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AIRLINE PILOT AGE, HEALTH, AND PERFORMANCE
Scientific and Medical Considerations

Report of a Study
by the Committee to Study Scientific Evidence
Relevant to Mandatory Age Retirement
For Airline Pilots

Division of Health Sciences Policy

INSTITUTE OF MEDICINE

March 1981

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NOTICE The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The Institute of Medicine was chartered in 1970 by the National Academy of Sciences to enlist distinguished members of the appropriate professions in the examination of policy matters pertaining to the health of the public. In this, the Institute acts under both the Academy's 1863 Congressional charter responsibility to be an advisor to the Federal Government, and its own initiative in identifying issues of medical care, research, and education.

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2101 Constitution Avenue, N.W., Washington, D.C. 20418

(202) 389-6187

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INSTITUTE OF MEDICINE
NATIONAL ACADEMY OF SCIENCES
2101 CONSTITUTION AVENUE WASHINGTON, D.C. 20418

FREDERICK C. ROBBINS, M. D.
PRESIDENT

March 31, 1981

Robert N. Butler, M.D.
Director
National Institute on Aging
National Institutes of Health
Building 31, Room 2C-02
9000 Rockville Pike
Bethesda, Maryland 20205

Dear Dr. Butler:

I am pleased to transmit to you the Institute of Medicine report Airline Pilot Age, Health, and Performance: Scientific and Medical Considerations. The National Institute on Aging requested this report to assist the National Institutes of Health in responding to Public Law 96-171, in which Congress asked whether mandatory retirement of airline pilots at age 60 is medically warranted and whether the present FAA medical examination is adequate to monitor a pilot's physical condition.

This report provides a comprehensive review of current knowledge about biomedical and behavioral factors that might influence the ability of airline pilots to carry out their job safely as they advance in age. I would like to emphasize that the charge to the committee was to evaluate relevant information from biomedical and behavioral research. This information should help to determine policies, but as the report notes, there are additional considerations to be taken into account when making decisions related to instituting changes in retirement policies or medical testing procedures--cost effectiveness and acceptable margins of safety, for example.

The report was prepared in the context of a specific congressional interest, but the information presented has implications throughout our society. Average life expectancy in the United States and the proportion of persons older than age 60 both have increased in the last two decades and are projected to continue to increase. These demographic changes provide the impetus for activities such as the planned White House Conference on Aging.

At the Institute of Medicine, we have a long-standing and continuing interest in the health policy implications of these demographic trends--this "aging" of America. Studies such as The Elderly and Functional Dependency and Aging and Medical Education and conferences such as "The Effect of Aging on Interaction of Health and Behavior" suggest the need for modifications in medical education, health care delivery systems, insurance practices, drug testing and physician prescribing practices, and perhaps even our very concept of what falls within the domain of "health care."

I hope that this report will be useful in helping NIH and Congress assess the relationships among airline pilot age, health, and performance. The report is only a small step in the necessary examination and modification of the many facets of our society that are affected by the growing numbers of elderly persons.

Sincerely,

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Committee to Study Scientific Evidence Relevant to
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CHAIRMAN

Robert F. MURRAY, Jr., M.D., Professor of Pediatrics and Medicine, Chief, Division of Medical Genetics, Howard University College of Medicine, and Senior Scholar-in-Residence, Institute of Medicine, National Academy of Sciences, Washington, D.C.

MEMBERS

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Peter EICHMAN, M.D., Professor of Neurology and Medicine, University of Wisconsin School of Medicine, Madison, Wisconsin

Ralph FLEXMAN, M.S., Professor of Psychology and Aviation, Acting Director, Aviation Research Laboratory, University of Illinois, Urbana, Illinois

Donald C. HARRISON, M.D., Chief, Cardiology Division, Stanford University School of Medicine, Stanford, California

Edward W. HAWTHORNE, Ph.D., M.D., Dean, Graduate School, Howard University, Washington, D.C.

James P. HENRY, Ph.D., M.D., Professor of Physiology, University of Southern California School of Medicine, Los Angeles, California

C. David JENKINS, Ph.D., Director, Department of Behavioral Epidemiology, Boston University School of Medicine, Boston, Massachusetts

Berton H. KAPLAN, Ph.D., Professor of Sociology, University of North Carolina School of Public Health, Chapel Hill, North Carolina

Donald KLINE, Ph.D., Associate Professor, Psychology Department, and Co-Director, Graduate Aging Program, University of Notre Dame, Notre Dame, Indiana

John K. LAUBER, Ph.D., Program Manager, Man-Vehicle Systems Research Division, NASA/Ames Research Center, Moffett Field, California

Richard A. LESTER, Ph.D., Professor of Economics and Dean of the Faculty, Emeritus, Princeton University, Princeton, New Jersey

Lawrence MARINELLI, M.D., President, Airline Medical Directors Association, Los Angeles, California

Richard MASTERS, M.D., Aeromedical Advisor, Air Line Pilots Association, Denver, Colorado

Sam L. POOL, M.D., Chief, Medical Sciences Division, NASA/Johnson Space Center, Houston, Texas

George E. RUFF, M.D., Professor of Psychiatry, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania

Ilene C. SIEGLER, Ph.D., Associate Professor of Medical Psychology, Department of Psychiatry, Senior Fellow, Center for the Study of Aging and Human Development, Duke University Medical Center, Durham, North Carolina

John SIMPSON, M.D., Ph.D., Associate Director, Cardiac Catheterization Laboratory, Cardiology Division, Stanford University School of Medicine, Stanford, California

Harvey L. STERNS, Ph.D., Director, Institute for Life-Span Development and Gerontology, Associate Professor of Psychology, The University of Akron, Research Associate Professor of Gerontology, Community Health Sciences, Northeastern Ohio Universities College of Medicine, Akron, Ohio

Samuel O. THIER, M.D., Professor and Chairman, Department of Internal Medicine, Yale University School of Medicine, New Haven, Connecticut

T. Franklin WILLIAMS, M.D., Medical Director, Monroe Community Hospital, Rochester, New York

INSTITUTE OF MEDICINE

Frederick C. Robbins, M.D.
President

STUDY STAFF

Elena O. NIGHTINGALE, M.D., Ph.D., Senior Program Officer, and Acting Director, Division of Health Sciences Policy*

Barbara FILNER, Ph.D., Study Director

Marcia B. GOLDBERG, B.A., Research Assistant

Barbara MANDULA, Ph.D., Senior Staff Officer

Allyn MORTIMER, Research Assistant

Roszel C. THOMSEN, II, B.A., Research Assistant

Michelle B. TRUDEAU, B.A., Research Associate

Sunny YODER, B.A., Research Associate

Linda DEPUGH, Administrative Secretary

SENIOR CONSULTANT

Peter E. DANS, M.D., Associate Professor of Medicine, Johns Hopkins University

CONSULTANT

Edith Katz

*Prior to October, 1980

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We thank Robert Houston for arranging a most informative site visit to the American Airlines Flight Academy in Dallas/Fort Worth. We appreciate the information provided to the committee by David Arenberg, Paul Costa, Arthur Norris, and Jordan Tobin of the NIA Gerontology Research Center in Baltimore. In addition, we gratefully acknowledge the many thoughtful and stimulating discussions we had with the speakers and consultants listed in Appendix D.

PREFACE

Airline travel is the safest form of transportation in the United States, and efforts are unceasing to make it even more safe. The infrequent serious accident involving passenger aircraft sets in motion an exhaustive investigation to determine the cause. Such investigations can easily pinpoint mechanical failure of the aircraft, but often have much greater difficulty in identifying the factor that has been found most often associated with fatal airline accidents—human error.

Errors of pilot performance are held to a minimum by means of regular proficiency checks during flights, familiarization sessions on aircraft simulators, and other programs of training and skill maintenance. The medical considerations of pilot performance, however, are monitored only by a program of regular examinations whose form and content have not kept pace with advances in medical technology.

A major regulatory action intended to reduce the human factor contribution to aircraft accidents was the establishment in 1959 of the so-called "age-60 rule" by the Federal Aviation Administration (FAA). The rule mandated retirement at age 60 of all airline pilots. The airline industry's shift to jet powered craft was a factor in making the FAA experts believe that age-related changes in health and behavior would adversely affect the performance of pilots in aircraft whose speed and passenger-carrying capacity both were increasing.

In the 21 years since the regulation was adopted, it has been repeatedly challenged as unjustified. Those in favor of the rule, however, contend that persons whose jobs directly involve the public safety, such as airline pilots, bus drivers, firemen, and air traffic controllers bear the burden of proving that increasing their retirement age will not jeopardize the public safety.

Ideally, one should have data from the flying records of pilots over 60 monitored over time in order to compare their incident and accident rates with those of younger pilots. But data that bear directly on this question are not available, in part because airline pilots have been retired at age 60 for the past 21 years. Other data are not directly pertinent to the question because of the way they have been collected or because the population from which they have been derived is not strictly comparable to the population of commercial airline pilots.

SUMMARY

Introduction

Federal aviation regulations prohibit the commercial airlines from assigning a pilot who has reached age 60 either as pilot-in-command or co-pilot. Since its promulgation in 1959, this age-60 rule has been the subject of continuing scrutiny and controversy. The Federal Aviation Administration (FAA), defends the age-60 rule as necessary to protect the public from age-related deteriorations of performance in pilots, contending that such deteriorations cannot dependably be measured in individuals at present. Persons who oppose the rule say it is discriminatory, because it is based on age alone and does not consider ability to do the job; arbitrary, because they believe there is no scientific basis for choosing age 60; and unnecessary, because they believe it now seems feasible to measure individual performance and estimate the risk of incapacitation.

Some pilot organizations and other groups concerned with age discrimination called for legislation to change the age-60 rule. Responding to this concern, in December 1979 Congress passed Public Law 96-171, which calls for "a study of the desirability of mandatory age retirement for certain pilots." The legislation directed the Director of the National Institutes of Health (NIH) in consultation with the Secretary of Transportation to conduct a study that would address several questions related to the age-60 rule and to review existing procedures for medical certification of airline pilots:

> "1) whether an age limitation which prohibits all individuals who are sixty years of age or older from serving as pilots is medically warranted;
>
> 2) whether an age limitation which prohibits all individuals who are older than a particular age from serving as pilots is medically warranted;
>
> 3) whether rules governing eligibility for first- and second-class medical certifications, as set forth in part 67 of title 14 of the Code of Federal

Regulations (as in effect on the date of enactment of this Act), are adequate to determine an individual's physical condition in light of existing medical technology;

4) whether rules governing the frequency of first- and second-class medical examinations, as set forth in part 67 of title 14 of the Code of Federal Regulations (as in effect on the date of enactment of this Act), are adequate to assure that an individual's physical condition is being satisfactorily monitored; and

5) the effect of aging on the ability of individuals to perform the duties of pilots with the highest level of safety."

The NIH, through the National Institute on Aging, requested that the National Academy of Sciences/Institute of Medicine establish a committee to provide an objective examination, summary, and assessment of scientific knowledge on medical and behavioral aspects of aging and pilot performance and to indicate the extent to which valid conclusions can be reached for the questions of PL 96-171. The specific charge to the committee was to

> "...go as far as possible within the limits of the time allotted in outlining the nature of the problem, developing criteria for evaluating scientific information relating to pilot performance, reviewing the significance of existing studies, describing the limitations of current knowledge for the questions asked in the Law, indicating the extent to which valid conclusions can be reached on aspects of the problem, and indicating lines of inquiry and research that might provide more precision in future evaluations of medical and psychophysiological factors affecting performance.
>
> The committee will consider the medically and behaviorally important characteristics and factors relevant to airline pilot performance, will assess the extent to which existing tests, techniques, procedures and instruments can measure these factors, will review existing and ongoing studies concerning the incidence of incapacitation or dysfunction resulting from medical, psychiatric, physiological and psychophysiological factors, and will identify the possible effect of these factors on pilot performance, with specific attention to the relationship of the incidence of those factors to aging processes.
>
> The committee also will consider human performance factors and their possible changes with age and

relationships of those factors to the mechanical and human environment in which a pilot's functions are carried out, including attention to workload, fail-safe mechanisms, pilot-crew interactions, and the nature of inflight emergencies and requirements.

The committee will not provide legislative or regulatory recommendations, but will focus on the examination, summary and assessment of scientific knowledge about medical and behavioral factors that can be considered by the government in reaching future policy decisions concerning aviation safety. The committee will attempt to make clear which conclusions can be based on existing data (stating where appropriate a range of probabilities associated with prediction of effects on pilot performance), and which conclusions are tentative and judgmental with firmer conclusions dependent on further research."

In order to respond to the charge most directly in the time available, the committee has limited its assessment of the effects of age to those functions and conditions most likely to affect pilot performance and safety.

The committee's report is divided into five parts. Part I (Chapters 1-5) describes the pilot's job, the U.S. airline safety record, and current medical and performance certification procedures for airline pilots. Part II (Chapters 6-9) examines information on relevant medical conditions. Cardiovascular, endocrine, pulmonary, renal, gastrointestinal, neurologic, and mental health status are considered. Part III (Chapters 10-11) assesses information on behavioral issues, including perceptual, psychomotor, and intellectual functions. Part IV (Chapter 12) addresses the FAA-mandated proficiency checking system and the testing possibilities provided by simulators. Part V (Chapters 13-14) identifies areas that require further research and summarizes the results of the committee's deliberations.

