   Data obtained from a literature survey of space flight accelerations and of crash impact forces are analyzed and discussed. The data are analyzed to show the effects of body restraint, acceleration direction, onset rate, and plateau duration on the maximum tolerable magnitude of rapidly applied accelerations. Recommendations are made for increasing impact survivability by use of adequate body support in both the forward- and aft-seated positions. A bibliography on human tolerances to acceleration is included.

7. Flight Safety Foundation. United States Army Aviation Crash Injury Research. TRECOM Tech. Rept. 63-23, December 1962 (See also TREC Tech. Rept. 62-13, September 1961).

   These documents summarize the projects contracted from the U. S. Army by AvCIR in 1961 and 1962. Research topics include: case studies of individual accidents; collection of accident data; study of crash safety equipment; training programs of crash injury investigators; and a restraint systems study. For more details the reader is invited to investigate the original reports. Examples are: Theory, Development, and Test of a Crash Fire-Inerting System for Reciprocating Engine Helicopters, TRECOM Tech. Rept. 63-49; Personnel Restraint Systems Study: Basic Concepts, TCREC Rept. 62-94; Helmet Design Criteria, TCREC Rept. 62-57; and Crew Seat Design Criteria for Army Aircraft, TRECOM Rept. 63-4.

8. Fryer, D. I. Passenger Survival in Aircraft Crashes. Aeronautics. Vol. 40, No. 2, 1959, 31-37.

   The factors governing survival in aircraft crashes, the forces acting upon the aircraft and passengers, and the influence of certain design features during accidents are described and evaluated. The ability of the airframe to absorb impact energy is discussed, and the advantage that can be taken of this in design is stressed. Particular attention is placed on the seat attachments, strength and arrangement. The advantages of using the backward-facing seat instead of the forward-facing seat are given.

9. FSF/FAA. Project SCAN. Interim Tech. Rept., Flight Safety Foundation, Contract FA-2352, November 30, 1961.

This project is a study of the near mid-air collisions which occur over the U. S. From statistical analysis of reports from pilots, controllers and other observers, it is concluded that the patterns of near-collisions differ from those reported in previous studies. The study reports an increase of these incidents near terminal areas and a higher ratio of IFR to VFR incidents. Recommended procedures are presented to the FAA to aid in reducing the hazard.

10. Hasbrook, A. H., Garner, J. D., & Snow, C. C. Evacuation Pattern Analysis of a Survival Commercial Aircraft Crash. Oklahoma City, Okla.: CARI Rept. 62-9, FAA, May 1962.

An analysis is made of the evacuation pattern of a jet transport that had crashed. Factors resulting in the death of some of the passengers are presented. Recommednations are made to improve the emergency evacuation of passengers.

11. Herbert, J. W. Weather as a Contributing Factor in Air Transport Accidents. Flight Safety Foundation, Contract Cwb-10098, November 1962.

By analysis of accident records this report investigates the influence of weather on aircraft approach and landing accidents. Conclusions and recommendations are presented for weather, navigation, aircraft design and performance, crew performance, and communications. Psychological factors are analyzed by means of the results of a pilot questionnaire.

12. Impact Acceleration Stress: A Symposium. National Academy of Sciences, National Research Council, Publ. 977, 1962.

This is a collection of papers given in a symposium at Brooks AFB in 1961. Its primary theme is the biological effects of acceleration impact. Studies from various types of impact accidents are cited, and reviews of research programs are given. A chronological bibliography is included.

13. Kulowski, J. Crash Injuries: The Integrated Medical Aspects of Automobile Injuries and Deaths. Springfield, Ill.: Charles C. Thomas, 1960.

This book, written primarily for physicians concerned with helping their crash and near-crash patients, goes into great detail about medical aspects of automobile accident injuries. The book is divided into 7 sections covering: 1) biomechanics; 2) pathomechanics; 3) autopsy pathology; 4) clinical pathology; 5) delayed complications; 6) human salvage; and 7) unified medical concept of crash injuries.

14. Lentz, E. C. Human Factors in 'Cause Undetermined' Accidents. Aerospace Medicine. Vol. 36, No. 3, 1965, 214-222.

A group of 182 Air Force flight accidents, listed as "cause undetermined" are studied and analyzed. The analysis indicates that the accidents occurred during stressful phases of flight. It is suggested that flight safety may be increased through improvements in personnel selection, flight crew training, and cockpit panel design.

15. Mason, J. K. Aviation Accident Pathology. A Study of Fatalities. London: Butterworths, 1962.

Chapters 4 and 5 deal with escape from aircraft in flight, and with safety equipment to prevent injury.

16. Mohler, S. R., Swearingen, J. J., McFadden, E. B. & Garner, J. D. Human Factors of Emergency Evacuation. FAA, AM-65-7, September 1964.

This report summarizes the procedures for emergency evacuation developed since World War II. Results of recent research are presented, with suggestions for air crew training and design improvement.

17. Moseley, H. G. & Zeller, A. F. Relation of Injury to Forces and Direction of Deceleration in Aircraft Accidents. Journal of Aviation Medicine. Vol. 29, October 1958, 739-749.

In studying the paths of cargo and transport type aircraft during crash, it is noted that most injuries occur when the aircraft experiences little deviation from its established path. Measures are suggested for improving structural and retention strengths in aircraft seats and moorings.

18. Payne, P. R. Personnel Restraint and Support System Dynamics. AMRL-TR-65-127, October 1965.

A dynamic model is developed to aid in minimizing deceleration stresses in determining the optimum dynamic characteristics for the restraint system.

19. Pearson, R. G. Relationships Between Tie-Down Effectiveness and Injuries Sustained in Light Plane Accidents: 1942-1952. Aerospace Medicine. Vol. 33, No. 1, 1962, 50-59.

An analysis of 1025 occupants involved in light plane accidents was conducted to investigate the relationship between seat-belt restraint and injuries. With use of seat belts, injuries to the upper head and torso area occurred even though the restraint system held. Different types of forces were found to be responsible for seat failure as contrasted with belt failure. Recommendations are offered for further protection, and suggestions are made for more investigations of seat-belt safety.

20. Preston, G. M. & Peeman, G. J. Accelerations in Transport - Airplane Crashes. NACA TN 3145, February 1958.

Full-scale aircraft crashes were made with low-wing pressurized, and high- and low-wing unpressurized, transport airplanes. The effects of the crash circumstances and the airplane configuration on the magnitude of the crash loads are indicated. The suggestion is made that aircraft size does not have a major effect in determining the decelerations that result from a crash.

21. Snyder, R. G. Human Survivability of Extreme Impacts in Free-Fall, CARI Rept. 63-15, FAA, August 1963.

Using the case-study approach, this report gives an analysis of survivability in free-fall impacts, taking into account such factors as the decelerative forces involved, materials impacted, and structural characteristics of the human body.

22. Space and Flight Equipment Association. Proceedings of 2nd National Flight Safety, Survival and Personal Equipment Symposium. October 1964.

This report contains articles on: rescue and survival from aircraft accidents; training of crews; safety equipment; and survival techniques.

23. Stapp, J. P., Mosley, J. D., Lombard, C. F., Nelson, G. A., Nichols, G. & Larmie, F. Analysis and Biodynamics of Selected Rocket - Sled Experiments, Brooks AFB, Texas: USAF School of Aerospace Medicine, July 1964.

Presented in two parts, this report is concerned with the effects of deceleration. The first section gives the details and results of 23 experiments which could be extremely relevant in aiding design of restraint systems. The second part of the report gives a detailed analysis of the relationships involved when a restraint subject is exposed to abrupt deceleration. Many of the relationships are presented in the form of graphs.

24. Swearingen, J. J. Tolerances of the Human Face to Crash Impact. Oklahoma City, Okla.: CARI Rept. 65-20, FAA, July 1965.

This report describes the forces which produce fractures, lacerations, or unconsciousness when applied to different parts of the face. On the basis of this study, recommendations are given for the evaluation of injury potentials of commercial airline seat structures, light-aircraft instrument panels and other deforming structures.

25. Swearingen, J. J. & McFadden, E. B. Studies of Air Loads on Man. CARI Rept. 63-9, FAA, May 1963.

Data are summarized from three experiments related to the effects of wind forces on man. These findings are discussed in terms of

the sudden failure of a small area in a pressure envelope, the physical displacement of man in corridor-like areas, and the aerodynamics of man.

26. Swearingen, J. J., Hasbrook, A. H., Snyder, R. G. & McFadden, E. B. Kinematic Behavior of the Human Body During Deceleration. Aerospace Medicine, Vol. 33, No. 2, 1962, 188-197.

This paper describes the areas which may be traversed by the human head, trunk, arms and legs during flailing motions in crashes with seat belt restraint only. These motions are related to present aircraft cockpit and seating arrangements. An analysis of aircraft injuries is presented, and impact forces of a survivable transport crash are discussed.

27. U. S. Coast Guard. Aircraft Emergency Procedures Over Water. CG 306, (Also OPNAV Instruction No. 3730.4 and AFM 64-6), November 1955.

The emergency procedures of aircraft over water are presented. Among the topics treated are: emergency communications; location aids; selection of ditching heading; basic ditching procedures; aid in ditching by ocean station vessel and by merchant vessel; intercept and escort of distressed aircraft; abandoning the aircraft; survival first aid; and the emergency check-off list.

V. BIOMECHANICS AND CABIN DESIGN
Anthropometric Considerations in Door, Seat, Personal Equipment, and Work Station Design

1. Advisory Group for Aeronautical Research and Development (NATO). Anthropometry and Human Engineering. AGARDograph 5, London: Butterworths, 1955.

   In this book a number of reports are presented on the topics of body measurements in relation to workspace, human engineering aspects of cockpit and display design, and factors influencing the validity and utility of aeromedical research data.

2. Alexander, M. & Clauser, C. E. Anthropometry of Common Working Positions. AMRL-TR-65-73, December 1965.

   Anthropometric measures of 26 dimensions of the human body in various working positions (standing, bending, kneeling, supine, squatting and sitting), are provided. While the data were collected so that more adequate work stations for missile workers could be designed, they would also be applicable to other job categories. The data are presented in percentiles, means and standard deviations for each dimension.

3. Bendix Corporation. Final Report on the Investigation of Mask Leakage in Passenger Oxygen Masks. Pub. No. 2266-62, FAA Contract No. FA-885, February 8, 1962 (AD 294 614).

   This document presents data on testing procedures to determine the effectiveness of oxygen masks in providing aircraft passengers with a highly reliable protection from decompression and its effect.

4. Damon, A., Stout, H. W. & McFarland, The Human Body in Equipment Design. Cambridge, Mass.: Harvard University Press, 1966.

   This book organizes current information on human body size and mechanical capabilities, and summarizes the applications of anthropometric data to the design of equipment. Part 2 of the book covers anthropometry and human engineering (applications, sources and factors influencing anthropometric data, static and dynamic body dimensions, body surface area and the center of gravity). In Part 3 the relation of biomechanics to equipment design is described, with emphasis on range of movement at the joints, muscle strength, and speed of body motion. Human body composition and tolerance to physical and mechanical force is presented in Part 4.

5. David Clark Company, Inc. Integration of Personal Equipment. WADC TR 59-382, October 1959.

This report presents some approaches, problems, and solutions to the integration of personal equipment for air crews.

6. Dempster, W. T. The Anthropometry of Body Action. WADD TR 60-18, January 1960. (AD 234 005). (Also in Annals of the New York Academy of Sciences. Vol. 63, Article 4, November 28, 1955, 559-585.)

This report urges the development of a dynamic anthropometry based on the understanding of body kinematics and the importance of forces in relation to posture and movement. Included are discussions of anthropometric methods, the nature of joints, joint movements and linkages, and work-space problems.

7. Floyd, W. F. & Welford, A. T. (Eds.) Symposium on Human Factors in Equipment Design, Ergonomics Research Society Proceedings, Vol. 2, London: H. K. Lewis and Co., 1954.

This book, although now somewhat dated, presents papers on specific aspects of equipment design in the areas of anthropometry, (its application in the design of workspaces and chairs, and the anthropometric and physiological considerations of work), environmental influences, visual factors in displays, (such as display arrangement, visibility and legibility, control-display relationships and attention and fatigue factors), and equipment layout. The result of a symposium, with many contributing authors, the emphasis is on equipment design as related to industry.

8. Fry, E. I. & Churchill, E. Bodily Dimensions of the Older Pilot. WADC TR 56-459, June 1956 (AD 97 217).

A comparison is made between 132 body dimensions on selected groups of older and younger pilots. It is pointed out that age differences in body dimensions should be taken into account in the designing of equipment.

9. Hanavan, E. P., Jr. A Mathematical Model of the Human Body, AMRL-TR-64-102, October 1964.

In this document a mathematical model for predicting the inertial properties of the human body in various fixed positions is developed. It is suggested that this model may be of use in establishing preliminary design specifications where knowledge of the inertial properties of the human body are required.