In brief, the committee derived the following responses to the questions raised by P.L. 96-171 from a review of the available scientific and medical information.

o <u>Is mandatory retirement of commercial airline pilots at age 60 or at any age medically warranted?</u>

The relevant medical concerns bearing on this question include whether there is an increased probability of sudden death or acute incapacitation and whether there is an increased probability of subtle incapacitation. For significant acute events (such as cardiovascular events and stroke), age 60 does not mark the beginning of a special risk or a special increase in risk, although, on the average, risk increases with age. Subtle changes that may adversely affect pilot performance also increase with age. In particular, the available evidence suggests that age-related changes occur in the ability to process and respond to information, especially under stressful and distracting conditions. However, age 60 is not an age of special significance for these subtle changes either. Furthermore, the general effect on pilot performance of these changes is unknown.

o <u>Is the content and frequency of the current FAA medical examination adequate?</u>

Medical problems are not a major contributor to airline accidents, according to available evidence. However, pilot error, a major factor associated with accidents, as it is affected by health status is a relatively unexplored area. Furthermore, there is no empirical information with which to gauge the adequacy of the medical examination for airline pilots over age 60. Incorporation of some recent advances in medical knowledge and technology would greatly improve the sensitivity of the current examination for pilots of any age. Disorders that might cause sudden death or incapacitation can be detected more effectively by less frequent but more careful and comprehensive medical examinations than are currently used. These should be timed and structured to take into account age and other individual risk factors. For example, rather than the annual resting electrocardiogram (ECG) now required by the FAA for every airline pilot over age 40, it would be better to use a risk-factor profile supplemented by exercise ECGs when specifically indicated. In addition, the medical examination, as now described, does not directly test intellectual function, which includes processes such as memory, problem solving, and decision making. Ways to test these should be developed, either as part of the medical examination or the proficiency check or both.

An improved examination would be of particular value from a health promotion perspective to those under age 60. Early identification often enables treatment and/or risk modification to prevent development of medically disqualifying conditions.

o <u>What is the effect of age on pilot performance?</u>

Available evidence suggests that on the average at least some of the skills necessary for the highest level of safety deteriorate with age. However, there is great variation among individuals in any age group. For the characteristics that are identified as important to performance and for which measures exist, changes with age often can be determined on an individual basis. Unfortunately, reliable measures are not available for the assessment on an individual basis of some factors that may be most salient to pilot performance, particularly intellectual function and processing of perceptual information. The committee calls attention to the need for further research to develop valid tests of these functions for airline pilots and to establish levels of function necessary for safe pilot performance.

A summary of the committee's review of the scientific literature, which led to these responses to the questions of P.L. 96-171, follows.

Description of the Pilot's Job

The airline cockpit crew usually consists of three pilots: the pilot-in-command (captain), the co-pilot (first officer), and the flight engineer (second officer). Their responsibilities are specific but overlap considerably, and all involve tasks of information gathering, problem solving, decision making, psychomotor coordination, and transmission of information to the other components of a complex man-machine system.

Various approaches have been taken in attempting to describe the skills the pilots need. One is to identify the psychological and physiological elements common to the functions that pilots perform, for example, attention and memory. Another approach is to identify the personal traits and qualities pilots should have, for example, reasoning, emotional stability, ability to plan ahead, mechanical aptitude, and managerial ability. (As cockpit technology has developed, the pilot's job has evolved from one requiring primarily manual control and psychomotor skills to one requiring much greater management skills.) A pilot's job also may be defined in operational terms, for example, carrying out specific routine tasks and handling unexpected situations.

Pilot Certification

To be certified as a pilot-in-command or second-in-command, a pilot must 1) initially demonstrate appropriate knowledge, skills, and experience, 2) periodically demonstrate proficiency in flying the aircraft, and 3) periodically demonstrate medical fitness.

Training and proficiency checks are an ongoing facet of a pilot's career, for continued certification, for a shift to a new aircraft, or for promotion. A FAA-designated check airman monitors routine and emergency flight maneuvers twice a year, in an aircraft or in a simulator. Line checks (observation of a pilot during a scheduled flight) occur at least once a year.

In addition to proficiency checks, federal aviation regulations require an active airline transport captain to posess a Class I medical certificate, obtainable by passing a semi-annual medical examination. The examination is intended to detect functional changes and disorders that increase the risk of sudden incapacitation or that otherwise might have a detrimental effect on pilot performance. It emphasizes tests of hearing and vision, and the evaluation of cardiovascular, neurologic, and endocrine health status.

Safety Record

The National Transportation Safety Board (NTSB) collects data on the frequency and causes of aviation accidents and incidents.* Because of the age-60 rule, information on airline pilots older than age 60 is not available. This study committee also reviewed general aviation** data, which includes pilots over age 60; however, general aviation pilots need not meet as rigorous medical and proficiency standards as do airline pilots.

The airline accident record and the general aviation accident record for pilots with at least 2,000 hours of experience indicate highest accident rates for pilots under 30, and either an age-related decline or no consistent trend for pilots over 30. However, these data do not take into account many factors, such as number and conditions of takeoffs and landings, that may be related to a pilot's safety record. More comprehensive data are needed before valid conclusions regarding age and performance can be derived from the safety record.

Pilot error was a cause or contributing factor in 63 percent of the 70 fatal accidents and in 40 percent of the total of 434 air carrier accidents that occurred between 1968 and 1977. In the period 1964-1974, there were 67 reported cases of acute pilot incapacitation, but none led to an airline accident. Thus, the airline accident record suggests that a review of the adequacy of medical testing and the potential impact of age on safe pilot performance must take into account medical conditions and age effects that might contribute to pilot error by affecting perceptual, psychomotor, or intellectual functioning, as well as life-threatening disorders.

Methodologic Issues

In reviewing scientific evidence related to age and pilot performance, two important questions arise about any criteria or tests. Does the test reliably and accurately measure the characteristic of interest? Does the characteristic, and therefore the test, provide useful information about the pilot's ability to meet the demands of the job?

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*Accidents are defined by the NTSB as events involving substantial or greater damage to the airplane and/or serious or greater damage to an occupant. Incidents are defined as events involving only minor damage to the airplane and/or minor injury to an occupant.

**General aviation refers to the operation of U.S. civil aircraft owned and operated by persons, corporations, etc., other than those engaged in U.S. air carrier operations (U.S. air carrier operations include the certificated route air carriers, supplemental air carriers, and commercial operators of large aircraft).

Considerable variability exists in any specific age group for almost any given measure, and this variability tends to increase with age. Consequently, group averages may be particularly poor predictors of individual performance among older persons. Furthermore, data obtained from a varied population should be applied with caution to pilots, who are predominantly white males and, on the average, better educated and more physically fit than the general population.

The design of aging studies presents some particular problems of interpretation. Cross-sectional studies on aging involve measuring function, behavior, or performance among individuals of different ages during a specified short time period. However, our society changes so rapidly that people age 40, 50, 60, and 70 years may have had totally different life experiences. Longitudinal studies involve repeated measurements on individuals at different time points, often extending over many years. Cross-sectional and longitudinal studies do not always suggest the same age effects, even when using data from the same population. These and other methodologic issues were considered as the committee reviewed data relating age to specific types of medical disorders or behavioral alterations.

The committee did not attempt to set quantitative standards for the various tests or procedures discussed; many of these already exist in medical practice, but others would have to be developed by expert groups convened for that purpose.

Cardiovascular Health Status

Cardiovascular disease is a major health problem among airline pilots, being the leading cause of medical retirement, for example. Age is a clear risk factor. The age-related increase in cardiac mortality in airline pilots parallels that for the general population, although the cardiac mortality remains lower for airline pilots at least through age 60.

The committee suggests means to improve testing of cardiac status. Echocardiography at the initial Class I medical examination would reveal valvular heart disease, congenital heart disease, and cardiomyopathy. The resting electrocardiogram is relatively insensitive when used alone, and a risk factor profile would be a useful addition to the protocol for ischemic heart disease screening. Such profiles could identify those at highest risk who require more detailed testing and who might benefit from preventive interventions. The risk factor profile for cardiovascular disease includes such factors as blood pressure, serum cholesterol, smoking history, lipoprotein profiles, blood sugar, and age. Because risk factor profiles are stable over time (in the absence of direct interventions) and because of the low yield and high false-negative rate before age 50, resting ECGs do not appear to be necessary every year as is currently required by the FAA for those older than 40; even after age

50, resting ECGs (with a 5 minute rhythm strip) every two years should be adequate, provided the risk factor profile is low. Follow-up of pilots with defined risk-factor profiles--at any age--should include exercise stress tests. A baseline exercise stress ECG at age 50 would be useful for subsequent comparisons.

Endocrine, Renal, Pulmonary, Hematologic, and Gastrointestinal Health Status

The committee examined data on organ systems in which age-related changes may be of most concern to pilot performance.

Clinically important diabetes mellitus and hypothyroidism increase with age. Gout occurs in early middle age in men and begins in women in the post-menopausal period. For women, post-menopausal symptoms also are an age-related concern. Pulmonary and renal function decrease somewhat with age, but changes associated with the normal aging process usually are not important clinically. The hematologic and gastrointestinal systems show little age-related changes likely to affect pilot performance.

Medical examinations designed to detect conditions that might affect pilot performance should include screening for important changes that are likely to occur with age. Thus, increased emphasis on screening for diabetes mellitus, hypothyroidism, pulmonary dysfunction, and renal dysfunction would be appropriate with advancing age. The FAA examination also could be improved by inclusion of screening for disorders such as anemia that are not age-related but that do affect level of function. The examination also should reflect the recognition that one disorder can increase the risk of another; for instance, by closer surveillance for cardiovascular disease in patients with diabetes mellitus.

Neurologic Health Status

Neurologic disorders that are more likely to occur in later years and are characterized by an abrupt onset include ischemic cerebrovascular disease (including embolism and vascular occlusion), cerebral hemorrhage, subarachnoid hemorrhage, epileptic seizure, vertiginous attacks, and syncope (fainting). Diseases such as dementia, Parkinson's disease, essential tremor, and peripheral neuropathy are characterized by a gradual onset and, frequently, a slow progression. Cerebrovascular disease and hemorrhage are more likely to occur in older subjects. Epileptic seizures in older persons are usually secondary to an underlying disease process--cerebrovascular disease and brain tumor are the most common. Vertiginous attacks (when secondary to cerebrovascular disease), dementia, and Parkinson's disease also increase with age. Some autonomic nervous system neuropathy is indirectly age-related when the underlying cause is diabetes, which is age-related.

To improve detection of disorders that may affect the central or peripheral nervous system the committee recommends 1) more detailed periodic neurologic examinations, 2) special emphasis on careful mental status examination after age 50, and 3) consideration of EEG in the 54-59 age range as a possible screening and baseline test for those who wish to continue their careers as airline pilots past age 60.

Mental Status

Mental disorders can vary greatly in how severely they interfere with normal function. Most either are not age-related or tend to begin well before age 60. Disorders that may affect performance but may not be readily apparent to observers include substance abuse disorders, especially alcoholism, and affective disorders, especially depressive disorders. Depression is the most common psychological problem among older persons. The peak incidence of alcoholism in the general population appears to be between the ages of 45 and 54.

Medical certificates may be denied or deferred for pilots with mental disorders specified by the FAA. A well-performed routine mental status examination would reveal most major disorders, but might not detect mild anxiety or depressive disorders, or early stages of dementia, especially if the pilot were motivated to conceal them. A successful peer identification and self-referral program that assists pilots with problem behavior, substance abuse, depression, and proficiency problems was established in 1974 by the Air Line Pilots Association Occupational Alcoholism Program. A useful adjunct to peer- and self-referral would be screening for subclinical levels of emotional distress, using standardized psychological screening tests.

Perceptual and Psychomotor Functions

Sensory receipt of information is the starting point for a chain of events that culminate in decisions and actions. Age-related changes in sensory perception, such as vision and hearing, may be less important to pilot performance than are changes in the ability to process the information. Much research is needed to understand the relationship between age and performance of continuously practiced skills by highly trained operators such as pilots.

Ability to process and respond to information slows with age, even among healthy persons. This change particularly is noted under stressful, distracting, or high workload situations. For example, older persons may have greater difficulty than younger ones, on the average, in understanding speech under noisy conditions. Many of these changes begin well before age 60, and any age group will show great variability in level of function.

In general, efforts should be made to develop procedures, probably incorporating the use of simulators, to test perceptual function under realistic, high workload conditions. For example, to detect age-related changes in vision, tests could be carried out in dim light or glare.

Intellectual Functions

Attention, memory, and ability to solve problems and make decisions alter with age. There may be changes in speed, capacity, or accuracy. However, variations among individuals are great, and performance decrements are not readily apparent for well-practiced skills. Age effects on memory are accentuated when unfamiliar material must be learned. Intelligence test performance does not appear age-correlated for pilots, although such a correlation is found among the general adult population for some tests.

Operational Assessment of Pilot Proficiency

Perhaps the best way to measure age-related changes in physical, perceptual, psychomotor, and intellectual functions would be in pilot tasks requiring integrated and coordinated functioning of all these systems. Are the existing FAA procedures adequate to detect changes in performance that are operationally significant and may be more likely to occur among older pilots?

Quantitative performance standards and criteria, and objective techniques for measuring performance, are not available at present. The standards presently are qualitative rather than quantitative, usually being based on subjective judgments of the evaluators. Because most pilot proficiency tests are of the pass/fail variety, it is not possible at present to generate an empirical, age-related functional index of pilot performance based on these data. Furthermore, the point at which demonstrable or measurable change in the performance of pilot tasks becomes operationally signficant has not been precisely determined.

Some of these problems may be studied by use of flight simulators. One promising approach for training and test development uses Line Oriented Flight Training (LOFT)-type simulations, which almost duplicate real flight, including unexpected complications and multiple or irrelevant communications. LOFT programs require a full crew who must exercise intellectual, communications, decision-making, and managerial skills, as well as the physical and psychomotor abilities needed to fly the airplane. Coordinated research to validate criteria developed for performance on laboratory tasks and in LOFT-simulations should enable eventual development of highly effective procedures to assess performance of pilots of any age.

Needs and Opportunities for Research

Data obtained from the semi-annual medical and proficiency examinations of the 35,000 United States airline pilots could provide a valuable data base for characterizing and analyzing the pilot population. At present, such data are not systematically collected and preserved. Research using these data could help determine the extent to which age and health affect flight safety and performance among these pilots.

In addition, the committee identified particular need for research related to 1) effects of fatigue, jet-lag, sleep disruption, emotional conflict, and flight emergencies on pilot health and performance; 2) development of more effective screening criteria for pilot performance; 3) age-related changes in intellectual functions involving well practiced skills; and 4) age-related changes in processing perceptual information, especially under conditions of high information load.

CHAPTER 1

INTRODUCTION

Background and Charge

Federal aviation regulations prohibit commercial airlines from assigning anyone who has reached the age of 60 as either pilot-in-command or second-in-command (co-pilot), although the pilots may continue to hold pilot certification, and may serve in other capacities, including flight engineer, flight instructor, and check airman.[1] This age-60 rule has been the subject of controversy since its promulgation as a regulation by the Federal Aviation Administration (FAA) in 1959.

The FAA's rationale for the age-60 rule, as summarized in recent congressional testimony, is that the risk to the safety of the public is increased because (1) numerous physiological and psychological functions deteriorate with age, (2) aging increases the probability of sudden incapacitation or death, and (3) it is not currently feasible to predict an individual pilot's future health or functional capacity with sufficient precision to enable case-by-case decisions about pilots over 60.[2]

The FAA position has been challenged several times. Petitions for exemption from the age-60 rule have been submitted (unsuccessfully) to the FAA by individual pilots. The Air Line Pilots Association and others have challenged the rule in court; it has been upheld in every case.[3] Legislation has been proposed to override the FAA regulation.[4] Arguments raised against the rule have been that (1) it is discriminatory, being based on age *per se* rather than inability to meet the demands of the job; (2) it is arbitrary, there being no scientific basis for choosing age 60 for mandatory retirement instead of age 61 or age 59; and (3) the technology is now available to evaluate an individual pilot's risks of incapacitation and to measure subtle decrements in performance, making an age criterion unnecessary.

Studies have been undertaken to help resolve the controversy. In the United States, the FAA has commissioned monographs on *Psychophysiological Effects of Aging: Developing a Functional Age Index for Pilots*[5-7] and *A Reassessment of the Rationale for Establishment of Federal Aviation Regulation 14 CFR 121.383(c)*[8]. A Canadian study commissioned by the Director of Civil Aviation Medicine, *Fitness for Flying After the Age of 60 Years*[9], and the panel discussion "Modern

Concepts of Pilot Aging"[10] at the September 1980 International Congress on Aviation and Space Medicine, reflect current international interest in the issues.

Although some of the studies have supported the continued application of the age-60 rule, these activities have not ended the controversy. Pilot organizations and groups concerned with age discrimination have continued to call for legislation to change the age-60 rule. Both the House Select Committee on Aging and the Aviation Subcommittee of the House Committee on Public Works and Transportation held hearings on the rule during 1979. A bill directed at the age-60 rule, H.R. 3948, was reported out of the House Public Works and Transportation Committee in September, 1979.[11] It would have increased the age limit for pilots to 61 1/2 for 18 months, during which time the National Institutes of Health would conduct a study to assess the medical justification for the rule and the adequacy of the existing system for evaluating a pilot's health. On the House floor, however, the interim increase in the age for retirement was eliminated.[12]

As signed into law December 29, 1979, Public Law 96-171, "An act to require a study of the desirability of mandatory age retirement for certain pilots, and for other purposes", directs the Director of the National Institutes of Health (NIH), in consultation with the Secretary of Transportation, to conduct a study to determine:

> "1) whether an age limitation which prohibits all individuals who are sixty years of age or older from serving as pilots is medically warranted;
>
> 2) whether an age limitation which prohibits all individuals who are older than a particular age from serving as pilots is medically warranted;
>
> 3) whether rules governing eligibility for first- and second-class medical certifications, as set forth in part 67 of title 14 of the Code of Federal Regulations (as in effect on the date of enactment of this Act), are adequate to determine an individual's physical condition in light of existing medical technology;
>
> 4) whether rules governing the frequency of first- and second-class medical examinations, as set forth in part 67 of title 14 of the Code of Federal Regulations (as in effect on the date of enactment of this Act), are adequate to assure that an individual's physical condition is being satisfactorily monitored; and
>
> 5) the effect of aging on the ability of individuals to perform the duties of pilots with the highest level of safety."

The controversy over the age-60 rule has arisen mostly because of conflicting interpretations of the evidence on the effects of aging and differing assessments of methods of evaluating pilot medical conditions and performance. The NIH--through the National Institute on Aging (NIA)--asked the National Academy of Sciences/Institute of Medicine to appoint an expert committee to undertake a study that would provide an objective examination, summary, and assessment of scientific knowledge that is relevant to the issues of P.L. 96-171.

The charge to the Institute of Medicine committee was to

> "...go as far as possible within the limits of the time allotted in outlining the nature of the problem, developing criteria for evaluating scientific information relating to pilot performance, reviewing the significance of existing studies, describing the limitations of current knowledge for the questions asked in the Law, indicating the extent to which valid conclusions can be reached on aspects of the problem, and indicating lines of inquiry and research that might provide more precision in future evaluations of medical and psychophysiological factors affecting performance.
>
> The committee will consider the medically and behaviorally important characteristics and factors relevant to airline pilot performance, will assess the extent to which existing tests, techniques, procedures and instruments can measure these factors, will review existing and ongoing studies concerning the incidence of incapacitation or dysfunction resulting from medical, psychiatric, physiological and psychophysiological factors, and will identify the possible effect of these factors on pilot performance, with specific attention to the relationship of the incidence of those factors to aging processes.
>
> The committee also will consider human performance factors and their possible changes with age and relationships of those factors to the mechanical and human environment in which a pilot's functions are carried out, including attention to workload, fail-safe mechanisms, pilot-crew interactions, and the nature of inflight emergencies and requirements.
>
> The committee will not provide legislative or regulatory recommendations, but will focus on the examination, summary and assessment of scientific knowledge about medical and behavioral factors that can be considered by the government in reaching future policy decisions concerning aviation safety. The committee will attempt to make clear which conclusions can be based on existing

data (stating where appropriate a range of probabilities associated with prediction of effects on pilot performance), and which conclusions are tentative and judgmental with firmer conclusions dependent on further research."

This report represents the Institute's response to that charge.

Study Context

The U.S. population has changed in the 20 years since the promulgation of the age-60 rule. In 1960, there were 23 million persons age 60 and older, constituting 13 percent of the total population[13]; in 1979, there were 34 million such persons, constituting 15.5 percent of the total population[14]. Life expectancy at age 60 for white males rose from 15.9 years in 1960[15] to 17.2 years in 1978[16].

Similar changes are evident in the airline pilot population. In 1965 there were 16,000 airline pilots, 600 (3.8 percent) of whom were age 55-59[17]. The total number of airline pilots and the percentage aged 55-59 increased steadily throughout the 1960s and 1970s, up to 1978. At the time P.L. 96-171 was passed, there were more than 35,000 airline pilots in the United States, about ten percent of whom were age 55-59[18].

It has been estimated that in the United States in the 1980s, between 500 and 1,000 airline pilots will reach age 60 each year[19]. The age 60 retirees constitute the majority of all airline pilots who terminate their service to airlines[20]. One airline employing about 4,000 pilots and flight engineers reported that typically 50 to 75 of them retire each year, about 65-70 percent because they have reached age 60. Other reasons for discontinuing careers as airline pilots include medical problems (5-10 percent), voluntary early retirement, death, discharge, or resignation[20].

Growth in the proportion of older persons in the U.S. population has increased public awareness of the issues surrounding their place in society. One of the manifestations of this awareness has been a re-examination of beliefs and practices concerning older workers. The Age Discrimination in Employment Act of 1967, an outgrowth of the 1964 Civil Rights Act, prohibited employment discrimination on the basis of age (up to 65) in hiring, retention, compensation, and other conditions of employment. In 1978 the Act was amended and its protection extended to age 70 for most U.S. workers; the amendments removed age completely from consideration for most federal employees[21]. However, the law continues to except the instance in which age is a "bona fide occupational qualification reasonably necessary to the normal operation of the particular business"[22].

Thus, while public policy and the law generally have tended toward removing age-related job requirements, age is still allowed to be a criterion if it can be shown to have a direct bearing on performance.

However, the burden is on the employer to show that accidents or incidents of incompetency are traceable to factors related to the aging process; that, statistically, accidents increase with age; that job performance by older workers is inferior to that of younger workers; that no practicable methods other than age criteria exist to evaluate performance capability; and that the effects of aging are related to the "capabilities needed to perform the duties in question..."[23].

An assessment of scientific knowledge on medical and behavioral aspects of aging and pilot performance and on the adequacy of available screening tests should lead to answers to some of the questions implied by those standards of evidence.

Study Scope and Organization

To make maximum effective use of the time and resources available, the committee chose to limit its assessment to those functions and conditions most likely to have an effect on pilot performance and safety.

Part I of this report presents the background information that guided the committee in its selection of topics for detailed examination. This background includes an analysis of pilot tasks, a summary of FAA pilot certification procedures, and a review of aviation accident data. In addition, Part I includes a discussion of the general methodologic issues that the committee deemed critical to the assessment of the available scientific evidence.

Part II of this report is an assessment of information on medical conditions that might lead to incapacitation, either acute or subtle. During a routine flight, sudden and unexpected physical incapacitation of one of the cockpit crew would constitute a threat to flight safety. Such acute incapacitation would, of course, be a threat to safety during an emergency as well. Subtle incapacitation, such as age- or illness-associated decrements in attention, memory, and judgment, also would constitute a threat to safety, especially during an emergency. The committee chose to examine 1) cardiovascular health status; metabolic, pulmonary, and renal health status; neurologic health status; and mental status. In each category, the relation to pilot performance, the relation to age, the current FAA medical screening requirement, and an optimal medical screening procedure are presented.

Part III is an assessment of information on behavioral issues, including perceptual, psychomotor, and intellectual functions. Because there is a complex interplay between physical health status and behavioral health status, the committee considered it essential to include behavioral issues in its assessment of the effect of age on pilot health and pilot performance. The report's separation of medical and behavioral issues is only an organizational convenience; unambiguous assignment of a condition to one category or the other is not always possible--as in the case of sensory perception loss, for example. Separation of the issues also reflects a lack of knowledge with which to make a distinction between "normal aging" and disease-associated changes. Decrements in an individual's psychomotor and intellectual functions, for example, might be due to underlying pathology.

The usefulness of the distinction between medical and behavioral issues becomes clear upon consideration of the official procedures for screening for level of function. The current FAA medical certification procedure is not designed to screen for behavioral deficits, although such deficits might be detected in FAA mandated proficiency checking procedures. Because the proficiency checking system does not explicitly set out to detect subtle decrements in function, a discussion of possible "enrichment" of this operational assessment of pilot performance--to focus attention on those functions that show age-related decrements--is included in Part IV of this report.

Part V presents an overview of the data presented in Parts II and III--in the context of the questions asked by P.L. 96-171. Some issues that were not dealt with in this study but that should be considered in determining mandatory age retirement policy for airline pilots are presented. Part V also describes topics for future research--identified during the committee's assessment of what is known.

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CHAPTER 2

DESCRIPTION OF THE PILOT'S JOB

An assessment of the possible effects of age upon pilot performance requires an understanding of the mental and physical demands placed upon pilots in their jobs. An overview of the major tasks performed in flying jet transport aircraft follows.

There are three pilots in the cockpit crew of most large jet transport aircraft: the pilot-in-command (captain), the co-pilot (first officer), and the flight engineer (second officer). Each has specific responsibilities but there is also considerable overlap of responsibilities. For example, the pilot-in-command and co-pilot typically alternate control of the plane; the co-pilot may be flying at any phase of the flight.