10. Hansen, R. & Cornog, D. Y. Annotated Bibliography of Applied Physical Anthropology in Human Engineering. WADC-TR-56-30, May 1958 (AD 155 622)

Annotated references are given in anthropometry, biomechanics and

comfort. In many instances detailed data and illustrations are reproduced from the original sources. Additional bibliography is included.

11. Hertzberg, H. T. E. Dynamic Anthropometry of Working Positions. Human Factors, Vol. 2, No. 3, 1960, 147-155.

    In the article the author reviews the principles and procedures of design or workspaces for engineers. The use of human body size and movement variability is emphasized in the design.

12. Hertzberg, H. T. E., Daniels, G. S. & Churchill, E. Anthropometry of Flying Personnel - 1950. WADC-TR-52-321, September 1954, (AD 47 953).

    The results and data of anthropometric measurements on 4,000 Air Force personnel at 14 Air Force bases in 1950 is presented. 132 body measurements, sociological data and 4 somatype photographs were collected for each person. The measurement techniques are presented and the statistics are discussed.

13. Human Mechanics: Four Monographs Abridged. (1) W. Braune & O. Fisher, Center of Gravity of the Human Body, (2) O. Fisher, Theoretical Fundamentals for a Mechanics of Living Bodies, (3) J. Amar, The Human Motor, and (4) W. T. Dempster, Space Requirements of the Seated Operator, AMRL-TR-63-123, December 1963.

    The first two monographs listed have been classics in human mechanics, published in Germany in 1889 and 1906, respectively. The first monograph, Center of Gravity, gives methods and data on determining the center of gravity. Theoretical Fundamentals presents an analysis of the joint systems in the human body.

    Amar's book published in France in 1914 is concerned with the mechanics of body movements in work situations. Dempster's work gives results of research on the general mechanics of the human body as applied to the seated operator.

14. Kennedy, K. W. Reach Capacity of the USAF Population, Phase I: The Outer Boundaries of Grasping-Reach Envelopes for the Shirt-Sleeved, Seated Operator. AMRL-TDR-64-59, September 1954.

    The purpose of this report is to describe the outer boundaries of the minimum, 5th and 50th and 95th percentiles grasping-reach envelopes of seated, shirt-sleeved operators. It also contains resumes of previous research on arm reach capacities.

15. McConville, J. T. & Alexander, M. Anthropometric Data in Three-Dimensional Form: Development and Fabrication of USAF Height-Weight Manikins. AMRL-TDR-63-55, June 1963.

    This report is one from a projected series intended to present designs of Air Force protective clothing and associated personal

equipment with detailed anthropometric data in three-dimensional form. The development of data and the sculpturing of manikins are described in this report. Data are also presented on the human body in a seated position.

16. Robillard, R. J. SST Seat Investigation. Lockheed-California, LR-18761, April 1965 (AD 478 768).

A passenger seat investigation and analysis has been conducted to determine the current state-of-the-art and the extent of research and development in process or under consideration for reduced seat pitch applications. (from DDC abstract)

17. Roebuck, J. A., Jr. Anthropometry in Aircraft Engineering Design. Journal of Aviation Medicine. Vol. 28, February 1957, 41-56.

The purpose of this article is to demonstrate requirements for an integrated, practical approach to the problem of economically providing space for crew and passengers within the limitations of aircraft design.

18. Roebuck, J. A., Jr. & Levedahl, B. H. Aircraft Ground Emergency Exit Design Considerations. Human Factors. Vol. 3, No. 3, 1961, 174-209.

Data are presented on the inflatable escape slide for low-wing aircraft, emergency exits and other installations. The use of anthropometry and consideration of passenger agility are discussed as important factors in the design of emergency exits.

19. Santschi, W. R., Dubois, J. & Omoto, C. Moments of Inertia and Centers of Gravity of the Living Human Body. AMRL-TDR-63-36, May 1963.

This study presents anthropometric data on the moments of inertia and centers of gravity for eight different positions in male subjects. These data would be useful for the design of seats and restraints which will be used under conditions of vibration, when the center of gravity would be altered by body position or restraint; also they would be useful in the design of aerospace systems in which human body weight is a significant percentage of the vehicle weight.

20. Slechta, R. F., Wade, E. A. et al. Comparative Evaluation of Aircraft Seating Accomodation. WADC TR 56-136, April 1957 (AD 118 097).

A series of aircrew seats currently in use in operational aircraft were tested for adequacy in limiting pilot fatigue and discomfort. Several subjective methods of comfort testing were devised and evaluated. The test data were analyzed for basic information about the nature and progression of seating discomfort.

21. Snow, C. C. & Snyder, R. G. Anthropometry of Air Traffic Control Trainees. FAA, AM 65-26, September 1965.

Anthropometric data, recorded in 1960 and 1961, from 75 body measurements on 684 Air Traffic Control trainees are presented. Percentiles, means, and standard deviations are reported. The data were collected both to aid in the human factors design of air traffic control equipment, and to provide information for longitudinal studies of air traffic control trainees.

22. Swearingen, J. J. Determination of Centers of Gravity of Man. Oklahoma City, Okla.: FAA, CARI Rept. 62-14, August 1962.

This report presents data on the center of gravity of the adult male in various body positions. The ability to shift the center of gravity by various body motions is also discussed.

23. Swearingen, J. J., Wheelwright, C. D. & Garner, J. D. An Analysis of Sitting Areas and Pressures of Man. CARI Rept. 62-1, FAA, January 1962.

In this study an analysis is made of the body sitting areas and pressures. An evaluation of chair arms, seat backs and foot rests for reducing sitting pressure is presented. This information may be of use in limiting fatigue and discomfort for air crew and passengers in long flights.

24. Whittenberger, R. K. Improved Seat and Back Cushions. WADC TR 59-376, November 1959.

This report presents the results of studies to design seat and back cushions which would provide comfort and reduce fatigue in aircraft crews.

VI. EQUIPMENT DESIGN
Human Engineering in Panels, Displays, Instrument Design, and Workspace Layout

1. Baxter, J. R. Projected Symbolic Displays for General Aircraft. Melbourne, Australia: Aeronautical Research Labs, March 1963 (AD 602 509).

   The projected symbolic display has gained increased support as a means of providing instrument information in a form wholly compatible with visual information from the outside world. While several such displays have been proposed for large transport aircraft, in this report the practicability of a simplified version for general aircraft is examined in detail.

2. Courtney, D. (Ed.) Human Factors in Airport Tower Design. Courtney & Co., Report No. 53, FAA/BRD 390, December 1, 1961.

   Detailed human factors recommendations based on three earlier studies are presented for the design of airport traffic control centers, including working environment. The specifications are based on an intensive field study of air traffic controller requirements and human limitations.

3. Damon, A., Stout, H. W. & McFarland, R. A. The Human Body in Equipment Design. Cambridge, Mass.: Harvard Univ. Press, 1966.

   Section 5 of this guide presents control design recommendations based on anthropometric and biomechanical data. General principles of control design are discussed and specific design recommendations are presented for hand controls, foot controls, seats and the seated workspace, passageways, doorways, and escape hatches. Also included are recommendations for lifting and carrying.

4. Department of the Air Force. Military Standard: Human Engineering Design Criteria for Aerospace Systems and Equipment, Part I, Aerospace System Ground Equipment. MIL-STD-803A-1, (USAF), January 27, 1964.

   This military standard presents detailed human engineering design criteria for visual and auditory displays, controls, labeling, workspace design, maintainability, operational and maintenance vehicles, and safety. This document's value to commercial aircraft equipment design may be limited as it is primarily a guide to design specifcations to be met by Air Force contractors.

5. Display Systems, A Report Bibliography. Prepared by DDC. DDC No. AD 265 432, November 1961 (Reprinted January 1964).

   This document presents bibliographical reports on references

catalogued by DDC and ASTIA under the word categories of display systems and equipment, applications and human engineering.

6. Elam, C. B., Emery, J. & Matheny, W. G. Redundancy in the Display of Spatial Orientation. Bell Helicopter Company Report No. D 228-421-009, August 1961.

   This research, part of the Army-Navy Instrumentation Program, questions the extent to which there should be redundancy in the display of attitude information.

7. Fogel, L. J. Biotechnology: Concepts and Applications. Englewood Cliffs, N. J.: Prentice-Hall, 1963.

   Aerospace-related topics include spatial orientation and illusions, instrument design, cockpit layout, lighting, approach and landing displays, optimal control dynamics, training and simulation. Comprehensive, technical treatise. Reviews USAF and ANIP research on integrated instrument panels, kinalog attitude display, and vertical tape instrumentation. Generous bibliography.

   Chapters 15, 16 and 17 consider factors involving the design of the immediate environment, consoles and cockpits, and present considerations for the future cockpit. Design recommendations are included in the discussion.

8. Hill, J. H. & Chernikoff, R. Altimeter Display Evaluation, Final Report. Naval Research Lab. Rept. 6242, January 26, 1965 (AD 610 664).

   The results of a series of investigations on the relative effectiveness of various altimeter displays are reported. Four types of altimeter presentations, the counter-pointer, the counter-drum-pointer, the drum pointer, and the three-pointer, were compared in a series of laboratory experiments measuring reading time and accuracy with both pilots and nonflying enlisted men. They were also tested in flight.

9. Hors, H. W., Case, R. W. & Burgess, J. L. Primary Illumination Systems, Military Aircraft, Control Panels and Instruments. Boeing Co. Rept. No. 036 292, December 20, 1963 (AD 439 860L).

   This document is a comprehensive guide to primary illumination methods and to lighting design requirements for military aircraft control panels and instruments. Characteristics affecting design and operation summarized.

10. Matheny, W. G., Dougherty, D. J. & Willis, J. M. Relative Motion of Elements in Instrument Displays. Aerospace Medicine. Vol. 34, No. 11, November 1963.

    Experiments were conducted investigating two types of motion display

under simulated motion, the outside-in display and inside-out display of aircraft attitude, to determine which is more effective in relaying information to the pilot. It was concluded that lack of motion cues may lead to erroneous conclusions about display systems. In some situations, kinesthetic cues may precede visual cues of motion.

11. McFarland, R. A. Human Factors in Air Transport Design. N. Y.: McGraw-Hill, 1946.

Chapter 10 presents design recommendations for controls, instrument panels, illumination of the cockpit, the windshield, and for individual and multiple crew stations.

12. McGrath, J. J. & Borden, G. J. Geographic Orientation in Aircraft Pilots: A Problem Analysis. Human Factors Research, Inc., Nonr 421800, November 1963 (AD 426 256).

The research reported in this document represents the initial phase of a research program whose ultimate goals are: 1) to identify the factors that produce geographic disorientation in aircraft pilots; and 2) to develop a body of empirical data relevant to the design of navigation displays and aeronautical charts.

13. National Supersonic Transport Programs, Control-Display Pilot Factors Programs. Randolph AFB: Instrument Pilot Instructor School, December 1963.

Intervening levels of control between full manual and full automatic were examined to determine the compatibility of the human pilot with an automatic flight control system, using force-wheel steering as the link between the two elements.

14. Ritchie, M. L. & Baker, C. A. (Ed.) Psychological Aspects of Cockpit Design - A Symposium Report. WADC TR 57-117, April 1957 (AD 118 079).

A presentation and discussion of cockpit design and research at various companies and govenment installations is presented in an effort to integrate ideas and research and to obtain more and better communication among those involved in cockpit design. This report might now be considered as a historic reference in cockpit design and instrumentation.

15. Rolfe, J. M. Altimeter Display Research: Summary of the Evaluation Program. Flying Personnel Research Committee Report 1215, R. A. F. Institute of Aviation Medicine, November 1963.

This report presents a summary of an evaluation program on the altimeter display for the purpose of developing an acceptable display for civilian use. Methodology and phases of the program are given and results of the studies are presented.

16. Siegel, A. I. & Wolf, J. J. A Technique for Whole Aircraft Instrument Panel Evaluation. Applied Psychological Services, Contract Rept. N62269-1349, U. S. Naval Air Development Center, February 1963.

Using flight simulation conditions, a technique is described to evaluate whole panel design by determining a numerical index of merit for each of several instrument panels. The methodology and proposed implementation of the procedure are discussed.

17. Silvestro, A. W., Kelly, J. B. & Courtney, D. Human Factors Considerations in the Design of Airport Traffic Control Quarters. Courtney & Co., FAA/BRD-89, August 1, 1959 (AD 226 877).

Specific design recommendations for air traffic control quarters are presented. Special sections are included on: 1) console design; 2) the sit-stand chair; 3) panel layout; 4) floor covering; 5) acoustical treatment; 6) lighting; 7) color; 8) air conditioning; and 9) safety and living facilities. Some of the recommendations are illustrated in drawings.