A pilot customarily is required to report for duty one hour before scheduled departure time. That period is spent in various preflight activities, including review of the flight plan, weather, anticipated operational problems (e.g., known delays), and other factors that can affect the flight. Although actual flight planning, including the selection of route, altitude, alternate airports, and fuel requirements is accomplished by the flight dispatcher, the captain is responsible for reviewing the flight plan, and either approving it or requesting appropriate changes as experience and judgment dictate. This is a complex information-gathering and decision-making process.

After the flight plan is approved and the navigation charts, weather reports and forecasts, fuel and aircraft loading data, and other operational data are obtained, the flight crew proceeds to the aircraft. In the 20 to 30 minutes prior to actual departure, the crew performs many activities. The co-pilot, or flight engineer if a three-man crew, is responsible for a thorough preflight "walk around" or external inspection of the aircraft. In the cockpit, hundreds of instruments, switches, circuit breakers, and other controls and indicators must be checked and set to the required position. Take-off flap settings, power settings, and airspeeds must be calculated and reviewed. Maintenance records must be reviewed; the flight attendants must be briefed as to weather, cruising altitudes, and possible emergency procedures, and the air traffic control clearance must be requested and received, via radio, from Air Traffic Control (ATC). The before-start checklist must be completed, and, when the aircraft doors are finally closed, a clearance to push the aircraft from the gate must be requested and coordinated with the ground crew. The engines must be started; hydraulic, electrical, air-conditioning, and pressurization systems must be brought on-line, and the before-taxi checklist must be completed.

After a taxi clearance has been received from ATC, the aircraft must be taxied, according to the ATC directed routing, to the takeoff runway. During the taxi, various aircraft systems must be checked and set for take-off. The before take-off checklist must be completed, the take-off clearance must be received, and the cabin crew must be informed that the aircraft is about to take off.

When ATC clears the aircraft for take-off, it must be taxied onto the runway, lined up on the runway centerline, and the engines must be adjusted to take-off power. Acceleration and airspeed, as well as engine instruments, must be carefully monitored during this period. This part of the take-off is particularly critical because of the high speeds of the aircraft and the short reaction times required to successfully abort the take-off. In the event of a malfunction before the aircraft attains a critical speed, the take-off must be aborted by reducing power, deploying spoilers, reversing engine thrust, and braking.

Following a normal take-off, the aircraft must be flown along the route assigned by ATC, landing gear and flaps must be raised, and special procedures, such as noise abatement climb profiles, must be performed. Communications workload can be heavy during this phase of flight, and a constant vigil must be maintained for other aircraft.

After departure from the terminal area, cockpit workload decreases considerably, particularly after climbing above 10,000 feet or so. The autopilot and, if present, the autothrottles usually are engaged, and the primary tasks turn to navigation, communication with ATC, and monitoring the many aircraft systems and the progress of the flight, fuel consumption, weather, and other factors.

The cruise phase of flight places lower demands upon the flight crew. Automatic systems are flying the aircraft and perhaps also performing most of the navigation. For flights over land, ATC is monitoring the progress of the flight by radar, but there is little communications workload. During over-ocean operations, the communications workload is further reduced; position reports usually are required only hourly. In fact, in some ways, long over-water night operations present a significant problem of crew underload--there is too little to do, and maintenance of required levels of vigilance can become a significant problem.

Planning for the descent and arrival must begin a few hundred miles from the destination (if the flight is a long one), taking into account traffic, weather, winds, and other factors. The descent must be initiated at the appropriate point, speeds and altitudes must be closely monitored--the navigation and communications workload increase abruptly. Weather at the destination airport must be received, and the appropriate navigation and approach charts must be consulted so that the approach and landing can be planned well in advance. The crew must be briefed on the routing and procedures used for the approach, including actions to be taken in the event that weather or other factors prevent a landing at the intended destination. Descent and approach checklists must be accomplished, aircraft systems must be set up for the approach and landing, and a constant watch is taken up again for other air traffic. Aircraft approach and landing speeds must be calculated on the basis of aircraft weight and winds, flaps must be lowered at appropriate airspeeds, and the landing gear must be lowered before beginning the final approach.

The approach and landing is considered to be the period of highest workload. As the aircraft nears the ground, margins for error are reduced and it becomes critical to maintain a precise descent path, oriented both laterally and vertically. Airspeed must be controlled to within a few knots, and in adverse weather situations, altitude and position with respect to the guidance information provided by aircraft and ground instruments must be closely monitored. At or prior to so-called decision height, the pilot must decide whether the aircraft can be safely landed from its current position, and, if not, undertake a "missed approach" or go-around. The landing itself is a highly complex psychomotor task, involving precise judgment of aircraft altitude and attitude, and requiring rapid correction for wind and other weather effects upon the aircraft.

After touchdown, the spoilers, brakes, and reverse thrust must be used to slow the aircraft to taxi speed. In situations of wet or icy runways, high cross winds, a heavy aircraft, and perhaps a short runway, pilot workload and the required level of manual control skills can be very high.

Once having cleared the landing runway, the aircraft must be taxied to the gate, and the aircraft systems must be reset or shut down as appropriate. After landing and parking checklists have been completed, maintenance items must be entered into the aircraft logbook, and the necessary paperwork must be gathered and completed.

Depending upon the length of the trip just completed, the pilots may be finished for the day, or, for short-haul operations, this could be only the first of as many as 10 to 15 trips to be flown during the rest of the duty day.

This overview of the major elements of a pilot's job assumes a routine or normal operation. Unanticipated events occur frequently and, in extreme circumstances, can result in emergency situations that place very great demands on the flight crew. Aircraft and system problems can occur at any time--some are serious and require immediate, precise corrective action. The airlines have developed checklists that are to be following during certain emergency situations, and pilots are trained to consult and follow these checklists. However, there are circumstances for which checklists cannot be provided. Weather can change on short notice and disrupt the planned trip so that the captain must decide when, and where, to divert. Even problems having to do with passenger injury or illness can require complex, critical decisions on very short notice. All are part of the airline pilot's job.

This short description indicates that the airline pilot's job is a complex one, requiring many different kinds of skills and knowledge. As cockpit technology has developed, the pilot's job has evolved from one requiring a preponderance of manual control and psychomotor skills to one requiring a much greater proportion of management and decision-making skills. Various approaches have been taken to identifying the component skills in the pilots job.

One approach is to identify the psychological and physiological elements common to different functions that pilots perform. For example, the task of monitoring communications and flight instruments requires perceptual skills (vision and hearing acuity) and a capacity for attention. The research literature on aging and medical disorders then can be reviewed for possible or probable causes of impairment in those psychological and physiological elements.

Another way of characterizing and analyzing the pilot's job is to determine the personal traits and qualities pilots should have, such as those listed in Table 1. This list represents the set of abilities and characteristics used in the pilot selection process by one U.S. airline. It is not linked to specific pilot tasks, although linkages could be made, for example, between technical knowledge and flying skill or between ability to plan ahead and to make correct decisions in adjusting to changing conditions. With advances in automation in new design aircraft, manual skills become less important. The pilot's role in managing the resources of the cockpit assumes greater significance[1]. Current managerial responsibilities are indicated in Table 2. Pilots generally have sufficient seniority to be a captain already by the time they reach 55-59 years of age.

The pilot's task also may be defined in operational terms. On-the-job operations of pilots, including nonroutine and emergency situations, are monitored and analyzed either in-flight or in a simulator. Research literature can be examined as a source of hypotheses regarding functional alterations with age, and these functions monitored specifically in the operational setting. This approach has the advantage of directly assessing those specific skills used in flying and revealing specific "in-flight" defects or errors in performance[2].

In pursuing its charge, this committee has drawn on each of these ways of specifying and analyzing the functions and abilities involved in piloting and captaining an airline.

Table 1. Attributes Sought in Pilot Candidates

- Flying Motivation: Strong career motivation in the aviation field, self-identity as a pilot, love of aircraft and flying, and preference for a flying job.

- Multiple-channel Information Processing Skills: Monitor complex information in real time, and make prompt and accurate decisions.

- Reasoning: The recognition, acceptance, and integration of information. Solve problems through logical inductive and deductive processes.

- Emotional Stability: With the responsibility that an airline captain has in terms of lives and equipment, any lack of emotional stability could easily become exaggerated, jeopardizing the safety of the passengers and crew.

- Sensitivity to Others: As the leader of a cockpit crew of three and a cabin crew of two or more, the captain must have the ability to accept the suggestions of other crewmembers. The tone set by the pilot can determine, in part, how effectively the cockpit crew works as a team.

- Planning Ahead: Ability to plan actions and to think ahead is of critical value. This involves both anticipation of problems and planning what should be done to react to these problems.

- Mechanical Aptitude: Although the procedures to be taken during any emergency are clearly defined by the airline, knowledge of the mechanical systems of the airplane allows greater understanding of the procedures to be taken and when and how to deviate from these procedures.

- Wide Attention Under Stress: Focus on the problem at hand in responding to that problem results in ignoring other possible problems in the cockpit. With the many sources of information available to the captain, it is critical not to limit attention during periods of stress.

- Education: Intelligence and motivation necessary to complete a college education.

Source: Adapted from material prepared for American Airlines by S.B. Sells, Institute for Behavioral Research, Texas Christian University.

Table 2. Managerial Functions of Captains

- Supervision and Leadership: The pilot-in-command has authority over the cockpit crew and and the cabin crew. By leadership and managerial skills, the pilot can influence the tone and functioning of both crews.

- Management of Resources: The pilot-in-command is responsible for allocating the operating functions among members of the cockpit crew. The pilot should aim to avoid overloading any one crew member while remaining free for the proper performance of decision-making functions.

- Planning and Decision-making: The pilot-in-command, in consultation with other crew members, plans the trip, makes decisions with respect to any change in the plan, and makes other operational decisions during the flight.

- Evaluation of Crew Members' Performances: In at least some airlines, new members during a 12-months' probationary period are rated on their performance by each pilot-in-command with whom they fly.

Sources: H.P. Ruffell Smith. A Simulator Study of the Interaction of Pilot Workload with Errors, Vigilance, and Decisions. NASA Technical Memorandum 78482, Scientific and Technical Office, 1979; and R.C. Houston, Director Training Support, American Airlines "Selective Criteria for Airline Pilots." July, 1977.

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CHAPTER 3

PILOT CERTIFICATION

The current system for assessing pilots' abilities to meet the demands of the job of pilot-in-command or second-in-command is defined in the Federal Aviation Regulations. There are three types of certification requirements: 1) initial demonstration of the knowledge, skills, and experience necessary to fly the type of aircraft; 2) initial and then subsequent periodic demonstration of current proficiency in flying the aircraft; and 3) initial and then subsequent periodic demonstration of medical fitness.

In order to serve as pilot-in-command, an individual must have an airline transport pilot certificate and a rating for the specific aircraft to be flown, specific training and proficiency checks, and a first-class medical certificate.

Pilot Certificate

To obtain an airline transport pilot certificate, an individual must have specific aeronautical knowledge (e.g. navigation, weather and meteorology, air facilities, radio communication), aeronautical experience (hours of various types of flight experience, including time as pilot-in-command), and aeronautical skill (demonstration of flying ability by a practical test)[1].

Training and Proficiency Checking

A pilot's current proficiency in routine and emergency flight maneuvers is monitored regularly by FAA-designated check airmen. The proficiency checks test ability to perform certain procedures and maneuvers within an aircraft or a simulator. In addition to proficiency checks--usually in a simulator--line checks are scheduled regularly. These involve observation of a pilot by a check airman during a scheduled flight.

The pilot-in-command undergoes either a proficiency check or a simulator training course every six months; there must be at least one proficiency check every year. In addition, the pilot-in-command receives a line check every year. All other pilots must have either a proficiency check or a line-oriented simulator training course every two years and either a proficiency check or any simulator training course every year.

Training is a continuing activity of a pilot's career. In addition to recurrent training as preparation for proficiency checks, all pilots must complete training as made necessary by (1) modification in the aircraft design, (2) promotion to a new type of aircraft, or (3) promotion in rank, e.g., from co-pilot to pilot-in-command.

Medical Certification

Federal Aviation Regulations require that an active airline transport captain possess a Class I medical certificate. The regulations pertaining to medical standards and certification procedures are in Part 67 of the Federal Aviation Regulations (see Appendix C). More detailed instructions for the examination are contained in the FAA's Guide For Aviation Medical Examiners[2].

The examination for the Class I certificate is intended to detect functional changes and disorders that increase the risk of sudden incapacitation or that otherwise might have a detrimental effect on pilot performance. Primary emphasis is on testing of hearing and vision, and evaluation of cardiovascular, neurologic, and endocrine health status. Some airlines provide additional prevention-oriented medical examinations, which generally are more comprehensive than the FAA examination.

The semi-annual medical examination is provided by one of more than 3,000 FAA-designated Senior Aviation Medical Examiners (AME) eligible to offer examinations for first-class certificates. Most AMEs are physicians in private practice. Pilots select their own examining physicians from among the eligible AMEs, and pay for their own examination. Their criteria for choosing a physician and the consistency of quality of the examinations have not been determined.

The AME enters the medical history and examination results on FAA Form 8500-8 (Figure 1). If the pilot passes the examination, the AME issues a first class certificate and forwards it to the FAA. That agency has 60 days in which to review the certificate; it is either affirmed or withdrawn.

A Class I medical certificate required of airline captains must be renewed every six months.

Figure 1. FAA Form 8500-8, Application for Airman Medical Certificate

COPY OF FAA FORM 8500-9 (MEDICAL CERTIFICATE), OR FAA FORM 8420-2 (MEDICAL/STUDENT PILOT CERTIFICATE) ISSUED. AA-742435[illegible]

MEDICAL CERTIFICATE ________ CLASS AND STUDENT PILOT CERTIFICATE

THIS CERTIFIES THAT *(Full name and address)*

DATE OF BIRTH	HEIGHT	WEIGHT	HAIR	EYES	SEX

has met the medical standards prescribed in Part 67, Federal Aviation Regulations for this class of Medical Certificate.

LIMITATIONS

DATE OF EXAMINATION | EXAMINER'S SERIAL NO.

EXAMINER: SIGNATURE

TYPED NAME

AIRMAN'S SIGNATURE

WHEN ISSUED AS A MEDICAL-STUDENT PILOT CERTIFICATE, the holder has met standards prescribed in Part 61, FAR's for such certificate, and is prohibited from carrying passengers.

APPLICATION FOR ☐ AIRMAN MEDICAL CERTIFICATE ☐ AIRMAN MEDICAL AND STUDENT PILOT CERTIFICATE

Please print these items

1. FULL NAME *(Last, first, middle)* | PATH CONTROL

2A. ADDRESS *(No. Street, City, State, ZIP No.)* | 2B. SOCIAL SECURITY No.

County:

2C. PLACE OF BIRTH *(Student pilot applicants only)*

3. DATE OF BIRTH *(Mo., day, year)*	4. HEIGHT *(Inches)*	5. WEIGHT *(Pounds)*	6. COLOR OF HAIR	7. COLOR OF EYES	8. SEX

9A. CLASS OF MEDICAL CERTIFICATE APPLIED FOR	9B. TYPE OF AIRMAN CERTIFICATE(S) HELD	
FIRST	AIRLINE TRANSPORT	FLIGHT INSTRUCTOR
SECOND	COMMERCIAL	PRIVATE
THIRD	ATC SPECIALIST	STUDENT
	FLIGHT ENGINEER	NONE
	FLIGHT NAVIGATOR	OTHER

10. OCCUPATION *(If ATC Specialist, specify position and facility)*

11. EXTENDED ACTIVE DUTY MEMBER OF

a. AIR FORCE	d. COAST GUARD
b. ARMY	e. NATL. GUARD
c. NAVY/MARINES	f. NONE

MILITARY SERVICE NO.

12. EMPLOYER

13. LENGTH OF TIME IN PRESENT OCCUPATION

14. PRIMARY TYPE OF FLYING: BUSINESS | PLEASURE

15. CURRENTLY USE ANY MEDICATION *(Including eye drops)*

YES — TYPE AND PURPOSE

NO

TOTAL PILOT TIME	16. TO DATE	17. LAST 6 MOS.	18. HAS AN FAA AIRMAN MEDICAL CERTIFICATE EVER BEEN DENIED, SUSPENDED, OR REVOKED		19. HAVE YOU, AS A PILOT, HAD AN AIRCRAFT ACCIDENT WITHIN THE PAST 2 YEARS		20. DATE OF LAST FAA PHYSICAL EXAM *(If none, state so)*
CIVIL			YES	DATE	YES	DATE	
MILITARY			NO		NO		

21. MEDICAL HISTORY – HAVE YOU EVER HAD OR HAVE YOU NOW ANY OF THE FOLLOWING: *(For each "yes" checked, describe condition in REMARKS)*

Yes	No	Condition	Yes	No	Condition	Yes	No	Condition	Yes	No	Condition
		a. Frequent or severe headaches			g. Heart trouble			m. Nervous trouble of any sort			s. Medical rejection from or for military service
		b. Dizziness or fainting spells			h. High or low blood pressure			n. Any drug or narcotic habit			t. Rejection for life insurance
		c. Unconsciousness for any reason			i. Stomach trouble			o. Excessive drinking habit			u. Admission to hospital
		d. Eye trouble except glasses			j. Kidney stone or blood in urine			p. Attempted suicide			v. Record of traffic convictions
		e. Hay Fever			k. Sugar or albumin in urine			q. Motion sickness requiring drugs			w. Record of other convictions
		f. Asthma			l. Epilepsy or fits			r. Military medical discharge			x. Other illnesses

REMARKS *(If no changes since last report, so state)* | FOR FAA USE REVIEW ACTION CODES

22. HAVE YOU EVER BEEN ISSUED A STATEMENT OF DEMONSTRATED ABILITY (WAIVER) — NO / YES *(Give defects and waiver no.)* | PHYSICAL DEFECTS NOTED ON STATEMENT OF DEMONSTRATED ABILITY (WAIVER) | WAIVER SERIAL NO.

23. MEDICAL TREATMENT WITHIN PAST 5 YEARS

DATE	NAME AND ADDRESS OF PHYSICIAN CONSULTED	REASON

– NOTICE –

Whoever in any matter within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or who makes any false, fictitious or fraudulent statements or representations, or makes or uses any false writing or document knowing the same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than 5 years, or both. (U.S. Code, Title 18, Sec. 1001.)

24. APPLICANT'S DECLARATION

I hereby certify that all statements and answers provided by me in this examination form are complete and true to the best of my knowledge, and I agree that they are to be considered part of the basis for issuance of any FAA certificate to me. I have also read and understand the Privacy Act statement that accompanies this form.

SIGNATURE OF APPLICANT *(In ink)* | DATE

FAA FORM 8500-8 (10-75) — SUPERSEDES PREVIOUS EDITION — Form Approved OMB No 04-R0089

Figure 1. (Continued)

REPORT OF MEDICAL EXAMINATION

NORMAL	CHECK EACH ITEM IN APPROPRIATE COLUMN *(Enter NE if not evaluated)*	ABNORMAL	NOTES: Describe every abnormality in detail, enter applicable item number before each comment. Use additional sheets if necessary and attach to this form.
	25. Head, face, neck and scalp		
	26. Nose		
	27. Sinuses		
	28. Mouth and throat		
	29. Ears, general *(Internal and external canals) (Auditory acuity under item 49)*		
	30. Drums *(Perforation)*		
	31. Eyes, general *(Visual acuity under items 50 & 51)*		
	32. Ophthalmoscopic		
	33. Pupils *(Equality and reaction)*		
	34. Ocular motility *(Associated parallel movement, nystagmus)*		
	35. Lungs and chest *(Including breasts)*		
	36. Heart *(Thrust, size, rhythm, sounds)*		
	37. Vascular system		
	38. Abdomen and viscera *(Including hernia)*		
	39. Anus and rectum *(Hemorrhoids, fistula, prostate)*		
	40. Endocrine system		
	41. G–U system		
	42. Upper and lower extremities *(Strength, range of motion)*		
	43. Spine, other musculoskeletal		
	44. Identifying body marks, scars, tattoos		
	45. Skin and lymphatics		
	46. Neurologic *(Tendon reflexes, equilibrium, senses, coordination, etc.)*		
	47. Psychiatric *(Specify any personality deviation)*		FOR FAA USE - PATHOLOGY CODE NOS.
	48. General systemic		

49. HEARING	RIGHT EAR				LEFT EAR			
WHISPERED VOICE (STANDING SIDEWAYS DISTANT EAR CLOSED)	FT.				FT.			
	500	1000	2000	4000	500	1000	2000	4000
AUDIOMETER *(Decibel Loss)*								

50. DISTANT VISION *(Standard test types only)*			51. NEAR VISION *(Use linear values)*	
RIGHT EYE	20/	CORRECTED TO 20/	20/	CORRECTED TO 20/
LEFT EYE	20/	CORRECTED TO 20/	20/	CORRECTED TO 20/
BOTH EYES	20/	CORRECTED TO 20/	20/	CORRECTED TO 20/

52. INTRAOCULAR TENSION *(Tonometry required for Air Traffic Control Specialist)*

	RIGHT EYE	LEFT EYE
TACTILE		
TONOMETRIC		

53. COLOR VISION *(Test used, number of plates missed)*

54. FIELD OF VISION		55. HETEROPHORIA DIOPTERS *(Not required for Class Three)*				
RIGHT EYE	LEFT EYE	DISTANCE	ESOPHORIA	EXOPHORIA	RIGHT H.	LEFT H.

56. BLOOD PRESSURE			57. PULSE *(Wrist)*		
RECUMBENT, MM MERCURY	SYSTOLIC	DIASTOLIC	RESTING	AFTER EXERCISE	2 MINUTES AFTER EXERCISE

58. URINALYSIS		59. ECG *(Date)*	60. OTHER TESTS
ALBUMIN	SUGAR		

61. COMMENTS ON HISTORY AND FINDINGS; RECOMMENDATIONS *(Attach all consultation reports, ECGs, X-rays, etc. to this report before mailing)*

FOR FAA USE	
CODED	
PUNCHED	
VERIFIED	
EXAMINER CODES	
CLINICAL REJECT	

62. APPLICANT'S NAME

HAS BEEN ISSUED ☐ MED. CERTIF. ☐ MED. AND STUDENT PILOT CERTIF.

☐ NO CERTIF. ISSUED - FURTHER EVALUATION REQUIRED

HAS BEEN DENIED - LETTER OF DENIAL ISSUED *(Copy attached)*

63. DISQUALIFYING DEFECTS *(List by item no.)*

64. MEDICAL EXAMINER'S DECLARATION *I hereby certify that I personally examined the applicant named on this medical examination report, and that this report with any attachment embodies my findings completely and correctly.*

DATE OF EXAMINATION	AVIATION MEDICAL EXAMINER'S NAME AND ADDRESS *(Type or print)*	AVIATION MEDICAL EXAMINER'S SIGNATURE

REFERENCES

1. Federal Aviation Regulations, Part 61, Subpart F.

2. Federal Aviation Administration. Guide for Aviation Medical Examiners. Department of Transportation, FAA Office of Aviation Medicine, 1970.

CHAPTER 4

SAFETY RECORD

An examination of the empirical evidence provided by accident records and analyses may indicate the medical, behavioral, neuropsychological, and human factors that should be assessed most carefully for possible decrements with age and consequent compromise of safe pilot performance.

In the United States, the National Transportation Safety Board (NTSB) collects data on the frequency of aviation accidents and incidents* and also investigates their causes.

The NTSB data were reviewed with two questions in mind:

1. Does the frequency of accidents change with age?

2. Do the causes of and factors related to accidents and incidents suggest a priority for assessing age effects on medical and behavioral status?

Because of the age-60 rule, no information on airline pilots older than 60 is available. However, some general aviation** pilots are over 60. Therefore, general aviation accident data were reviewed in addition to airline accident data, although the committee was cognizant that general aviation pilots are not required to meet the same medical or proficiency standards as airline pilots, and their selection and licensure are not as rigorous.

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*Accidents are defined by the NTSB as events involving substantial or greater damage to the airplane and/or serious or greater damage to an occupant. Incidents are defined as events involving only minor damage to the airplane and/or minor injury to an occupant.

**General aviation refers to the operation of U.S. Civil Aircraft owned and operated by persons, corporations, etc., other than those engaged in U.S. air carrier operations (U.S. air carrier operations include the certificated route air carriers, supplemental air carriers, and commercial operators of large aircraft).

Frequency of Accidents

The total number and the frequency of U.S. air carrier accidents and incidents, by age of the pilot, for the period 1966 through 1978 are presented in Table 3. Data on general aviation accidents in the United States by age of pilot and by experience, for the year 1974, are presented in Table 4.

The number of accidents plus incidents per 1,000 pilots per year (the incidence) for commercial air carriers declines with age (Table 3). However, the data should be interpreted with caution because older pilots have greater seniority than younger ones, and may be flying routes with substantially different inherent levels of hazard (e.g., number of take-offs and landings, and air corridors and airports used). Valid generalizations regarding the effect of pilot age on air carrier safety cannot be derived from these data.

The general aviation data in Table 4 are of interest because they provide information on pilots over the age of 60. As shown in Table 4, there is a higher accident rate among general aviation pilots in the age range of 60 and above, compared to those younger than 60. In contrast, when only those general aviation pilots with more than 2,000 hours of cumulative flying experience* are considered, the rates of accidents are highest in pilots under age 30. There is no consistent trend for accident rates among these experienced pilots in the age range 30-70. The rates in this table, however, fail to take into account the "exposure to flying" during the year. If older pilots have considerably less flying time or significantly fewer take-offs and landings, for example, the actual risk may be underestimated with these data. The true state of affairs can be determined only if more adequate data are collected and analyzed at the national level.

Causes of Accidents and Incapacitation

Table 5 shows the causes of or factors related to accidents involving certificated route air carriers for 1968-1977. A more detailed itemization of the causes and related factors of certificated route air carrier accidents for 1977 is given in Table 6. Table 7 shows the causes of or factors related to U.S. general aviation accidents for 1978.