18. Svimonoff, C. The Air Force Integrated Flight Instrument Panel. WADC TR 58-431, October 1958 (AD 155 788).

This report presents a summary and analysis of the knowledge obtained from pilot experience with the Air Force Integrated Flight Instrument Panel and with new instruments and instrument systems related to it. Production implementation of the design recommendations and primary considerations for present and future product and production improvement programs are defined.

19. U. S. Air Force. Handbook of Instructions for Aerospace Personnel Subsystems Design (HIAPSD). AFSCM 80-3, Basic Issue, July 1, 1961, Reprinted July 15, 1962.

This handbook, which is revised every 3 to 6 months, gives information applicable to the management, design, and development of aerospace equipment. It is a guide to human factors design of personnel subsystems, and includes a current bibliography on human engineering problems. The distribution of this manual is limited to those doing official or contractual work for the Air Force.

20. VanLaer, J., Galanter, E. H. & Klein, S. J. Factors Relevant to the Development of Aircraft Warning and Caution Signal Systems. Aerospace Medicine. Vol. 31, No. 1, 1960, 31-39.

The problems associated with the priority of information presentation in aircraft, with particular reference to warning and caution signals, are discussed. This article reports that visual stimuli serve best as directing signals, while auditory and vibratory/tactile stimuli are most useful as alerting signals.

21. Vernon, M. D. Perceptual Problems Involved in Observing Displays. Chapter 11 in Floyd, W. F. & Welford, A. T. (Eds.) Symposium on Human Factors in Equipment Design. Ergonomics Research Society Proceedings, Vol. 2, London: H. K. Lewis and Co., 1954.

This paper discusses factors influencing the observation of visual displays including concentration and distribution of attention, importance of display arrangement, display-control relationship, visibility and legibility, and fatigue. The emphasis is placed on obtaining maximum operator efficiency by controlling the operator's work environment.

22. Wulfeck, J. W., Weisz, A. & Raben, M. W. Vision in Military Aviation. WADC TR 58-399, November 1958 (AD 207 780).

Chapter 13 of this report discusses the design of instruments and their arrangement in relation to the visual aspects of aircraft operation.

VII. CONTROL SYSTEM DYNAMICS
Simulation
Operator Tracking

1. Bekey, G. A. An Investigation of Sampled Data Models of the Human Operator in a Control System. ASD-TDR-62-36, February 1962 (AD 273 347).

   An analytical and experimental study of mathematical models of the human operator based on discrete rather than continuous operations is presented. Using methodology from sampled-data control system theory, two models are developed and tested experimentally with subjects in a tracking task. The experimental results resembled the predicted output from the mathematical models. The implications of the sampled-data models for the design of man-machine systems are discussed.

2. Birmingham, H. P. & Taylor, F. V. A Design Philosophy for Man-Machine Control Systems. Chapter 3 in Sinaiko, H. W. (Ed.) Selected Papers on Human Factors in the Design and Use of Control Systems. N. Y.: Dover Publications, Inc., 1961.

   Discussed are applications of principles to control-tracking systems. This is a classic paper in this area. Methods of optimizing the man-machine control system by "unburdening" (relieving the operator of the task of acting as an integrater) and "quickening" (providing the operator with immediate knowledge of the effects of his responses) are discussed.

3. Elkind, J. I. & Green, D. M. Measurement of Time-Varying Characteristics and Nonlinear Dynamic Characteristics of Human Pilots. ASD TR 61-225, December 1961 (AD 271 948).

   A model matching technique is described and applied in this report. The purpose of the technique is to measure the human pilot dynamic response in closed loop flight control tasks. The special characteristics of the human operator in this situation are that he is adaptive, time-varying and a nonlinear controller. The paper is primarily theoretical.

4. McRuer, D. T. & Krendel, E. S. Dynamic Response of Human Operators. WADC TR 56-524, October 1957 (AD 110 693).

   This report represents a comprehensive attempt to arrive at a mathematical description of human operator response for application to aircraft design. The study analyzes continuous closed-loop control systems with visual input and with manual output tracking, and includes an extensive review and critique of previous research in the field.

5. Taylor, F. V. & Garvey, W. D. The Limitations of a "Procrustean" Approach to the Optimization of Man-Machine Systems. Ergonomics. Vol. 2, 1959, 187-194.

This paper shows the limitations of attempting to optimize man-machine system performance through operator training alone. Results of a study indicate that operator performance under stress is enhanced by well-designed control-system dynamics.

6. Thomas, R. E. Development of New Techniques for Analysis of Human Controller Dynamics. MRL-TDR-62-65, June 1962.

This report describes two new mathematical methods, Bellmon's dynamic programming and Pontryagin's maximum principle, which can help analyze human controller dynamics.

7. Wasicko, R. J. & Magdaleno, R. E. Effects of Nonlinearities on Human Operator Tracking Performance: A Review of the Literature. AMRL-TR-65-1[illegible], October 1965.

This report presents a review of the literature on the effects of nonlinearity on human control-tracking performance. The report points out the need for considerably more experimentation in this area.

VIII. VISUAL FACTORS IN AIR NAVIGATION AND GROUND CONTROL

Radar, Conspicuity, Approach and Runway Lighting, Air-to-Air Visibility, and Visual Fatigue Problems

1. Applied Psychology Corporation. The Role of Range and Altitude Judgement in Midair Collision Prevention. FAA/BRD 127 110 512 R, May 1963 (AD 418 430).

   This report summarizes that portion of a research program on visual midair collision prevention techniques which deals with pilot ability to judge range and altitude of observed aircraft. (from DDC abstract)

2. Baker, C. H. Man and Radar Displays. N. Y.: Macmillan Co., 1962.

   Among the topics treated in this book on the radar-operator system are the following: radar scope brightness; pip decay time; ambient illumination; visual perception; estimation aids in reporting range and bearing; plotting and transmission of radar display data; and operator as a monitor. Research data are reviewed, and where appropriate, some presented in graphical form. The information should be valuable to writers of radar specifications, radar designers and instructors.

3. Brown, R. H. (Ed.) Illumination and Visibility of Radar and Sonar Displays. Washington, D. C.: National Academy of Sciences, National Research Council, Publ. 595, 1958.

   The result of a symposium sponsored by the Armed Forces and the National Research Council, this publication presents research reports in the areas of: 1) operational requirements for cathode ray tubes and displays in relation to illumination problems; 2) methods for controlling ambient illumination; 3) display requirements imposed by visual factors; and 4) new techniques under development.

4. Cook, K. G., Beazley, R. M. & Robinson, J. E., Jr. Aircraft Conspicuity and Flight Attitude Information Provided by Exterior Paint Patterns. Journal of Applied Psychology. Vol. 46, No. 3, 1962, 175-182.

   Experiments were conducted to determine the relative conspicuity of aircraft exterior paint patterns, and to investigate whether such paint patterns aided pilots in determining the attitude of the aircraft.

5. Havron, M. D. Information Available from Natural Cues During Final Approach and Landing. Human Sciences Research, Inc. HSR-RR-62/3-MK-X, March 1962.

   This report describes and evaluates the effectiveness of visual

ground cues for pilot control of aircraft approach and landing. Suggestions are made for using cues based on the apparent expansion pattern of areas on the ground.

6. Kraft, C. L. A Broad Band Blue Lighting System for Radar Approach Control Centers: Evaluations and Refinements Based on Three Years of Operational Use. WADC TR 56-71, August 1956 (AD 118 090).

This report presents a review of the effectiveness of the Broad Band Blue lighting system in radar rooms. It also reviews and evaluates alternate lighting systems.

7. Lazo, J. & Bosee, R. A. Visual Factors in Aircrew Station Lighting Design. Aerospace Medicine. Vol. 34, No. 10, 1963, 910-914.

The problems of lighting in aircraft are discussed in relation to human factors design criteria for meeting the visual requirements of the aircrew member.

8. Mercier, A. (Ed.) Visual Problems in Aviation Medicine. N. Y.: Pergamon Press, 1962.

This book presents research papers given by the Aerospace Medical Panel of AGARD to study ophthalmological problems raised by aviation. Some of the topics covered are visual problems of high altitude flight, displays and cockpit design, eye protection, and problems of empty visual fields.

9. Miller, J. W. (Ed.) Visual, Display, and Control Problems Related to Flight at Low Altitude. ONR Symposium Rept. ACR-95, March 3-5, 1964. (AD 602 823).

This report deals primarily with visual problems, inside and outside the cockpit, related to low altitude flight. Topics covered include mission and operational analysis; geographic orientation; navigational aids; displays and controls; television systems; pilot task loading; visual detection and recognition; need for operational flight data; training and selection; simulation; stress; vibration and buffeting; and automatic systems to aid the pilot.

10. Pazera, E. E. An Analysis of Requirements for Displaced Threshold Runway Lighting. National Aviation Facilities Experimental Center, May 1963 (AD 417 446).

This study summarizes the human factors aspects of the problem of lighting a runway threshold that has been displaced from the end of the pavement to insure approach clearance of obstacles. Included is an analysis of the relation between the runway dimensions and the approach lighting system.

11. Pfeiffer, M. G., Clark, W. C. & Danaher, J. W. The Pilot's Visual Task: A Study of Visual Display Requirements. NAVTRADEVCEN 783-1, March 1963 (DDC AD 407 440).

This report analyzes the pilot's visual task in terms of his use of dials, displays, maps and cues from outside the cockpit. On the basis of this analysis, the report makes recommendations for improvement of flight simulation training.

12. Projector, T. H. & Robinson, J. E., Jr. Analysis of the Usefulness of Coded Information in Visual Collision Avoidance. Applied Psychology Corp., Tech. Rept. No. 1, January 1961.

An investigation into the incorporation of different types of light-coded information into the navigation light systems of aircraft was conducted. The usual fixity-of-bearing technique which many pilots use is shown to have limited usefulness in collision avoidance. Altitude coding was found to be the major type of coding to improve the pilot's ability to distinguish between threats and non-threats. Types of altitude-coded navigation light systems are analyzed and the problems arising from the design of such systems is discussed.

13. Siegel, A. I. & Federman, P. Development of a Paint Scheme for Increasing Aircraft Detectability and Visibility. Journal of Applied Psychology. Vol. 49, No. 2, 1965, 93-105.

Five studies were performed in order to derive a paint coloration scheme which will allow maximum aircraft visibility and detectability.

14. Swets, J. A. (Ed.) Signal Detection and Recognition by Human Observers. N. Y.: John Wiley & Sons, 1964.

This volume contains a collection of reports on theory and research in signal detection. A broad array of topics includes: recognition of signals; physiological applications; frequency analysis; speech communications; and auditory and visual detection tasks.

15. Vanderplas, J. M. Radar Operator Fatigue: A Summary of Available Evidence and Some Preliminary Suggestions for the Reduction of Visual Fatigue. Tech. Note WCRD-52-44, August 1952.

Problem survey; analysis; recommendation.

16. Vaughan, W. S., Jr., Luce, T. S. & Kassebaum, R. G. Airport Marking and Lighting Systems: A Survey of Operational Tests and Human Factors, 1959-1961. Human Sciences Research, Inc., HSR-RR-61/13-MK-X, May 1962.

This report summarizes operational tests for lighting and marking of beacon systems, approach and runway combined systems, and angle of approach indicators. Human factors in the perception of airport lighting and marking are summarized. An annotated bibliography is included.

17. Whiteside, T. C. D. The Problems of Vision in Flight at High Altitude. London: Butterworths, 1957.

While this book deals primarily with visual problems in flying at high altitudes (40,000 feet), some of the discussion is also applicable to flight at lower altitudes. Among the topics discussed are the visual effects of changes of light intensity and of spectral distribution of light outside the cockpit, physiological changes affecting visibility inside the cockpit, and the physiological factors affecting air-to-air visibility.

18. Williams, S. B. Visibility of Radar Scopes. Chapter 4 in Committee on Undersea Warfare, National Research Council. A Survey Report on Human Factors in Undersea Warfare. Washington, D. C., 1949.

Considers the physical and psychological factors influencing the visibility of CRT used as radar scopes.

19. Wulfeck, J. W. & Taylor, J. H. (Eds.) Form Discrimination as Related to Military Problems. National Academy of Sciences - National Research Council Publication 561, 1957.

This book contains the proceedings of a symposium devoted to research in form discrimination. Many of the papers are of interest to human factors problems relating to radar design and operation, and to navigation.

20. Wulfeck, J. W., Weisz, A. & Raben, M. W. Vision in Military Aviation. WADC TR 58-399, November 1958 (AD 207 780).

This report represents a fairly comprehensive study of vision as it is involved in aviation. Written for the aircraft designer, air crewmen and others concerned with visual aspects of flying, the report presents sections on the principles of vision, and factors influencing vision from both inside and outside the aircraft. Included are sections of air-to-air and air-to-ground visibility, instrument design, cockpit illumination, and airport approach and runway lighting.