Pilot error is identified as a cause or contributing factor in about half of the air carrier accidents. (In Table 5, the designation pilot is equivalent to pilot error, because there were no airline accidents due to pilot incapacitation in this time period.) In 1977, there were 17 air carrier accidents involving pilot error. As enumerated in Table 6, these errors included failure to follow approved procedures, failure to see and

*A large proportion of airline pilots will have accumulated 1000-2000 hours of piloting experience before being hired by an airline.

Table 3. Accidents and Incidents[a] of U.S. Air Carriers[b] by Age of Pilot[c], 1966-1978

Age	Airline Pilot Years[d]	Total Number of Accidents and Incidents	Incidence[e]
20-24	6,037	15	2.48
25-29	38,913	98	2.52
30-34	88,064	197	2.24
35-39	92,141	176	1.91
40-44	69,587	95	1.37
45-49	57,733	45	0.78
50-54	44,972	14	0.31
55-59	25,941	15	0.58
All ages	423,388	655	1.54

[a]Accidents entail substantial or greater damage to the airplane and/or serious or greater injury to an occupant; incidents entail minor damage to the airplane and/or minor injury to an occupant.

[b]U.S. air carriers refers to any carrier operating under the Code of Federal Regulations Title 14, Part 121. This includes those operators who have been issued a Certificate of Public Convenience and Necessity by the C.A.B., i.e., certificated route air carriers, supplemental air carriers, and commercial operators of large aircraft (over 12,500 lbs).

[c]The accident or incident is attributed to the age interval for the pilot-in-command.

[d]Pilot years are calculated as the sum of the number of pilots in the given age interval each year from 1966-1978.

[e]Incidence is calculated as accidents plus incidents per 1000 pilot years.

Sources: Accident plus incident data: National Transportation Safety Board.

Airline pilot population data: Aeromedical Certification Statistical Handbook. Civil Aeromedical Institute, Aeromedical Certification Branch, Medical Statistical Section; RIS: AC 8500-1.

Table 4. General Aviation Accidents, By Cumulative Flying Experience and Age, 1974

Age	All General Aviation Pilots[a]		General Aviation Pilots With more than 2000 Hours Cumulative Experience	
(Years)	Number of Accidents[b]	Accidents per 1000 Pilots	Number of Accidents	Accidents per 1000 Pilots
Less than 20	116	2.5	4	24.8
20-29	1207	5.2	213	24.9
30-39	1359	6.3	372	14.0
40-49	1059	6.6	315	12.1
50-59	592	6.5	243	9.7
60-69	123	8.6	68	12.8
70 and above	20	10.3	8	8.3
All ages	4491	5.9	1223	13.2

[a]General aviation refers to the operation of U.S. Civil Aircraft owned and operated by persons, corporations, etc., other than those engaged in U.S. air carrier operations (U.S. air carrier operations include the certificated route air carriers, supplemental air carriers, and commercial operators of large aircraft).

[b]Accidents entail substantial or greater damage to the airplane and/or serious or greater injury to an occupant. The data exclude 17 accidents for which the pilot's age is unknown.

Source: C.F. Booze, Jr., "An epidemiologic investigation of occupation, age, and exposure in general aviation accidents," Office of Aviation Medicine, Federal Aviation Administration, Report Number FAA-AM-77-10, April 1977.

Table 5. Causes/Factors of Certificated Route Air Carrier[a] Accidents[b], 1968-1977

Causes/Factors	Percentage of Total Accidents	Percentage of Fatal Accidents
Weather	48	45
Personnel[c]	47	42
Pilot[d]	40	63
Airport/airways/facilities	9	5
Landing gear	9	3
Powerplant	7	5
Systems	7	9
Instruments/equipment	3	3
Airframe	2	6
Terrain	2	0
Rotorcraft	1	3
Miscellaneous	6	12
Undetermined	1	6

[a]A certificated route air carrier is designated as "an air carrier holding a Certificate of Public Convenience and Necessity issued by the Civil Aeronautics Board authorizing the performance of scheduled service over specific routes, and a limited amount of nonscheduled service" (FAA Statistical Handbook, 1978). Most large commercial airline transportation falls into this category, but commuter air carriers do not.

[b]Accidents entail substantial or greater damage to the airplane and/or serious or greater injury to an occupant. These data include 434 accidents, 70 of which were fatal.

[c]"Personnel" refers to all individuals on the airplane and on the ground who are involved in the flight of the airplane, except the pilot-in-command and the co-pilot.

[d]"Pilot" refers to both the pilot-in-command and the co-pilot.

Note: The percentage totals exceed 100 percent because multiple causes/factors can be cited in an accident.

Source: "Annual review of aircraft accident data, U.S. air carrier operations, 1977," National Transportation Safety Board, Report Number NTSB-ARC-78-2, September 6, 1978.

Table 6. Detailed Causes/Factors[a] Of U.S. Air Carrier[b] Accidents[c], 1977

Detailed Causes/Factors	Number of Accidents	Number of Fatal Accidents
Personnel[d]	22	4
All Pilots	17	5
Pilot-in-command:		
Failed to follow approved procedures, directives, etc.	3	1
Failed to see and avoid other aircraft	2	
Attempted operation with known deficiencies in equipment	1	1
Diverted attention from operation of aircraft	1	
Failed to see and avoid objects or obstructions	1	
Improper IFR operation	1	1
Improper in-flight decisions or planning	1	1
Exercised poor judgement	1	1
Initiated flight in adverse weather conditions	1	
Misjudged distance, speed, and altitude	1	
Misjudged clearance	1	
Failed to maintain directional control	1	
Direct entries	1	
Co-pilot:		
Failed to follow approved procedures, directives, etc.	1	
Weather	15	2
Airports/airways/facilities	7	
Powerplant	5	3
Systems	2	3
Airframe	2	1
Terrain	1	
Miscellaneous	24	7
Total	23	4

[a]Three accidents with no causal assignments are excluded from the data.

[b]U.S. air carriers refers to any carrier operating under Code of Federal Regulations Title 14, Part 121. This includes those operators who have been issued a Certificate of Public Convenience and Necessity by the C.A.B., i.e., certificated route air carriers, supplemental air carriers, and commercial operators of large aircraft (over 12,500 lbs.).

[c]Accidents entail substantial or greater damage to the airplane and/or serious or greater injury to an occupant.

-Continued-

Table 6. (Continued)

[d]"Personnel" refers to all individuals on the airplane and on the ground who are involved in the flight of the airplane, except the pilot-in-command and the co-pilot.

Note: The sum of the individual causes/factors exceeds the total number of accidents that occurred because multiple causes/factors can be cited in an accident.

Source: "Annual review of aircraft accident data, U.S. air carrier operations, 1977," National Transportation Safety Board, Report Number NTSB-ARC-78-2, September 6, 1978.

Table 7. Causes/Factors of U.S. General Aviation[a] Accidents[b], 1978

Causes/Factors	Percentage of Total Accidents	Percentage of Fatal Accidents
Pilot[c]	81	85
Weather	21	41
Terrain	19	13
Powerplant	15	9
Personnel[d]	9	10
Airport/airways/facilities	7	1
Landing gear	3	0
Systems	1	2
Rotorcraft	1	2
Airframe	1	2
Instruments/equipment and accessories	1	1
Miscellaneous	3	3
Undetermined	3	9

[a]General aviation refers to the operation of U.S. Civil Aircraft owned and operated by persons, corporations, etc., other than those engaged in U.S. air carrier operations (U.S. air carrier operations include the certificated route air carriers, supplemental air carriers, and commercial operators of large aircraft).

[b]Accidents entail substantial or greater damage to the airplane and/or serious or greater injury to an occupant. The data include 4424 accidents, 761 of which were fatal.

[c]"Pilot" refers to the pilot-in-command, the co-pilot, dual student pilots, and check pilots.

[d]"Personnel" refers to all individuals on the airplane and on the ground who are involved in the flight of the airplane, except those individuals included in the category of "pilot."

Note: The percentage totals exceed 100 percent because multiple causes/factors can be cited in an accident.

Source: "Annual review of aircraft accident data - U.S. general aviation, calendar year 1978," National Transportation Safety Board, Report Number NTSB-ARG-80-1, May 20, 1980.

avoid other aircraft, and a variety of misjudgments and misperceptions. Whether the errors resulted from impaired pilot functioning, flawed cockpit design, or other causes is not discernible from these data.

Acute incapacitation of the pilot is not significant as a cause of airline accidents. No accidents were attributed to incapacitation during the period 1968 to 1977. Because the cockpit crew includes a co-pilot and a flight engineer who can take over the controls, most incapacitations, when they occur, do not cause accidents. Table 8 shows the causes of incapacitation in U.S. air carrier pilots for 1965-1974, as determined by the NTSB. (Data on the age of the pilots was not available.) The cause of slightly more than half of the 67 incapacitations is unknown. Of the number whose cause is known, cardiovascular disease accounts for 36 percent, and gastroenteritis, convulsive seizure, and kidney stone attack each account for an additional 10 to 20 percent.

Incapacitation and impairment were identified as causes of a very small percentage of the general aviation accidents in 1978: 1.7 percent of all accidents and 7.8 percent of fatal accidents. Table 9 is a summary of the physiological and psychological causes of general aviation accidents during the period 1965-1975.

Of the 49,000 general aviation accidents during this period, slightly more than one percent were attributed to physiological or psychological incapacitation or impairment. Within that one percent, alcohol is by far the most frequent physiological/psychological cause, accounting for about 68 percent of these accidents. Cardiovascular disease and fatigue/sleep are the next most frequent cause, each accounting for an additional 10 percent of such accidents. The data on incapacitation and impairment may not readily be applicable to airline pilots because general aviation pilots do not undergo as rigorous medical surveillance as do airline pilots. The selection, licensing, and performance testing of airline pilots also are more stringent and thus further weaken the predictive power of general aviation data.

The NTSB data provide some insight into causes of incapacitation during flights, but information on the causes of incapacitation among pilots--regardless of whether the incapacitation occurs while in command of an airplane--is also of interest. The loss-of-license insurance program has been used as a source of such information.

Loss of license insurance participants are eligible to collect insurance payments if they fail to meet medical standards for licensure and are therefore ineligible to fly. A pilot who stops flying for other than medical reasons is not eligible for payment. Table 10 gives the incidence of death and permanent disability by cause and pilot age among airline pilots participating in the loss-of-license insurance program during the period of 1955 to 1966.

Table 8. Causes of U.S. Air Carrier[a] Pilot Incapacitation[b], 1965-1974

Cause	Number of Incapacitations	Percentage
Cardiovascular disease	12	18
Gastroenteritis	6	9
Convulsive seizure	5	7
Kidney stone attack	4	6
Faintness	2	3
Chest pains	1	1.5
Sinus attack	1	1.5
Cervical strain	1	1.5
Pneumonia attack	1	1.5
Unknown causes	34	50
Total	67	100

[a]U.S. air carriers refers to any carrier operating under Code Federal Regulations Title 14, Part 121. This includes those operators who have been issued a Certificate of Public Convenience and Necessity by the C.A.B., i.e., certificated route air carriers, supplemental air carriers, and commercial operators of large aircraft (over 12,500 lbs.).

[b]Incapacitation: any physical condition that results in the pilot's inability to physically control the aircraft.

Note: Only one of these incapacitations resulted in an accident.

Source: J.W. Danaher, "The incidence of incapacitation in aircraft accidents," National Transportation Safety Board. Talk presented at a Symposium on Aviation Medicine and the Airline Pilot, British Air Line Pilots Association, Heathrow, U.K., October 9-10, 1975.

Table 9. General Aviation[a] Accidents[b] Attributed to Physiological or Psychological Causes, 1965-1975

Cause	Number of Accidents	
Total Accidents (any cause)	49,000	
Impairment[c]	523	
Incapacitation[d]	110	
Total	633	
Alcohol		407
Cardiovascular		58
Fatigue/sleep		46
Psychological		26
Consciousness/seizure		10
Drugs		7
Respiratory		4
Gastrointestinal		3
Cerebral hemorrhage		2
Miscellaneous		18
Unknown		19
Total by medical cause		600

[a]General aviation refers to the operation of U.S. Civil Aircraft owned and operated by persons, corporations, etc., other than those engaged in U.S. air carrier operations (U.S. air carrier operations include the certificated route air carriers, supplemental air carriers, and commercial operators of large aircraft).

[b]Accidents entail substantial or greater damage to the airplane and/or serious or greater injury to an occupant.

[c]Impairment denotes those physical conditions in which less than total incapacitation occurs.

[d]Incapacitation is any physical condition that results in the pilot's inability to physically control the aircraft.

Note: The accidents enumerated by specific cause are included in the totals for impairment and incapacitation. The values for impairment and incapacitation are from a different source than the values by cause, and do not exactly equal the total by specified cause.

Source: National Transportation Safety Board In: "FAA response to the comptroller general of the United States, Report NO. CED-76-154, November 3, 1976," September 22, 1978; and J. W. Danaher, "The incidence of incapacitation in aircraft accidents." Talk presented at a Symposium on Aviation Medicine and the Airline Pilot, British Airline Pilots Association, Heathrow, U.K., October 9-10, 1975.

Table 10. Airline Pilot Loss-of-License Insurance Record, 1955-1966

Age	Pilot Years[a] At Risk	Total Number	Permanent Disability[b] Per 1000 Pilot Years: Cardio-vascular	Psychi-atric	Eye	GI	Subtotal All Diseases[c]	All Causes[d]
30	6,089	22	0.00	0.66	0.00	0.00	1.48	3.61
30-34	19,833	72	0.20	0.35	0.25	0.00	1.26	3.63
35-39	30,966	145	0.78	0.58	0.16	0.26	2.91	4.68
40-44	29,727	221	2.49	1.11	0.27	0.34	5.65	7.42
45-49	16,366	205	5.13	1.41	0.73	0.37	10.20	12.52
50-54	5,951	144	11.59	2.18	1.34	1.34	20.84	24.19
55-58	1,756	82	26.20	2.85	3.42	5.13	44.99	46.71
All Ages	110,718	891	2.72	0.93	0.40	0.37	5.98	8.05

[a]Pilot years are calculated as the sum of the number of pilots in the given age interval each year from 1955 to 1966 who participated in loss-of-license insurance programs. During this time period, over 63 percent of U.S. airline pilots participated.

[b]Loss-of-license insurance participants are eligible to collect insurance payments if they fail to meet medical standards for licensure and are therefore ineligible to fly scheduled airline transports. A pilot who stops flying for other than medical reasons is not eligible for payment. However, deaths entered in the in the insurance records are included in the total.

[c]Other diagnostic categories:
- Dermatological and allergic disease
- Endocrine disease
- Hemotological disease
- Musculoskeletal disease
- Nephrological and urological disease
- Neurological disease
- Otolaryngeal disease
- Respiratory disease
- Systemic disease of uncertain cause

[d]The total includes disability due to accidents--both flying and non-flying--as well as disease.

Sources: L.L. Kulak, R.L. Wick, Jr., and C.E. Billings. Epidemiological study of in-flight airline pilot incapacitation. Aerospace Medicine 42:670-672, June 1971; and R.L. Wick, Jr., L.L. Kulak, D. Howland, and C.E. Billings. "In-flight airline pilot incapacitation." The Ohio State University Research Foundation, Report Number RF 2699-1, August 1969.

Cardiovascular disease was the most frequent cause of career termination among these pilots, and the incidence of such disease increased with age. Psychiatric, ocular, and gastrointestinal diseases were the next most frequent causes of career termination; other disease-related causes are far less frequent.

In summary, pilot error contributes to many airline accidents, but physical impairment and incapacitation do not appear to. Cardiovascular disease is the most significant medical problem among airline pilots. Although not an important contributor to the overall accident rate, cardiovascular disease is the leading known cause both of in-flight incapacitation among airline pilots and loss of license for medical reasons (as indicated by insurance claims). Thus, the empirical evidence suggests that a review of the adequacy of medical testing and the potential impact of age on safe pilot performance must consider not only life-threatening disorders--most notably cardiovascular--but also medical conditions and aging processes that might contribute to decrements in the perceptual and cognitive functioning of pilots.

CHAPTER 5

METHODOLOGIC ISSUES

Many methodologic issues are encountered in assessing the scientific evidence bearing on the effects of aging on airline pilot health and performance. Specific issues are discussed as they arise in the context of each of the sections of Part II and III, but this chapter raises some important general issues that are common to most of the studies of medical and behavioral factors.

Applicability of Research Results to Pilots

Although there is a large and growing literature on aging* in humans and in many animal species, most of the research is not conducted on populations of pilots. The extent to which a study can be safely generalized to the aging process in pilots depends, in part, on the degree of similarity between the subject population and airline pilots.

By virtue of airline hiring procedures and FAA medical certification requirements, pilots are a select population. They are better educated than the general population and are more physically fit; most are white males. Thus, the physical health status, level of formal education, fitness, gender, and race of study subjects need to be evaluated carefully. For those conditions or attributes for which the changes with age have been shown to be consistent and not to vary by levels of health, education, or fitness, the data from general populations can be expected to apply to pilots of a similar age.

A few studies have employed pilots as experimental subjects, for example, The Navy Thousand Aviator Study, a longitudinal study of men who were Navy pilots in training in the 1940s. The Navy study continues to this date, but with follow-up and testing of only some of the original cohorts, most of whom no longer are pilots[6-9]. A study by the Lovelace Foundation included 503 pilots at the first testing: 63 test pilots, 128 military pilots, 259 commercial pilots, 41 private pilots and 12 executive pilots[10,11]. A study of pilots and air traffic controllers who

*Recent literature reviews[1-5] cover a broad variety of biomedical and behavioral aspects of aging, with a special emphasis on human health and psychological and psychiatric functioning.

were receiving their medical evaluations at the FAA's Georgetown Clinical Center in Washington, D.C., and volunteered for special cognitive testing, also has been published[12,13].

Interpretation of Studies Using Cross-Sectional Versus Longitudinal Design

In cross-sectional studies on aging, measurements of function, behavior, or performance are made in one short time period on individuals of different ages, whereas in longitudinal studies, measurements are made on the same individuals at different points in time. Figure 2, from the Framingham Study, shows that cross-sectional and longitudinal data--in this case, on diastolic blood pressure--may provide different profiles. The differences are inevitable because the circumstances of life have been very different from one decade to the next. Cross-sectional and longitudinal profiles would only be the same if each group had lived through exactly the same experiences for fewer or greater numbers of years.

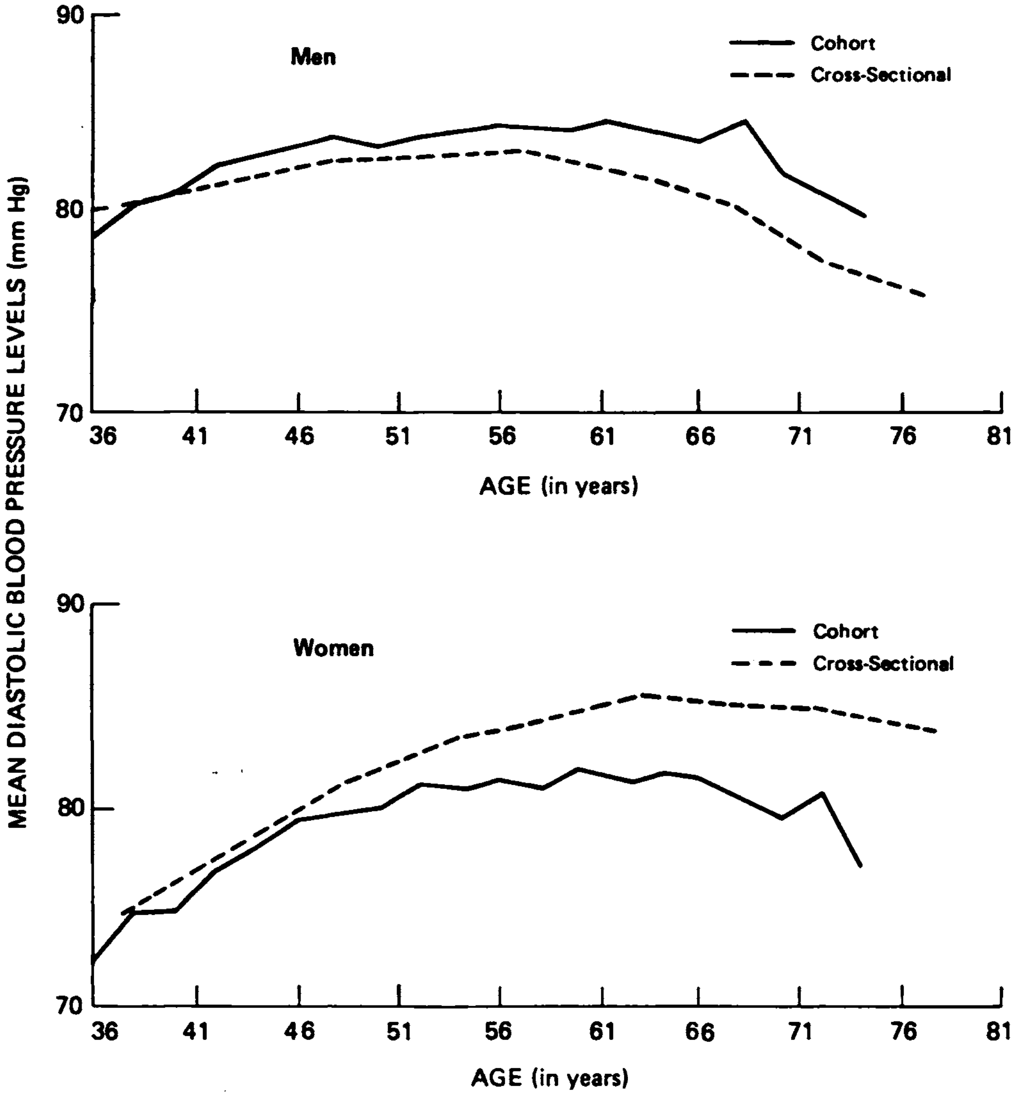
The difficulty in interpreting cross-sectional studies is well illustrated in a quotation from Kastenbaum:

> "Occasionally I have the opportunity to chat with elderly people who live in the communities near Cushing Hospital. I cannot help but observe that many of these people speak with an Italian accent. I also chat with young adults who live in these same communities. They do NOT speak with an Italian accent. As a student of human behavior and development I am interested in this discrepancy. I indulge in some deep thinking and come up with the following conclusion: as people grow older they develop Italian accents. This must surely be one of the prime manifestations of aging on the psychological level."[14]

An observed difference among persons of different ages in the same time period may not represent an effect of aging, but may be a cohort effect. In an Italian-American community, people of a certain age or birth cohort are more likely to have been immigrants, while a younger birth cohort would probably have been born in the United States. The difference in manner of speech is a cohort effect, not an aging or "developmental" effect.

A cohort effect is the presumed result of experiences, training, and environmental influences, up to the time of measurement, that are unique to a particular group; the group is often defined as those born in the same year. Thus, individuals who are 60 years old when measured in 1980 (born in 1920) may provide different results than persons who are 60

Figure 2. Age Trends in Diastolic Blood Pressure for Cross-Sectional and Cohort (Longitudinal) Data. Framingham Study exams 3-10.



Source: Adapted from T. Gordon and D. Shurtleff. Means at each examination and inter-examination variation of specified characteristics: Framingham Study, Exam 1 to Exam 10. The Framingham Study, Section 29. DHEW Publ No. (NIH)74-478. Washington, D.C.: U.S. Government Printing Office, 1974.

years old in 1960 (the 1900 cohort) or who will be 60 when tested in the year 2,000 (the 1940 birth cohort). Cross-sectional data on persons of varying ages at one time point may show age differences, but these are confounded with (i.e. difficult or impossible to separate from) cohort differences.

Longitudinal studies follow the same individuals through time, thereby avoiding the confounding of cohort and age. Such studies are valuable because they permit the direct measurement of the changes with age in the incidence of specific conditions or attributes. Such prospective studies are relatively few, because they require a long time to complete and are expensive. Also, in studying relatively rare conditions or occurrences, the chance of observing any new cases is virtually zero unless the initial group is very large. In general, the results of even large studies become difficult to interpret as a significant number of subjects can no longer be studied. For example, when most of the subjects have died or have otherwise left the study, the reliability of incidence rates becomes poor because the sample size is small. Even if a sufficient number of individuals is followed successfully over the years, longitudinal observations may be subject to a time of measurement effect[15]. Culture, technology, and environment change with time, as does the precision of tools of measurement. Thus, time effects can confound attempts to identify "pure" aging effects in longitudinal studies. Despite these potential difficulties, data on survivors in longitudinal studies may be especially relevant, because older pilots are themselves "survivors" of a larger group.

To keep a clear distinction between interpretation of longitudinal and cross-sectional studies, the committee has generally referred to "change" with respect to longitudinal data and to "difference" with respect to cross-sectional data.

Are the Tests Valid and Reliable Measures of the Characteristic of Concern?

The validity issue arises in two ways. First, does a given assessment instrument (for instance a laboratory test or an intelligence test) gives a "true" reading of the characteristic of concern? This might be termed descriptive validity. The second issue is that of predictive validity: does the characteristic really bear on a pilot's ability to meet the demands of the job?

Descriptive Validity

An ideal screening test would identify the presence or absence of a particular disorder or characteristic with absolute accuracy. However, this ideal descriptive validity is seldom achieved. Most tests produce some false positives (persons who are free of the disorder but who are designated "positive") and/or some false negatives (persons who have the disorder but who are designated "negative").

Epidemiologists have developed a terminology for measures of the accuracy of medical or behavioral screening tests. These measures of validity are known as "sensitivity," "specificity," and "predictive value." Sensitivity refers to the proportion of persons with a given condition or attribute who are found positive by a test. Specificity refers to the proportion without the condition who are correctly identified as negative. Predictive value, which combines both sensitivity and specificity, refers to the proportion of all persons tested correctly identified as either positive or negative for the condition or trait under consideration.