IX. AIRSPACE UTILIZATION
Navigation
SST Profiles
Automatic Landing
Adaptive Control Systems
Community Reactions
Sonic Booms

1. Arcon Corporation. System Analysis of the North Atlantic Air Traffic Complex. R62-3, Lexington, Mass.: Arcon Corp., Contract FAA/BRD-334, Project No. 116-97, December 1962.

   This report has as its main objective the investigation and evaluation of the methods by which the capacity of the North Atlantic Air Traffic system can be increased. Special emphasis is given to improvement of system performance through modifications of navigation, communications, weather forecasting and air traffic control procedures, and through improved separation standards systems.

2. Barbour, A. B. & Whittingham, H. E. Human Problems of Supersonic and Hypersonic Flight. London: Pergamon Press, 1962.

   This volume includes papers of particular interest to civil aviation by: C. S. R. Marshall on human factors problems in the supersonic transport; P. C. R. Craft on problems in modern navigation systems; and A. M. A. Menjendie on automatic control systems.

   Among the human factors problems which need to be solved with the advent of supersonic flight Marshall includes the need for control systems with high frequency of action, improved design of instruments systems, an optimum division of labor between automatic and crew systems, and a more advanced approach to air traffic control. He makes recommendations for considering the effect of time zone changes on biological rhythms and on crew performance, and the physiological and psychological problems created by the stress of high speed aircraft.

   In Craft's chapter are outlined various human engineering problems associated with the development of new methods of data reduction and presentation, and with their incorporation into flight control and navigation systems.

   Majendie discusses the role of man in automatic control, including requirements for the appropriate display of information, and for the management of the system.

3. Borsky, P. N. Community Reaction to Sonic Booms in the Oklahoma City Area. Vol. II. Data on Community Reactions and Interpretations. AMRL-TR-65-37, Vol. II, October 1965.

The report examines community reaction to a schedule of 8 sonic booms per day for a 6 month period in Oklahoma City. Design of the study, interview procedures and reactions are presented.

4. Clark, D. C., Notess, C. B., Pritchard, F. E., Reynolds, P. A. & Schuler, J. M. Application of Self-Adaptive Control Techniques to the Flexible Supersonic Transport. ASD-TDR-63-831, Vol. 1, August 1963 (AD 440 169).

   The purpose of this study was to determine whether self-adaptive control techniques could be applied successfully to the supersonic transport flight control system. The study was restricted to longitudinal control systems. (from DDC abstract)

5. Federal Aviation Agency. A System Design for the Provision of a Safer, More Economic, and More Efficient Air Traffic Service for the ICAO North Atlantic Region. August 1964 (AD 608 722).

   This is a report on the Systems Planning Approach North Atlantic team, which was formed to produce a system design plan to provide the most practical solution to the major problems incident to the provisions of safe, regular, and efficient air operations in the North Atlantic region.

6. Federal Aviation Agency, Systems Research and Development Service. Design for the National Airspace Utilization System (1st Edition). June 30, 1962.

   This preliminary report is offered as a base to build a satisfactory airspace utilization system for the next 15 years. The report is presented in 5 parts, covering: 1) definition and basic components of an airspace utilization system; 2) application of the basic components to U. S. airspace; 3) significant operational and terminal design involved; 4) description of the system from an operational standpoint; and 5) detailed technical papers on aspects of the systems which require further discussion.

7. Fitts, P. M. (Ed.) Human Engineering for an Effective Air-Navigation and Traffic-Control System. National Research Council, Division of Anthropology and Psychology, March 1951.

   This report deals with the application of human engineering to the improvement of air-navigation and traffic-control systems. A pioneering effort in the area, it presents a long-range program of research aimed at obtaining an orderly and integrated solution to these problems.

8. Jervis, E. R., Garafola, J. R., Dagen, H. & Brady, F. B. Analysis of Safety Aspects of Aircraft Landing Operations. Washington, D. C.: Arinc Research Corp., September 1963 (AD 430 087).

Equipment and operator failures were correlated with landing-operation safety in civil aircraft. To accomplish this objective, the various equipments used in present instrument landing systems in jet aircraft of two major airlines and ground equipments of five airports were analyzed for an estimate of their reliability and safety.

9. Kamrass, M., Rosenshine, M. R., Schmeyer, S. & Smith, M. D. The Evaluation of Airport Noise and Community Reaction. Cornell Aeronautical Laboratory, Inc., September 1960 (AD 263 053).

Problem survey and recommendations.

10. Majendie, A. M. A. Automatic Landing: The Role of the Human Pilot. Aerospace Engineering. Vol. 21, No. 9, 1962, 24-34.

An examination is made of basic human problems in the application of automatic landing techniques to commercial aircraft. This paper discusses the use of human operators and of automatic systems in operational tasks, analyzes control and monitoring functions, and draws conclusions for an effective man-machine system design.

11. Reich, P. G. An Analysis of Planned Aircraft Proximity and its Relation to Collision Risk, with Special Reference to the North Atlantic Region 1965-71. Fairnborough, England: Royal Aircraft Establishment, November 1964 (AD 457 276L).

Expressions are derived for estimating the number of collisions to be expected within a traffic area in a period of time. These are given in terms of the frequency of large flying errors and the total time during which aircraft fly normally at or near a statutory minimum of separation from each other.

12. SST Goals. whole issue of Astronautics and Aeronautics. Vol. 2, No. 9, September 1964.

This issue presents several articles on various aspects of the SST, including recent supersonic transport research, safety, power, SST materials, ionizing radiation, and the sonic boom.

13. The Supersonic Transport: A Special Issue from the Supersonic Transport Seminar. Navigation: Journal of the Institute of Navigation. Vol. 10, Whole No. 1, Spring, 1963.

This special issue is dedicated to articles concerning navigation factors and problems with the supersonic transport. Topics include flight path management, North Atlantic traffic effects, factors influencing vertical and horizontal planes, navigation system capabilities and requirements, meteorological factors, communications, and ground environment.

14. White, M. D., Sadoff, M., Bray, R. S. & Cooper, G. E. Assessment of Critical Problem Areas of the Supersonic Transport by Means of Piloted Simulators. Aerospace Engineering. Vol. 21, No. 5, 1962, 12-21.

Two piloted-simulator studies investigate the aerodynamic stability required in the case of augmentation failure. A third study examines the aircraft handling qualities required for a successful landing approach.

X. AIR TRAFFIC CONTROL SYSTEMS
Operation,
Design, and Effectiveness

1. ASTIA. Air Traffic Control Systems: A Report Bibliography. January 1962 (AD 268 000).

   This bibliography presents abstracts on various aspects of the air traffic control system. Subjects covered include control centers, control operators, communication systems, computer applications, control towers, display systems, ground control approach, human engineering, instrument flight, instrument landing systems, navigational aids and radar approach control.

2. Clark, W. C., Courtney, D. & Colman, K. W. Capabilities and Limitations of the Pilot Operating in a Terminal Area Without Tower Control. Courtney & Co., Rept. 31, FAA/BRD-27, November 15, 1959.

   The study examines the pilot's ability to maintain separation and establish high landing rates at uncontrolled airfields. This ability is analyzed in relation to elements in the approach pattern which demand the pilot's attention, the perceptual cues which he uses in landing, and various decisions he must make. Other factors discussed are the aircraft control loop, airfield characteristics and air traffic control regulations.

3. Cole, G., Bender, M., Shoquist, R., Santella, R. & Lovinger, D. Study of Pilot-Controller Integration for Emergency Conditions. RTD TDR 63-4092, 1963 (AD 428 320).

   This report describes a program to develop a design concept which would minimize catastrophic flight control failures. This report describes a systematic procedure for pilot-controller integration, making use of techniques in the field of flight control design, reliability, and human factors.

4. Colman, K. W., Courtney, D. & Wallace, W. H. Human Factors in Air Traffic Control Systems Design. (Summary Report) Courtney & Co., Rept. 24, Project K, NONR-2346 (00), December 1, 1958. (See also Summary Report, Part II, November 30, 1959).

   This report describes human factors studies conducted at the request of the Air Navigation Board and Airways Modernization Board (forerunners of FAA). Specific problems which were investigated include air traffic control data processing and display, evaluation and development of air traffic control systems, and air traffic control simulation. A section of the report discusses and makes recommendations for the design of air traffic control systems.

5. Davis, C. G., Danaher, J. W. & Fishel, M. A. The Influence of Selected Sector Characteristics Upon ARTCC Controller Activities. Matrix Corp., Contract No. FAA/BRD-301, Task Order No. 2, June 1963.

Using a simulated sector of a representative Air Route Traffic Control Center, a study was conducted to determine how controller performance is affected by variations in sector characteristics. The variations used in this report were the number of aircraft, number of terminals, and the proportion of enroute versus transitioning aircraft. The results indicate that time spent in communication is the most sensitive index of controller activity, and that the primary impact on the controller concerned with more than one terminal in his sector was in the kinds of activities affected rather than the amounts.

6. Hoisman, A. J. & Schaeffer, J. A. Pilot-to-Forecaster Evaluation. FAA/BRD-366, American Institute for Research, May 1962 (AD 602 839).

An operational evaluation of the pilot-to-forecaster test service is reported. The purpose of the evaluation was to assess the operational benefits to aviation and air traffic control from a program of meteorological information and assistance provided to airborne pilots and air route traffic control centers. (from DDC abstract)

7. Howell, W. C., Christy, R. T. & Kinkade, R. G. System Performance Following Radar Failure in a Simulated Air Traffic Control Situation. WADC TR 59-573, September 1959.

In a simulated air traffic control situation, the ability of the controllers to take over and maintain control of aircraft after loss of PPI information is investigated. The effect of monitoring or controlling and the level of control flexibility were the main variables studied.

8. Kidd, J. S. A Summary of Research Methods, Operator Characteristics, and System Design Specifications Based on the Study of a Simulated Radar Air Traffic Control System. WADC TR 59-236, July 1959.

In this report a series of studies on human engineering aspects of radar air traffic control systems are summarized. Consistent human operator characteristics in the task setting are described and recommendations for system design and management are presented. Work by such researchers in the area as Fitts, Kidd, Kinkade, Schipper, Versace, Kraft, at Ohio State University, is reported and reference to their work is included.

9. Kidd, J. S. Some Sources of Load and Constraints on Operator Performance in a Simulated Air Traffic Control Task. WADD TR 60-612, March 1961.

To investigate the influence of task load on operator capacity

and the effects of situational constraints on operator adaptability four variables were manipulated. These variables were traffic input rate, control zone area, control team organization, and arrival sequencing procedures. The results indicate that physically defined constraints are more detrimental to performance than those imposed by organizational structure or rules.

10. Kidd, J. S. Work Team Effectiveness as a Function of Mechanical Degradation of the Intrateam Communication System. ESD Tech. Note 61-57, May 1961.

    A simulated radar air traffic control task was used as a setting for assessing the effects on team performance of various types of mechanical degradation of the communication system. The communication barriers included channel noise, low signal-to-noise ratio, high traffic density, poor frequency band-pass conditions, and channel interruption. The roles of feedback and sender-receiver cooperation are indicated in the results.

11. Kidd, J. S. & Kinkade, R. G. Operator Change-Over Effects in a Complex Task. WADC TR 59-235, August 1959.

    Experiments are described which are concerned with the loss in system performance due to operator change-over and extended work duration in a simulated air traffic control task. The use of prechange-over participation by the replacement worker is recommended. This study represents part of a longer investigation of output of the human operator in a continuous man-machine operation system.

12. Kraft, M. A. & Gregg, L. W. FSF/FAA Air Traffic Control Personnel Study. Flight Safety Foundation, July 15, 1959.

    An intensive study of air traffic control personnel was undertaken with the following objectives: 1) to analyze human performance capacities in relation to such variables as work load, equipment characteristics, and workspace environment; 2) to study tension, stress and anxiety in relation to work loads, environment and personal characteristics; 3) to review and evaluate available experience regarding shift rotation and its physical effect on personnel; and 4) to make recommendations for correction of adverse conditions created or aggravated by environmental factors. The procedures, methods, results and recommendations of the study are presented.

13. Martin, R. (Ed.) A System Description for Air Traffic Control 1962-1970. System Development Corporation, FAA Contract No. FAA/BRD-81, SDC Tech. Memorandum TM-444, January 1960.

    This paper gives the system operating description of an Air Route Traffic Control Center coordinated with the Air Defense Direction

Center planned for Albuquerque in 1962. The chapter headings are: 1) system concept and recommendations; 2) data processing; 3) human factors and system training; 4) equipment and facilities; and 5) implementation planning.

14. Mitre Corporation. Satin: An Experimental En Route Air Traffic Control System. SR-32, FAA/ARDS-497, Bedford, Mass., August 1962.

    This report outlines the SATIN system design as it existed in 1962. The purpose of the SATIN project was to investigate the possible use of SAGE air defense equipment and techniques for enroute air traffic control. Aspects of design considered in this report are teletype inputs, flight plan processing, radar input and tracking, conflict prediction, and test facilities and techniques.

15. Moss, S. M., Kraft, C. L. & Howell, W. C. The Influence of Overlay Configuration on the Estimation of Heading and Speed. WADD TR 61-141, March 1961.

    The influence of range rings and angle marks on the PPI radar scope in judgments of heading and speed is evaluated in two experiments reported here. The results of these studies indicate: 1) that range rings had no influence on these judgments; and 2) that angle marks improved heading estimation, while causing decrements in speed estimation judgments.

16. Webster, J. C. & Thompson, P. O. Factors Affecting Speech Intelligibility in Aircraft Control Towers. Navy Electronics Laboratory Rept. 357, March 1953 (AD 13 397).

    Noise, intelligibility of signal, and operator fatigue were studied as they affect Navy Air Station control-tower operations. Two different mock control towers were constructed in which licensed air-controllers were tested for the ability to discern critical transmissions.

XI. PERSONNEL FACTORS
Selection
Physical Standards
Job Requirements
Training and Training Devices
Performance Aids
Appraisal

1. Baxter, J. R., Cumming, R. W., Day, R. H. & Feather, N. T. A Study of Three Pilot Operation of a Jet Transport Aircraft. Melbourne, Australia: Human Engineering Rept. 3, Dept. of Supply, September 1963.

   This report presents data on the measured performance and subjective experience of three pilots in the Boeing 707. Problems of pilot performance are discussed, and recommendations are made for the operation of supersonic transports.

2. Buckhout, R. A Bibliography on Aircrew Proficiency Measurement. MRL-TDR-62-49, May 1962.

   This bibliography is organized into 6 sections: 1) measurement dealing with proficieny on single task elements and job segments; 2) total job performance and inclusive job segments; 3) reliability and validity of proficiency measures; 4) equipment and techniques used in measurements; 5) general reviews, summaries and theory; and 6) background information on psychomotor performance and transfer of training. The selection of articles emphasizes the use of simulators as measurement devices in assessing aircrew efficiency.

3. Davis, C. G., Kerle, R., Silvestro, A. W. & Wallace, W. H. Identification of Training Requirements in Air Traffic Control. (Rept. No. 3 of 9). Courtney & Co., Rept. No. 36, FAA/BRD-40, April 29, 1960 (AD 261 248).

   This report describes the duties, knowledge, and skill requirements of controllers as viewed by field facility operating and training personnel. The requirements are presented for each operating position in centers, towers, and stations, and are organized according to their implications for an integrated training program. (Author Abstract)

4. Department of the Air Force. Flight Surgeon's Manual. AF Manual 160-5, October 1954.

   In section 8 general principles of training are discussed, and recommendations are presented for medical indoctrination and training of air crew, technical training of medical personnel, fields of training, requirements of training programs and methods of training.

5. Finch, G. (Ed.) Air Force Human Engineering Personnel, and Training Research. National Academy of Sciences, National Research Council, Publication 783, 1960.

About one third of the papers presented in this symposium report deal with various aspects and problems on the selection and training of air crew personnel.

6. Folley, J. D., Jr. Research Problems in the Design of Performance Aids. ASD TR 61-548, October 1961 (AD 270 866).

Written primarily for the researcher in human factors systems design, this report presents the problems and issues involved in the development of aids to facilitate on-the-job performance.

7. Gagne, R. M. (Ed.) Psychological Principles in System Development. N. Y.: Holt, Rinehart, and Winston, Inc., 1962.

This book deals with the human factors aspects of man-machine system design. The technology for each stage in the development of the system is described. The topics include task description and analysis; job design and job aids; selection, examining and training devices; performance measures and team training.

8. Glaser, R. (Ed.) Training Research and Education. University of Pittsburg Press, 1962.

This book is the result of a conference concerned with training problems and research. Each chapter is devoted to research in a specific area of training. Training procedures, measurement, simulators, instrumental aids and training for multi-man systems are a few of the topics covered.

9. Keenan, J. J., Parker, T. C. & Lenzycki, H. P. Concepts and Practices in the Assessment of Human Performance in Air Force Systems. AMRL-TR-65-168, September 1965.

The current practices of human performance assessment in Air Force Systems are described and evaluated. The test programs are reviewed for specific systems and subsystems of major interest to the Air Force. The topics include: 1) AF policies and requirements for the development and assessment of systems tests and human performance; 2) behavioral science approach and technology for assessing human performance; and 3) AF practices in the assessment of human performance.

10. Kinkade, R. G. & Kidd, J. S. The Use of an Operational Game as a Method of Task Familiarization. WADC TR 59-204, July 1959.

The use of an operational game to familiarize air traffic control trainees with their subsequent tasks is compared to the use of an

electronic simulator for this step in training. The limitations and advantages of using this type of task familiarization method are discussed.

11. Kraft, M. A. FSF/CAA Medical Study Report No. 1: Physical Qualifications for Air Traffic Control Personnel. Flight Safety Foundation, February 21, 1958.

This study reviews the procedures and standards for the physical qualifications of persons engaged in air traffic control activities. Findings from a survey of 12 facilities involved in air traffic control are presented and analyzed in relation to worker characteristics, work schedules, personnel practices, work areas, and working conditions. Specific recommendations are made regarding medical examinations, psychological qualification tests, environmental factors, and areas needing further study.

12. Miller, N. E. (Ed.) Psychological Research on Pilot Training. U. S. Army Air Force Aviation Psychology Program Research Reports. Rept. No. 8, 1947.

This book reports on and summarizes the research done in World War II on pilot training, selection and factors influencing performance.

13. Miller, R. B. Task and Part-Task Trainers and Training. WADC 60-469, June 1960.

This report gives a procedure for partitioning total job requirements into segments and for setting up training procedures for these separate segments. It also identifies major types of training devices that are available.

14. Muckler, F. A., Nygaard, J. E., O'Kelly, L. I. & Williams, A. C., Jr. Psychological Variables in the Design of Flight Simulators for Training. WADC TR 59-369, January 1959 (AD 97 130).

This report surveys the problem of transfer of training from the simulator to the aircraft. Primarily theoretical in approach, it considers such variables as fidelity of simulation involving "G" forces, movement cues, and control feel.

15. Oberman, A., Mitchell, R. E. & Graybiel, A. Thousand Aviator Study: Methodology. Monograph 11, Joint Report of U. S. N. School of Aviation Medicine, U. S. Public Health Service, and NASA, July 1965.

This report presents the methodology used in the Pensacola Study of Naval Aviators which began in 1940 with physiological and psychological testing of 1000 flight instructors and trainers.

Repeated testing of many of these men has been conducted over a period of 23 years. The purpose of the original study was to improve methods of selection for pilots. Although this document gives only the methodology, it does include a bibliography of reports that have come out of this research.

16. Price, H. E., Behan, R. A. & Ereneta, W. J. Requirements and Constraints of Potential Roles of Supersonic Transport Crews. NASA CR-146, January 1965.

The overall purpose of this report is to provide a study of operational crew task requirements for supersonic transports. The report gives information on SST flight profiles, requirements and constraints, and outlines potential roles of the SST crew.

17. Ritchie, M. L. & Hanes, L. F. An Experimental Analysis of Transfer Effects Between Contact and Instrument Flight Training. Ritchie, Inc., Contract No. FA-WA-4691, June 1964.

The effects of instrument experience in the airplane and in a Link Trainer on subsequent learning of contact flight and instrument flight in the airplane are analyzed. Evidence shows that instrument flight is harder to learn than contact flight. Experience with instruments in the airplane proved to be more effective than experience in the Link Trainer in reducing the subsequent learning time in both instrument and contact flying.

18. Symposium on Training. Ergonomics. Special Issue on Training, Vol. 2, No. 2, February 1959.

This whole issue presents papers on various types and problems of training procedures. Among the topics examined are: the role of the operator's perception of the task in skilled performance; how manual skills are learned; and the influence on learning of certain factors such as knowledge of progress.

19. Trites, D. K. & Cobb, B. B. Age, Aptitude, and Experience as Predictors of Air Traffic Controllers. CARI Unnumbered Report, FAA, January 1964.

This unnumbered report summarizes in a nontechnical fashion several FAA Office of Aviation Medicine reports by the authors on problems in air traffic management (CARI Rept. 62-2196, also Aerospace Medicine, Vol. 33, 1962, 702, CARI Rept. 61-1, also Aerospace Medicine, Vol. 32, 1961, 1112, and CARI Rept. 62-3, 1962). Some of the conclusions from this research program are: 1) selection of air traffic control trainees by aptitude tests is the most effective program to date; 2) job-related experience does not appear essential for selection; 3) the older the trainee when entering training the less likely he is to become a successful ATC specialist; and 4) training programs for individuals selected on the basis of aptitude tests alone should take the trainee's lack of aviation - relevant knowledge into account.

20. Trites, D. K. & Kubala, A. L., Jr. Characteristics of Successful Pilots. Journal of Aviation Medicine. Vol. 28, 1957, 34-40.

This paper presents methods for assessing the characteristics of successful pilots by the use of personality measures obtained during training, and measures of pilot effectiveness obtained several years later. Variables emphasized are general level of adjustment, flying aptitude and educability, need for self-endorsement, expressed symptom frequency and likability.

XII. SKILLED PERFORMANCE

Fatigue
Biological Rhythms
Work Schedules
Speech and Hearing
Communication Networks
Information Processing
Stress

1. Bartley, S. H. & Chute, E. Fatigue and Impairment in Man. N. Y.: McGraw-Hill, 1947.

   Although somewhat dated, this book remains the most comprehensive survey of research on various aspects and definitions of the elusive concept of fatigue. It considers the physiological and psychological effects of fatigue on man and also various factors which cause fatigue.

2. Bergum, B. O. Vigilance: A Guide to Improved Performance. Human Resources Research Office, George Washington University, Research Bulletin 10, October 1963.

   This is an informal report on the data in vigilance research. Vigilance is defined as the ability to concentrate on a task for a length of time.

   For a more detailed report see HumRRO Research Rept. 8, A Survey and Analysis of Vigilance Research, May 1961.

   Also, HumRRO Research Rept. 11, Vigilance as a Function of Task and Environmental Variables, May 1963.

3. Broadbent, D. E. Vigilance. British Medical Bulletin. Vol. 20, No. 1, 964, 17-21.

   A review of the history and research on vigilance is presented. Reported factors which influence vigilance performance are probability of signals, general state of alertness, distracting and competing stimulation, inspection at one's own speed, simultaneous use of different senses, and caution or riskiness in reporting.

4. Buckner, D. N. & McGrath, J. J. Vigilance: A Symposium. N. Y.: McGraw-Hill, 1963.

   A result of a symposium sponsored by the Office of Naval Research, this book presents recent research, methods and theory in the area of vigilance. Topics include vigilance in relation to irrelevant stimulation, performance in two visual vigilance tasks, and a comparison of performance under conditions of single and dual sensory vigilance tasks (involving one or more of the human senses at the same time).

5. Committee on Undersea Warfare, National Research Council. A Survey Report on Human Factors in Undersea Warfare. Washington, D. C., 1949.

   Chapter 10 by M. H. Abram is concerned with the selection and training of personnel for voice communications. A summary of the research on masking and distortion in speech inteligibility is discussed in Chapter 11 by G. A. Miller.

6. Engineering Psychology. Annual Review of Psychology. Vol. 9, 1958; Vol. 14, 1963; Vol. 17, 1966.

   The volumes cited include a review of such topics as man-machine systems, displays and controls, environmental problems including noise and illumination, information processing and decision making, and skilled performance. Authors of these research reviews appearing at irregular intervals, have been P. Fitts, A. Chapanis and E. Poulton.

7. Flaherty, B. E. (Ed.) Psychophysiological Aspects of Space Flight. N. Y.: Columbia University Press, 1961.

   While this book deals primarily with psychological and physiological problems of space flight, many of the reports are also applicable to the civil aviation. Topics include operator characteristics and experience, selection, physiological aspects of stress, and the influence of such factors as isolation, sensory overloading, interpersonal relationships, and motivation on human performance.

8. Floyd, W. F. & Welford, A. T. Symposium on Fatigue. The Ergonomics Research Society, London: H. K. Lewis & Co., 1953.

   This symposium gives a good overview of the effects of fatigue on performance. Although somewhat dated, a useful background of fatigue studies is presented. Among the various topics covered are tropical fatigue, the physiology of fatigue, visual fatigue, and effects of prolonged muscular exertion.

9. Fogel, L. J. Biotechnology: Concepts and Applications. Englewood Cliffs, N. J.: Prentice-Hall, 1963.

   This book aims to present, within the limitations of the state of the art, a synthesis of theory and practice in human engineering. While there are several useful chapters on human factors design, this book is not a design guide as such. Among the topics presented are the human sensory channels; manual tracking; decision making; human motor systems; equipment design; workspace and environmental design requirements; man-machine task allocation; role of the operator in complex systems.

10. Hauty, G. T. & Adams, T. Phase Shifts of the Human Circadian System and Performance During Periods of Transition: III. North-South Flight. OAM 65-30, December 1965, See also by same authors Part I: East-West Flight, OAM 65-28, December 1965 (also in Aerospace Medicine, Vol. 37, No. 7, 1966, 668-674), and Part II: West-East Flight, OAM 65-29, December 1965.

    These three studies on human reactions to jet-flight in varying directions give rise to the following major conclusions: 1) East-West and West-East flights produced primary shifts in the circadian periodicity as measured by certain physiological functions, while the North-South flight did not; 2) all three flights produced a significant decrement in subjective fatigue; and 3) significant impairment of psychological test performance occurred only in the East-West flight.

11. Hauty, G. T., Trites, D. K. & Berkley, W. J. Biomedical Survey of ATC Facilities: I. Incidence of Self-Reported Symptoms. FAA, OAM 65-5, March 1965 (See also by same authors, Biomedical Survey of ATC facilities: II. Experience and Age. OAM 65-5, March 1965.)

    A biomedical inventory, completed daily for 90 days by journeymen and assistant controllers at 6 enroute and 6 terminal air traffic control facilities selected on the basis of differences in shift-rotation schedules and high traffic volume, obtained information on health, morale, behavioral habits and side effects of medications. One index of information used in these studies, stress-related symptoms, shows the following relationships: 1) the number of reported symptoms differed for the various facilities, but was not attributed to shift-rotation schedules; 2) the highest incidence of reported symptoms occurred with 8 hours or less between two successive shifts; and 3) the incidence of reported symptoms increased with both age of the controller and years of ATC experience.

12. Jerison, H. J. & Pickett, R. M. Vigilance: A Review and Re-evaluation. Human Factors. Vol. 5, No. 3, 1963, 211-238.

    The experimental work on the detection of visual signals in monitoring tasks is reviewed and evaluated in terms of a decision-theory model. Emphasis is placed on the application of laboratory findings to field applications. Suggestions and recommendations are presented for a visual vigilance task in CRT monitoring in a manned space system.

13. Juin, G. Considerations on the Increase of Fatigue Factors Concerning Air-Crew Flying on Jets. in Barbour, A. B. & Whittingham, H. E. (Eds.) Human Problems of Supersonic and Hypersonic Flight. N. Y.: Pergamon Press, 1962.

    This chapter discusses jet aircraft crew fatigue in relation to high altitude, acceleration and speed. Methods of research to investigate this problem are suggested.

14. McIntosh, B. B., Milton, J. L. & Cole, E. L. Pilot Performance During Extended Periods of Instrument Flight. AF Tech. Rept. 6725, May 1952.

One of the first reports on the effects of extended flights on pilot performance, this study investigated the influence of flights of 10, 15, and 17 hours duration. Recording equipment measured the amount of time the flight indicators were kept within tolerance limits and the continuous variation of flight indicators and control positions. Pilots' subjective reports were also obtained. The results indicated that the pilots' performance was as good after 10, 15 and 17 hours of instrument flight as after the first hours of flight. Although the reports of the pilots show they were preoccupied with their physical discomfort, this did not appear to influence their flying ability.

15. Mohler, S. R. Fatigue in Aviation Activities. FAA, AM 65-13, March 1965.

This article reviews and discusses causes and symptoms of biological fatigue in aviation activities; flight-time limitations; indicators of excessive fatigue; new developments in intercontinental flights and forest service flights; methods for reducing fatigue by improved cockpit design factors; scheduling; and close cooperation between federal officials, pilots and airline officials.

16. Oswald, I. Sleeping and Waking: Physiology and Psychology. N. Y.: Elsevier Publishing Co., 1962.

This paper reviews and discusses the physiological and psychological aspects of sleep. Of particular interest is Chapter 11 dealing with effects of deprivation of sleep.

17. Potocko, R. J. Bibliography Related to Human Factors System Program. (July 1962-February 1964), NASA SP-7014, 1964.

This bibliography covers 21 categories relevant to NASA research in the broad areas of advanced concepts, human research and performance, and life support and protective systems.

18. Ray, J. T., Martin, O. E., Jr. & Alluisi, E. A. Human Performance as a Function of the Work-Rest Cycle - A Review of Selected Studies. National Academy of Sciences, National Research Council, Publication 882, 1961.

This review includes studies where performance observations cover periods of 24 hours or longer and where the objective is to optimize the work-rest cycle. The studies, in general, show that man's performance and physiological processes exhibit variations that are a function of his adaptation to a 24-hour day.

19. Rosenblith, W. A. (Ed.) Sensory Communications. Cambridge, Mass.: M. I. T. Press, 1961.

The proceedings of a symposium held at M. I. T. in 1959, this book presents papers on various aspects of communications involving the human senses. Many types of research projects are reported and reviewed in vision and hearing. Of particular interest to human engineering design is the description of new concepts for developing psychophysical scales.

20. Sampson, P. B. & Wade, E. A. Literature Survey on Human Factors in Visual Displays. RADC TR 61-95, June 1961 (AD 262 538).

This report gives a series of annotated studies dealing with information handling capabilities of the human operator, and with methods for optimizing the presentation of visual information. The studies cover the period from 1940 to 1961.

21. Schreuder, O. B. Medical Aspects of Aircraft Pilot Fatigue With Special Reference to the Commercial Jet Pilot: A Special Report. Aerospace Medicine. Vol. 37, No. 4, Section II, April 1966, 1-44.

This report discussing fatigue in relation to the jet pilot is presented in four chapters. The first chapter presents a general discussion of fatigue, reviews the literatue, discusses the different aspects of stress and fatigue, and examines the problem of measuring stress. The second chapter discusses the operational aspects of fatigue (such as environment, climate conditions, vibration, etc.) and the non-operational aspects (such as psychological factors, off-duty activities, physical condition), work-rest cycles, adaptation, and flight time. Aging, health and prevention of fatigue are discussed in the third chapter. Comments and conclusion are given in Chapter 4.

22. Silverman, M. Human Engineering, A Report Bibliography Prepared by ASTIA. May 1962 (AD 274 800).

This report presents an abstracted bibliography in human engineering from the period 1953 to February 1962. Among the topics included are communication systems and equipment, controls and displays, data processing systems and computers, training devices, and visual aids.

23. Simon, C. W. Some Immediate Effects of Drowsiness and Sleep on Normal Human Performance. Human Factors. Vol. 3, No. 1, 1961, 1-17.

The experimental literature on the effects of sleep and drowsiness on performance is reviewed. The behavioral responses examined are reflexes, simple movements, detection, discrimination, learning and recall.

24. Smith, H. P. R. An Investigation of Pilots' Work Load and Working Conditions in a Civil Air Line. Flying Personnel Research Committee. FPRC/1190, November 1961.

A report of the working conditions of commercial airline pilots in Britain is presented. Investigated were environmental conditions, air traffic control, communications, navigation, setting, lighting, and stresses on the ground. Recommendations are made to reduce stress and fatigue for the pilot.

25. Spector, H., Brozek, J. & Peterson, M. S. Performance Capacity: A Symposium. Quartermaster Food and Container Institute for the Armed Forces, National Academy of Sciences, National Research Council, February 1961.

The reports presented in this symposium are concerned with the detriments of performance capacity and the factors that can influence this capacity. The reports are organized under three topics: 1) ready functions involved in work and their use to predict performance capacity; 2) application of standard work tests; and 3) effects of environmental stresses on performance capacity.

26. Swets, J. A. (Ed.) Signal Detection and Recognition by Human Observers. N. Y.: John Wiley & Sons, 1964.

This book is a compilation of many documents, reports, and unpublished papers. The theory of signal detectability grew out of application of statistical decision theory to signal detection problems in electrical engineering. Included in the volume are papers on such topics as signal recognition, frequency analysis, speech communication, and visual and auditory processes.

27. Wallis, D. & Samuel, J. A. Some Experimental Studies of Radar Operating. Ergonomics. Vol. 4, No. 2, 1961, 155-168.

Experiments on three aspects of radar operating are described and discussed. The areas of investigation were: 1) the influence of long watches on performance; 2) the limits of target density load; and 3) the eye-movement patterns in radar operating. The implications of the results for radar operating are discussed.

28. Wilkinson, R. T. Effects of Up to 60 Hours Sleep Deprivation on Different Types of Work. Ergonomics. Vol. 7, No. 2, 1964, 175-186.

The effects of sleep deprivation upon performance vary widely with the nature of the work being carried out. It is suggested that the variables determining the effect of sleep deprivation on performance are the complexity of the task, incentive, interest and reward. The most important variable appears to be that of incentive.

XIII. ENVIRONMENTAL FACTORS
Noise
Temperature
Lighting
Ventilation
Climate

1. American Industrial Hygiene Association. Industrial Noise Manual, 2nd Edition. 1966.

   This manual is concerned primarily with 1) physical measurement of noise; 2) medical evaluation of persons exposed to it; and 3) control of noise exposure. Of particular interest for human factors are Chapters 7 and 10 on the effects of noise on man, and on methods of protection from noise. Chapter 7 discusses the medical effects of noise on hearing and lists various criteria that have been set up for noise limits. Chapter 10 presents methods of reducing noise effects by using personal equipment such as ear muffs and ear plugs. These are evaluated in terms of effectiveness, comfort and fit.

2. A. S. H. R. A. E. Guide and Data Book 1961, Fundamentals and Equipment. N. Y.: American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1961. (Also see Vol. 2, 1962.)

   This handbook contains eight sections as follows: 1) theory; 2) materials; 3) load calculations; 4) system components; 5) unitary refrigeration equipment; 6) air conditioning units; 7) refrigerant systems: charging, cleaning and lubrication; and 8) general.

   For rapid reference to equipment needed for installation of various types of systems, a Catalog Data Section shows products of leading manufacturers in heating, refrigerating, ventilating and air conditioning.

3. Barwood, A. J. An Investigation of Pilot's Work-Load and Working Conditions in a Civil Air Line: Environmental Factors. Flying Personnel Research Committee, FPRC/1190 (a), November 1961.

   This study reports the humidity and temperature variations in the cockpits of civil airlines for a period of two months, and makes recommendations for standards in environmental control.

4. Bedford, T. Researches on Thermal Comfort. Ergonomics. Vol. 4, No. 4, 1961, 289-310.

   The work in the area of thermal comfort for the past 40 years is described. Emphasis is placed on obtaining an adequate methodology for measuring the state of the thermal environment. Variables cited as influencing thermal comfort are air movement, humidity, wall

temperature, room air temperature, and temperature differences between floor level and head level.

5. Bell, C. R. & Provins, K. A. Effects of High Temperature Environmental Conditions on Human Performance. Journal of Occupational Medicine. Vol. 4, 1962, 202-211.

This article reviews studies of the effects of high temperature environment on the performance of tasks which demand little physical effort. Results of studies of discomfort, performance of mental tasks and of complex operator tasks are presented. A bibliography of high temperature environment studies is included.

6. Blockley, W. V., McCutchan, J. W., Lyman, J. & Taylor, C. L. Human Tolerance for High Temperature Aircraft Environments. Journal of Aviation Medicine. Vol. 25, No. 5, 1954, 515-522.

This paper examines the problem of predicting the net effect of the combination of the various physical factors which constitute the thermal environment of man. Criteria are outlined for predicting the duration of unimpaired psychomotor performance and the maximum tolerable duration of exposure before reaching a state of collapse. Tolerance limits are presented in graph form. The effect of clothing in extending the limits is discussed.

7. Burton, A. C. Man in a Cold Environment. London: Edward Arnold, Ltd., 1955.

This book examines the physical and physiological problems of the maintenance of a thermal steady state in man, and discusses the physiological mechanisms of body temperature regulation.

8. Edholm, O. G. The Physiological Effects of Climate on Man. Chapter 7 in Floyd, W. F. & Welford, A. T. (Eds.) Symposium on Human Factors in Equipment Design. Ergonomics Research Society Proceedings, Vol. 2. London: H. K. Lewis and Co., 1954.

While this book is based on early studies, it contains much useful material on the effects of hot and cold climates, and on protection and adaptation to cold. Implications for human factors design are presented.

9. Harris, C. M. (Ed.) Handbook of Noise Control. N. Y.: McGraw-Hill, 1957.

This volume covers many aspects of the problem of noise control, with contributors from various disciplines. Relevant topics in this volume are: properties of sound; effects of noise on men; instrumentation and noise measurement; techniques of noise control; noise control in buildings; sources of noise and examples of noise

control; noise control of machinery, electrical equipment; noise in transportation; community noise, and legal aspects of noise problems.

10. Leithead, C. S. & Lind, A. R. Heat Stress and Heat Disorders. Philadelphia: F. A. Davis Co., 1964.

Concerned with the problems of men in confronting heat stress, this book covers the aspects of heat stress related to: effects of short exposure; nature of effects on performance; acclimatization effects; prevention of heat effects and control of the heat hazard; comfort considerations; techniques for evaluating temperatue and humidity effects; the role of clothing, age, physical fitness, race, sex, physique and nutrition; the definition of tolerable work environments; and the management of personnel in heat environments.

11. McFarland, R. A. Human Factors in Air Transport Design. N. Y.: McGraw-Hill, 1946.

Chapters 6 and 7 consider the control of ventilation, humidity, temperature and noise in aircraft. Recommendations for control of these factors are presented.

12. Plutchik, R. The Effects of High Intensity Intermittent Sound on Performance, Feeling and Physiology. Psychological Bulletin. Vol. 56, No. 2, 1959, 133-151.

The literature on the effects of loud, irregular or interrupted noise on performance is reviewed. Evidence is presented for the generalization that loud or intermittent noise produces discomfort and irritability in man, while irregular loud noises produce decrements in performance tasks, especially monitoring.

13. Wick, R. L., Jr., Roberts, L. B. & Ashe, W. F. Light Aircraft Noise Problems. Aerospace Medicine. Vol. 34, No. 12, 1963, 1133-1137. (See also Wick, R. L., Noise in the Cabin. The AOPA Pilot. Vol. 7, No. 8, 1964, 32-36.)

This investigation of noise levels in the light airplane discloses that, from a hearing loss point of view, noise hazards exist in all the aircraft studied. The need for reduction in noise level is emphasized, and the use of protective devices are urged.

14. Wing, J. F. A Review of the Effects of High Ambient Temperature on Mental Performance. AMRL-TR-65-102, September 1965.

Reviewing 15 experiments on the effects of high ambient temperature on mental performance, the author is able to obtain upper thermal limits for unimpaired mental performance by considering both the effective temperature and the exposure time.

15. Wing, J. & Touchstone, R. M. A Bibliography of the Effects of Temperature on Human Performance. AMRL-TDR-63-13, February 1963.

This report lists studies of the effects of high and low ambient temperatures on: 1) sensory thresholds and simple reaction time; 2) attention and perception; 3) psycho-motor performance; 4) heavy or prolonged physical work; and 5) mental performance.

16. Work in Cold Environments. Vol. 2, Nos. 3 and 4, Journal of Occupational Medicine. 1960.

These two issues of this journal contain six articles reviewing the effects of cold environments on work. Topics include: recommended types of clothing for cold environments; human tolerance and acclimization to cold; nutritional factors; and the effects of cold on reaction time, tracking proficiency, general dexterity, tactile discrimination, and muscle strength. Recommendations are given for the design of controls to be operated by those who wear heavy clothes.

XIV. ACCELERATION AND VIBRATION EFFECTS
Disorientation (Vertigo)

1. Bennett, E., Degan, J. & Spiegel, J. (Eds.) Human Factors in Technology. N. Y.: McGraw-Hill, 1963.

   Two chapters in this book are relevant to the areas of acceleration and vibration. Chapter 4 by C. Clark reviews research conducted on the Navy centrifuge at Johnsville on problems of the acceleration environment, body distortions, and restraint systems. E. B. Magid and R. R. Coerman, in chapter 5, discuss the physical, psychological and physiological responses of humans to vibration.

2. Bonner, R. H. Spatial Disorientation - Current Concepts and Aeromedical Implications. Aeromedical Reviews 7-63. USAF School of Aerospace Medicine, August 1963.

   This paper discusses the types and mechanisms of spatial disorientations, the flying safety implications, and a method of preventing disorientation.

3. Chambers, R. M. Effect of Acceleration on Pilot Performance. NADC-MA-6219, March 1962.

   This report attempts to consolidate the findings of both early and recent research in the area of acceleration effects upon performance, and to relate these findings to pilot performance. The known effects of acceleration upon the ability of pilots to "fly" both simple and whole-system simulations are cataloged, with special attention given to the ways in which such variables as system complexity, controller construction, restraint and life-support equipment, and pilot experience and training serve to augment or reduce these effects.

4. Chambers, R. M. Operator Performance in Acceleration Environments. Chapter 7 in Burns, N. M., Chambers, R. M. & Hendler, E. (Eds.) Unusual Environments and Human Behavior. London: Free Press of Glencoe, 1963.

   Chapter 7 presents a comprehensive survey of the literature on studies relating to human behavior in acceleration. The survey covers acceleration environments, role of the human senses in acceleration, effects of acceleration on simple and complex operator performance, on higher mental abilities, and on emotional response to stress (personality, emotion, and maturation). Space flight simulation and acceleration training are also discussed. General principles concerning human performance capabilities during exposure to stressful acceleration environments are included, and problem areas for future research are defined.

5. Clark, C. C. Human Control Performance and Tolerance Under Severe Complex Waveform Vibration With a Preliminary Historical Review of Flight Simulation. Baltimore, Md.: The Martin Co., Engr. Rept. No. 12406, April 1962.

Problems of terminology of acceleration and flight simulation are reviewed, with a preliminary historical review of particular moving base flight simulation. The capabilities and limitations of the Navy Johnsville human centrifuge and the North American Aviation (Columbus) "G-Seat" for jostle simulation are presented. Potential developments of restraints, displays, and controls for use in severe jostle environments are noted. A "relative jostle biological effectiveness" concept is suggested for test as a means of comparing the biological effects of jostle environments with different frequency components.

6. Cope, F. W. Problems in Human Vibration Engineering. Ergonomics. Vol. 3, No. 1, 1960, 35-43.

The effects of vibration on vehicle operators, including aircraft pilots, are examined in this paper, along with methods of reducing these effects. This discussion is limited to the frequency range of 0-50 c.p.s. The first section of the article discusses the transmissions of vibration from the vehicle to man and the methods of preventing this transmission. The second section outlines the harmful effects of vibration on man, and relates the experimental work on vibration to practical methods of providing vibration protection.

7. Gauer, O. H. & Zuidema, G. D. (Eds.) Gravitational Stress in Aerospace Medicine. Boston, Mass.: Little Brown, 1961.

The book summarizes much research on the physiological and psychological effects of acceleration. Included are discussions of the physical aspects of acceleration, its physiological effects on the heart and respiration, its effect on performance, and methods of providing protection against acceleration.

8. Goldman, D. E. A Review of Subjective Responses to Vibratory Motion of the Human Body in the Frequency Range 1 to 70 Cycles per Second. Naval Medical Research Institute, AN No. 47359, March 1948.

In this report is presented a review of subjective responses to mechanical vibration. These responses are analyzed in terms of 1) perceptual threshold; 2) discomfort threshold; and 3) tolerance threshold. The ranges of these thresholds are plotted for the range of frequencies.

9. Goldman, D. E. & VonGierke, H. E. The Effects of Shock and Vibration on Man. Lecture and Review Series No. 60-3. Bethesda, Md.: Naval Medical Research Institute, January, 1960. (This article is closely parallel to a chapter in Harris, C. M. & Crede, C. E. (Eds.) Handbook

of Shock and Vibration Control. N. Y.: McGraw-Hill, 1961).

This review deals with the following topics: the human body as a mechanical and biological system, the effects of shock and vibration on this system, and the protection needed for the human body under these conditions.

10. Harris, C. M. (Ed.) Handbook of Noise Control. N. Y.: McGraw-Hill, 1957.

Chapters 11-15 describe the effect of vibration on man, outline the principles of vibration control, and discuss methods of vibration isolation, damping and measurement.

11. Human Factors: Special Vibration Issue. Vol. 4, No. 5, 1962, 227-333.

Among the topics covered in this issue are: the effects of vibration on human performance and visual acuity; the mechanical impedance of vibration in sitting and standing positions; body deformation caused by vibration; effects of buffeting on the internal pressure of man; and human reaction to whole-body vibration.

12. Hyde, A. S. & Raab, H. W. A Summary of Human Tolerance to Prolonged Acceleration. AMRL-TR-65-36, February 1965.

This report summarizes data from past research on human tolerance to acceleration as related to the onset rate, magnitude, and duration of sustained acceleration force. Data are presented in graphs and tables.

13. Kraus, R. N. Disorientation in Flight. Aerospace Medicine. Vol. 30, No. 9, 1959, 664-673.

After presenting a brief discussion of the physiological mechanisms for maintaining spatial orientation, the author describes three flight experiments in which the causes of disorientation are investigated.

14. Linder, G. S. Mechanical Vibration Effects on Human Beings. Aerospace Medicine. Vol. 33, No. 8, August 1962, 939-949.

This paper is a review of the literature on the effects of mechanical vibration on man. It is intended to provide a readily accessible compilation of vibration information for those persons concerned with aerospace vehicle design and operation.

15. Psychophysiology Branch, Office of Naval Research. A Symposium: Psychophysiological Factors in Spatial Orientation. NAVEXOS P-966, October 1950.

This symposium presents a series of papers on problems and research in spatial orientation. The general topics covered are orientation to visual and postural vertical; accelerative forces; and theoretical issues in orientation research.

16. VonGierke, H. E. On Noise and Vibration Exposure Criteria. AMRL-TR-65-84, September 1965. (Reprinted from Archives of Environmental Health, Vol. 11, 1965, 327-339).

This article emphasizes the need to have national and international criteria on noise and vibration exposure. The author points out that generally there are accepted criteria for many kinds of noise exposure, but none for vibration exposure.

17. White, W. J. Quantitative Instrument Reading as a Function of Illumination and Gravitational Stress. Journal of Engineering Psychology. Vol. 1, 1962, 126-133.

This research article concludes that decrement which occurs in dial reading performance as a function of acceleration can be counteracted, up to a point, by increase in illumination.

XV. ALTITUDE PHYSIOLOGY

1. Adler, H. F. Dysbarism. USAF School of Aviation Medicine, Review 1-64, February 1964.

   This report presents a detailed discussion of the symptoms and signs resulting from changes in barometric pressure, with emphasis on altitude dysbarism. Beginning with definitions and classifications, the author examines the theories of the causes of altitude dysbarism, and outlines the methods useful for preventing its occurrence.

2. Balke, B. Human Tolerances. CARI Rept. 62-6, FAA, April 1962.

   This article defines human tolerances for various types of stress, such as those produced by gravitational forces, hyperventilation, high altitude, decompression, oxygen loss, temperature extremes and physical work.

3. Balke, B. Work Capacity and its Limiting Factors at High Altitude. in Weihe, W. H. (Ed.) The Physiological Effects of High Altitude. London: Pergamon Press, 1964, 233-240.

   This report describes work-output of physically trained and untrained men in a high altitude (mountain) environment. Acclimitization to high altitude environments is discussed, and the limiting factors imposed by the human respiratory and circulatory systems are indicated.

4. Barron, C. I. Research Studies on Investigation of the Effects of Slow and Rapid Decompression upon Humans at 45,000 Feet. Lockhead-California Co., FAA Contract FA-3082, May 31, 1963.

   This report presents results of studies to determine the effects of decompression on men subjected to altitudes from 8,000 to 45,000 feet. Tolerances to slow decompression and to rapid decompression are compared.

5. Blockley, W. V. & Hanifan, D. T. An Analysis of the Oxygen Protection Problem at Flight Altitudes Between 40,000 and 50,000 Feet. Webb Associates, FAA Contract No. FA-955, February 20, 1961.

   This report reviews the literature of 25 years, analyzes recent research, and reports on the results of an intensive 6-month study of the problems peculiar to civil aviation in the flight altitude range of 40,000 to 50,000 feet. Tables and figures describing typical oxygen equipment are presented, plus a bibliography of over 200 reports. Suggestions and recommendations are given.

6. Boothby, W. M. (Ed.) Handbook of Respiratory Physiology. Air University, USAF School of Aviation Medicine, September 1954.

This handbook presents a number of articles surveying research on respiratory function, and analyzes the results of studies of physiological limitations imposed by altitude. While somewhat dated, the volume makes useful recommendations for the development of protective devices and procedures in high altitude flights.

7. Department of the Air Force. Flight Surgeon's Manual. AF Manual 160-5, October 1954.

Section I discusses a number of factors having a bearing on air crew effectiveness, including acceleration, motion, reduced oxygen and barometric pressures, temperature and other toxicological and environmental conditions.

8. Department of the Air Force. Physiology of Flight. AF Manual 160-30, July 1953.

Among the topics discussed in this manual are: altitude physiology; the effects of noise; acceleration; gases and vapors; escape from aircraft; comfort, nutrition and survival problems.

9. German Aviation Medicine: World War II, Vol. I and II. U. S. Air Force. Washington, D. C.: U. S. Government Printing Office, 1950.

These volumes represent a collection of the work in aviation medicine in Germany during World War II. Topics covered include aerodynamics, high altitude, acceleration, vibration, heat and cold, special senses, selection and training, emergency procedures, and blast effects.

10. Schaefer, K. E. (Ed.) Environmental Effects on Consciousness. N. Y.: MacMillan Co., 1962.

This is a collection of papers given at the First International Symposium on Submarine and Space Medicine. It includes reports on the physiological and psychological effects of altitude on man.

11. Tune, G. S. Psychological Effects of Hypoxia: Review of Certain Literature from the Period 1950 to 1963. Preceptual and Motor Skills. Vol. 19, No. 2, 1964, 551-562.

The effects of hypoxia on sensory function, performance and cognition are reviewed in this paper. Certain recommendations are made for methodology of research in hypoxia.

12. Van Liere, E. J. & Stickney, J. C. Hypoxia. Chicago: University of Chicago Press, 1963.

The book presents the effects of an inadequate oxygen supply on various bodily functions. The literature on hypoxia is reviewed and discussed.

13. White, C. S. & Benson, O. O., Jr. (Eds.) Physics and Medicine of the Upper Atmosphere. Albuquerque: University of New Mexico Press, 1952.

This book presents papers given at a symposium sponsored by the Air University School of Aviation Medicine. The emphasis is on problems to be overcome in high altitude flight. Included are papers on the physical environment of space, the hazards in space, and escape procedures in space-flight.

XVI. TOXICOLOGY
Radiation, Fuels, Dusts,
Sprays, Ozone, and Toxic Gases

1. Altman, P. L. & Dittmer, D. S. Biology Data Book. AMRL-TR-64-100, October 1964. (Supercedes WADC-TR-56-273, Handbook of Biological Data. October 1956).

   This book presents numerical data primarily of interest to biology and medicine in the form of tables, charts, diagrams and graphs. Data which may be useful in the development of design criteria for personal equipment and for systems are included under such headings as metabolism, respiration, environment and survival.

2. Buchanan, A. R., Heim, H. C. & Stilson, D. W. Biomedical Effects of Exposure to Electromagnetic Radiation: Part I: Ultraviolet. WADD TR 60-376, May 1960.

   This report reviews both the biological effects of ultraviolet radiation on cells, nerves, muscles, skin, the eyes, and other parts of the body, and the behavioral effects of this radiation on visual acuity, dark adaptation and intensity sensitivity.

3. Department of the Air Force. Flight Surgeon's Manual. AF Manual 160-5, October 1954.

   This volume discusses a number of factors having a bearing on air crew effectiveness, including acceleration, motion, reduced oxygen and barometric pressures, noise, drugs, fatigue, and temperature.

4. Hekhuis, G. L. Biologic Dosimetry. Chapter 6 in Bennett, E., Degan, J. & Spiegel, J. (Eds.) Human Factors in Technology. N. Y.: McGraw-Hill, 1963.

   After a brief summary of the applicable principles of atomic physics, the author examines the variety of measurement techniques which have been used in the study of radiation dosage. He discusses the concepts of exposure dose and absorbed dose, and concludes that present methods of biologic dosimetry are empirical and unrefined.

5. International Commission on Radiological Protection. Radiobiological Aspects of the Supersonic Transport. Health Physics. Vol. 12, 1966, 209-226.

   This report considers the biological hazards from solar flares and other high energy radiations during flight at altitudes of 60,000 to 80,000 feet. Possible radiation doses for crew and passengers of the supersonic transport (SST) are compared with the maximum

permissible doses established for radiation workers and the public. The recommendations of the report cannot be extrapolated to altitudes above 80,000 feet.

6. Jaffe, L. S. & Estes, H. D. Ozone Toxicity Hazard in Cabins of High Altitude Aircraft - A Review and Current Program. Aerospace Medicine. Vol. 34, No. 7, 1963, 633-643.

The problem of ozone is reviewed in relation to jet aircraft and planned supersonic air transport. Ozone concentration and distribution for different altitudes is presented in graphical form. Studies on the effects of ozone are reviewed. Suggested research programs are proposed and recommendations are made for the use of filtering devices in aircraft cabins to decrease ozone concentration.

7. Levedahl, B. H. A Survey of Radiobiology for Engineers. Human Factors. Vol. 1, No. 3, 1959, 1-68.

This paper reviews the effects of radiation on biological systems, with emphasis placed on the consideration of simple systems of single tissues and on detailed examination of radiation effects on the skin, reproductive system, circulatory system and digestive tract. Theories of radiation are compared. A summary of permitted human tolerances is included.

8. McFarland, R. A. Human Factors in Air Transport Design. N. Y.: McGraw-Hill, 1946.

Chapter 6 deals with effects of carbon monoxide and other gases on the crew and passengers of aircraft.

9. Mullinax, P. F., Jr. & Bleisher, D. E. Oxygen Toxicity in Aviation Medicine: An Analysis of Recent Literature. Journal of Aviation Medicine. Vol. 29, No. 9, 1958, 660-667.

Oxygen toxicity and its effect on man at pressures of one atmosphere and less is reviewed. Topics covered are the mechanisms of toxicity, symptoms and signs of toxicity in man, and safe limits of exposure to oxygen.

10. Patty, F. A. (Ed.) Industrial Hygiene and Toxicology. 2nd revised Edition. N. Y.: Interscience Publishers, Inc., Vol. 1, 1958, Vol. 2, 1963.

The first volume of this set is concerned with general principles of industrial hygiene. The coverage is wide and chapter headings include human engineering and industrial safety; industrial sanitation; mode of entry and action of toxic materials; sampling and analysis of atmospheric contaminants, air conditioning; air cleaning; ventilation; respirators and respiratory protective devices; pulmonary

dust diseases; air pollution; fire and explosion hazards of combustible gases, vapors, and dusts; physiological effects of abnormal atmospheric pressure; industrial noise and conservation in hearing; radiant energy; illumination; and heat control.

The second volume presents data on the toxicology of numerous chemical products.

11. Smith, P. W. Toxic Hazards in Aerial Application. CARI Rept. 62-8, FAA, Oklahoma City, April 1962.

An analysis is made of the hazards accompanying aerial application of toxic pest-control chemicals. The nature of the chemicals, the symptoms of toxicity, recommended treatment, and suggestions for safe-handling are discussed.

12. Stumpe, A. R. Health Hazards of New Aircraft and Rocket Propellants: A Review of the Literature. Journal of Aviation Medicine. Vol. 29, No. 9, 1958, 650-659.

Written for those concerned with aviation medicine, this report reviews the toxicity and health hazards of new fuels and oxidizers. The fuels include methyl and ethyl alcohol, ammonia, JP-4 fuel and the borons. The oxidizers include nitric acid, fluorine, hydrogen peroxide, ozone and liquid oxygen. The data are based on animal studies and on studies of human patients accidentally exposed to these substances.

13. Williams, D. W. The Acute Radiation Hazard. Chapter 7 in Bennett, E., Degan, J. & Spiegel, J. (Eds.) Human Factors in Technology. N. Y.: McGraw-Hill, 1963.

The discussion of radiation hazard is organized around the topics of: effects of ionizing radiation on cells, tissues, and organs; variation of radiation-exposure effects by reason of amount of dose, rate of exposure, percentage of body area exposed, portion of the body exposed, and physical condition of exposed subject. The radiation syndrome is outlined, with case histories showing medical and behavioral effects of ionizing radiation.

XVII. AIRCREW AND PASSENGER COMFORT AND HEALTH
Comfort, Preventive Medicine, Drugs, Diet, Aging

1. Aerospace Medical Association and the Industrial Medical Association. Medical Aspects of Business Aviation: A Guide for Physicians in Industry. Aerospace Medicine. Vol. 35, No. 8, August 1964.

   This article aims to provide physicians with basic information for maintaining the health and flight safety of industrial personnel. A number of common aeromedical problems are discussed.

2. Birren, J. E. The Psychology of Aging. N. Y.: Prentice-Hall, Inc., 1964.

   This book discusses the various biological, psychological and social changes taking place in the individual with aging. Of particular interest to design engineers are the sections on special senses and perception (Chapter 4), speed and timing in development and aging (Chapter 5), psychomotor skills (Chapter 6), and learning and thinking (Chapter 8).

3. Committee on Medical Criteria for Passenger Flying of the American Medical Association. Medical Criteria for Passenger Flying. Aerospace Medicine. Vol. 32, No. 5, 1961, 369-382.

   In this article are presented criteria for determining when a patient may safely be transported by air. The discussion includes a consideration of passenger comfort and well-being.

4. Cutting, W. C. Guide to Drug Hazards in Aviation Medicine. Federal Aviation Agency, 1962.

   Written primarily for aviation medical examiners, this guide describes drugs which have undesirable effects on flight personnel, and indicates the time limits of their effects.

5. Department of the Air Force. Flight Surgeon's Manual. AF Manual 160-5, October 1954.

   A number of aspects of preventive medicine related to flying are presented in section 2. Among the topics discussed are various diseases in relation to flying; epidemiology, sanitation and personal hygiene; insect and rodent control; food sanitation and inspection; and water control.

6. Ellingson, H. V. Medical Problems of Modern Air Travel. F. A. Davis Co., USAF Medical Service School, 1960.

This monograph attempts to summarize medical developments in aviation. Among the topics presented are: physical standards for private and commercial flying; medical conditions which contraindicate flying; prevention of motion sickness; selection of pilots; disorders related to flying; personal equipment and flying safety.

7. Funk, J. W. The Common Cold - A Continuing Aeromedical Problem. Aerospace Medicine. Vol. 34, No. 11, 1963, 1058-1061.

The symptoms, treatment, aeromedical implications and suggested aeromedical management of the common cold are outlined in this paper. The dangers of the common cold to flying are discussed, with some preventive measures (including controlled humidity in the aircraft), and a program of therapy for pilots.

8. Harper, C. R. & Albers, W. R. Alcohol and General Aviation Accidents. Aerospace Medicine. Vol. 35, No. 5, 1964, 462-464.

The study of 158 fatal accidents in general aviation reveals that 35% of the pilots had alcohol in their blood or tissues. This is a much higher percentage than had been found in previous studies. Evidence from other studies is adduced to show that low levels of alcohol are detrimental to performance.

9. McFarland, R. A. Human Factors in Air Transport Design. N. Y.: McGraw-Hill, 1946.

The effects of pressurized cabins, the control of insects and airborne diseases, and the design requirements for passenger accommodations are covered in Chapters 3, 5 and 11 of this book.

10. Mohler, S. R. Aging and Pilot Performance. Geriatrics. Vol. 16, 1961, 82-88.

The need to relate functional age as well as chronological age to flying ability is discussed. Four aspects of functional age are considered: physiological, psychological, social and pathological.

11. Nash, H. Alcohol and Caffeine: A Study of Their Psychological Effects. Springfield, Ill.: Charles C. Thomas, 1962.

This book reports on the background and results of a large study to determine the psychological effects of alcohol and caffeine. Their effects on emotional response to stress and on performance are discussed.

12. Plotnikoff, N., Birzis, L., Mitoma, C., Otis, L., Weiss, B. & Laties, V. Drug Enhancement of Performance. Menlo Park, Calif.: Stanford Research Institute, (SRI Project No. SU-3024), September 1960.

This paper is a survey and report of the published literature on the pharmacological, physiological, biochemical and behavioral effects of drugs which appear to be stimulants in normal populations (as opposed to clinical populations). Included are the alerting drugs (caffeine, amphetamines, etc.), psychic energizers (impramine, iproniozid) and the hallucinogenic stimulants (ibozeine, psilocybine and LSD).

13. Smith, H. P. R. An Investigation of Pilots' Work Load and Working Conditions in a Civil Air Line. Flying Personnel Research Committee, FPRC/1190, November 1961.

A report of the working conditions of commercial airline pilots in Britain is presented. Included in the investigation are environmental conditions, air traffic control, communication, navigation, seating and lighting, and stresses on the ground. Recommendations are made to reduce stress and fatigue for the pilot.

14. Weiss, B. & Laties, V. G. Enhancement of Human Performance by Caffeine and Amphetamines. Pharmacological Reviews. Vol. 14, No. 1, 1962, 1-36.

This article reviews the literature of the effects of caffeine and the amphetamines on human physical endurance and capacity, motor coordination and skill, monitoring, learning, performance of simple and complex verbal and arithmetic tasks, and judgement and mood.