In behavioral research a major concern is "construct" validity. As stated by Cronbach and Meehl, "construct validation is involved whenever a test is to be interpreted as a measure of some attribute or quality which is not 'operationally defined'."[16] The aim of validation is to identify the constructs accounting for variation in test performance, constructs being abstractions such as "intelligence."

Predictive Validity

Predictive validity is critical to the consideration of altering the age-60 rule. Eliminating or raising the age standard can be considered seriously if there are measures that are valid predictors of performance. If there are high sensitivity laboratory or clinical measures of quantitative skills, for example, these measures are relevant only if quantitative skills predict successful functioning in meeting real demands in the cockpit of an airplane.

For measures that have predictive validity, the question of predictive term arises--what is the period of time for which the prediction holds? This is important in determining the appropriate periodicity of screenings and assessments.

Reliability and Variability

In addition to being valid, assessment methods must be reliable. This means that with repetition the test or measure must not exceed a reasonable range of variation in results. Repetition means that the test is given to the same person more than once or is given to more than one person; the repeat test may be administered by the original tester or by another person. In any case, a test is of little value if repeated administrations yield widely varying results.

Group and individual variability in level of performance generally increase with age[17-20]. With samples of older people, group averages may be poor predictors of attributes of individual members of that group, and differences among age groups may not reflect developmental (longitudinal) curves for individuals. Factors such as lifestyle, life experience, and health status account for the increased variability with age.

Guiding Questions

The question before this committee is whether scientific research to date provides any evidence as to whether airline pilots can safely continue to fly after the age of 60. A whole set of questions must be considered simultaneously in reviewing the research literature:

1. Is the behavior or function related to pilot performance?

2 Does the behavior or function change with age in ways that would impair pilot performance?

3. If so, at what age is the change seen?

4. Is there anything about age 60 that makes it a particular time point of concern?

5. At what level does the change have an impact on pilot performance?

6. Do current procedures adequately screen for decrements in this behavior or function?

7. Can current procedures be extended or modified adequately to monitor such changes?

The information gleaned from a review of the research literature, with careful attention to the methodologic concerns enumerated earlier, is presented in Part II and Part III of this report--in the context of specific medical, behavioral, and performance factors.

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PART II: MEDICAL ISSUES

This part of the report provides information to answer two questions basic to this study: What are the physical and mental disorders and diseases that might affect pilot performance at any age and which of these is likely to appear in pilots age 60 and over? What changes in the FAA medical examination are needed to maximize the chance of identifying these conditions before they affect pilot performance enough to compromise safety?

No attempt has been made to list every conceivable condition. There are very rare diseases (less than 1 in 100,000 population) that might adversely affect pilot performance. They may not be listed or discussed here, but the changes recommended in the FAA medical examination, especially those related to follow-up testing, offer a high probability of detecting them early. Many, if not most, of these conditions are not related to age 60.

Neither has the committee specified the numerical values required to distinguish normal from abnormal in those biochemical or quantitative measures that have been recommended. Those decisions and other details concerning the definitions of acceptable and unacceptable findings on the medical examination should be the responsibility of an expert medical panel constituted for that specific purpose.

The proposals for more detailed examinations usually are coupled with the suggestion that the exams be less frequent than every six months. The frequencies should be matched to age and risk profiles for each relevant disorder and expected rates of change of risk. Specific recommendations as to frequency would need to be developed by an expert panel.

If changes in the FAA medical examination are instituted, and more technically advanced tests are incorporated, it may become necessary to reevaluate the training and specialty requirements for recognition as a Senior Aviation Medical Examiner in order to assure quality control in the administration of the medical tests. At present a senior AME is not required to have any specialty training. The possible role of medical centers in providing portions of the examination also should be considered.

The committee believes that many of the changes suggested in the medical exam not only can increase the likelihood of detecting disorders that might affect pilot performance, but also can be linked to programs to bring about changes in health status necessary to keep experienced pilots flying rather than inevitably disqualifying them.

CHAPTER 6

EVALUATION OF CARDIOVASCULAR HEALTH STATUS

There is a gradual decrease in cardiac function with age, but in the absence of cardiovascular disease the decrement is sufficiently small that no significant effect on pilot performance would be likely. However, cardiovascular disease is the most common cause of loss of license by U.S. airline pilots between the ages 30 and 59[1] and must be given serious consideration. This chapter will discuss the relation of major cardiovascular disorders to pilot performance, risk factors for the disorders, the relation to age, the present FAA medical examination for cardiovascular problems, and possible alternative strategies for testing that take advantage of scientific and technical advances made in the last two decades.

Relation to Pilot Performance

Cardiovascular problems influencing pilot performance in multi-crew airlines were reviewed in 1975 at the Eighth Bethesda Conference of the American College of Cardiology[2]. This conference made recommendations regarding identification and evaluation of pilots with ischemic heart disease, cerebral vascular disease, hypertension, valvular heart disease, congenital heart disease, myocardial-pericardial disease, and arrhythmias. Of primary interest to this study are those features of the enumerated cardiovascular disease process that put the pilot at risk for sudden incapacitation during flight. Attention also is given to cardiac processes that may lead to more subtle decrements in performance.

Sudden Incapacitation

Sudden loss of consciousness without prior symptoms is a serious, but rare, event among pilots. If cardiac in origin, it usually results from ventricular fibrillation, which produces loss of circulatory function and total incapacitation within a few seconds.

The consequences, in terms of flight safety, of sudden incapacitation of a pilot because of myocardial infarction, cardiomyopathy, valvular heart disease, or serious atrial or ventricular arrhythmia will depend upon the time in the flight sequence at which the event occurs , the availability of other crew members to assume control, and the speed with which they can take over piloting functions.

Ventricular fibrillation occurs with higher frequency in persons with coronary artery disease, cardiomyopathies (especially those with hypertrophic myopathic disorders), and valvular disease[3]. Prior cardiac symptoms are absent in 20 to 30 percent of these individuals[4,5]. In others, the symptoms of angina pectoris and cardiac arrhythmias are disregarded. However, postmortem examination generally reveals the presence of severe disease. Such disease might have been detected with appropriate testing[6-8].

In individuals with coronary disease, the likelihood of sudden cardiac arrest due to ventricular fibrillation is probably greater under conditions of stress. Stress increases the myocardial oxygen demands, producing ischemia of the heart, and activates the autonomic nervous system . Take-off and landing, and in-flight emergencies, could put a person with latent coronary heart disease at greater risk. In 1971, five of 40 incidents in Canada related to cardiac events occurred near the take-off and landing period[9]. The heightened physical and mental demands provide the milieu for serious and potentially fatal circulatory collapse at a time when take-over of command pilot function by another crew member might be most difficult and perhaps not occur rapidly enough to prevent a crash.

The relationship between cardiac dysfunction and fatal accidents is a subject of serious debate. With the single-pilot crew, such cardiovascular incapacitations are a well-known but infrequent cause of fatal crashes[10]. In multi-crew airliners, available data suggest that only a small minority of fatal crashes can be traced conclusively to cardiac dysfunction in the pilot. The International Civil Aviation Organization reported five airline accidents worldwide between 1961 and 1968 in which sudden incapacitation of pilots resulted in accidents--causing 148 deaths among passengers and crews[11]. In contrast, there were only 11 in-flight cardiac events reported for pilots of scheduled U.S. air-carrier planes between 1961 and 1970, with eight captain deaths but no known fatal aircraft accidents[12].

Nonetheless, major cardiac arrhythmias in pilots could lead to fatal airline crashes. Modern medical technology provides means to detect those at higher risks for such events whether or not they have symptoms. Screening for important cardiac findings associated with valvular heart disease and cardiomyopathies is fairly simple and can be accomplished by proper entry and follow-up screening examinations. Screening designed to detect ischemic heart disease is more complex. Careful analysis of risk-factor profiles and non-invasive treadmill testing are useful in identifying individual pilots who should have more extensive evaluation, which may include coronary angiography.

Subtle Incapacitation

Airlines have given implicit recognition to the potential importance of subtle incapacitation or decrements in function. Training programs include procedures to recognize and respond to such incapacitation--for example, by requiring that pilots repeat information provided to them by co-pilots. The role of cardiovascular disease--such as milder arrhythmias or anginal pain--in subtle incapacitation that occurs in-flight is not well established. Subclinical cardiovascular disease has been found to be associated with decrements in performance on laboratory tests of reaction time and speed of information processing [13].

Risk Factors

There have been many epidemiologic studies bearing on the prediction of risk associated with cardiovascular disease in asymptomatic persons[14-19]. Because the data are derived from general populations, they must be applied with caution in predicting risk among a selected group such as the pilot population. Data from the Framingham Study and from the Air Line Pilots Association (ALPA) indicate that, below the age of 50, pilots as a group have a substantially lower risk for cardiac events than the general population. This is probably because of the entry level exclusion from the pilot population of persons with congenital cardiac defects, significant murmurs, hypertension, and electrocardiographic abnormalities. Age-related increases in heart disease among pilots parallel increases for the general population. However, airline pilots remain at somewhat lower risk from age 30 through age 60. Published data are not available for airline pilots beyond that age. Data from general populations could be used as the basis for estimates of group risk, at least until adequate data could be generated directly from populations of older pilots.

Using the risk profile data generated by epidemiologic studies, it is possible to separate persons into deciles of risk for coronary artery disease, near future myocardial infarction, and sudden coronary death. For example, the lowest decile has a 30-fold lower risk of dying than the highest decile [15]. The best-established risk factors at present are age, sex, blood pressure, serum cholesterol, cigarette smoking (most reliably indexed by serum thiocyanate levels), certain electrocardiographic changes, and glucose intolerance[15]. In the near future, other factors, such as the coronary-prone behavior pattern, may be included if sufficient data have been accumulated to establish that they contribute independent predictive power[20].

A major value of the risk factor profile is that it can benefit the pilot prior to the development of disqualifying disease. Risk can be estimated and serve to identify subgroups requiring further testing. This also provides an opportunity to the pilot and the physician to institute a program of interventions that might reduce the risk of a cardiac event. Cessation of cigarette smoking[21] and the treatment of hypertension[22-24] are examples of interventions that have been shown to be of value. The effectiveness of other risk factor inverventions remains less clear[25].

There is no agreement on what constitutes an unacceptably high level of coronary heart disease risk in pilots, but implicit estimates can be adduced from current regulations. The FAA excludes from pilot licensure persons with a history of previous myocardial infarction. Such persons have an annual mortality of four percent[26]. The Civil Aviation Medical Division of Canada estimates that there is a three percent annual mortality for persons who have already experienced a cardiovascular event, and argues that this rate should be the upper limit of acceptable risk for piloting[9]. An even lower risk level would probably be advisable for pilots transporting passengers without a co-pilot.

If the risk factor profile were to be adopted as a guideline for determining medical acceptability for Class I flight status, it would be necessary to decide what risk would be acceptable and to reject those pilots at any age who do not meet that risk within a specified period. In addition it would be necessary to define those risks or combinations of risks that would make further testing mandatory.

Relation to Age

The committee has considered carefully the reports by Kannel[15], Keys[17], Kleinbaum[18], and Epstein[19]. The data support the conclusion that age is a clear risk factor for coronary disease, but these major epidemiologic studies do not demonstrate a sudden increase in coronary risk at any specified age. Kannel, for example, reported on follow-up of 5209 men and women in the Framingham study. Over the age range of 35 to 70 years, the risk of developing cardiovascular disease increases approximately 13-fold. This results from a fairly constant increase in risk without any particularly abrupt change. Similarly, Keys's study of 11,132 men age 40-59 years (followed for five years) documented age as a coronary risk factor, but with no sudden increase in age-related risk over the 19-year age range included in the study.

FAA Medical Examination

At the present time, the FAA excludes any pilot with overt coronary disease from Class I and II certification. The medical standards as set forth in Part 67 of Title 14 of the Code of Federal Regulations require a medical history and a physical examination every six months and a resting electrocardiogram (ECG) annually after age 40 for Class I medical certification. It only requires a medical history and a physical examination for Class II and Class III certification. The guidelines for cardiovascular examination for Class I, II, and III medical certification as set forth in the Guide for Aviation Medical Examiners[27] are detailed and comprehensive but do not include the improvements in knowledge and technology for evaluation of cardiovascular status, developed in the past decade. Personal communications to this committee also indicate that the thoroughness with which the FAA-mandated testing actually is performed is subject to wide variation across the more than three thousand authorized Senior Aviation Medical Examiners. This committee finds that the evaluation process for pilots needs updating to include the most recent clinical and epidemiologic knowledge about cardiovascular disease.

Preferred Screening/Examination

During the past two decades, there has been considerable progress in cardiovascular epidemiology, physiology, and medical technology, making possible a more comprehensive assessment of cardiovascular function. Strategies for non-invasive detection of coronary disease have been developed. These strategies take into account the influence of disease prevalence on interpretation of test results, probability estimates of disease, and the value of this approach in assessing risk for an individual patient[28,29].

Epidemiologic research reveals a remarkable stability of clinical, ECG, and laboratory risk factor measures over time, especially for those under age 50[30]. Risk factor profiles also are quite stable over time in the absence of direct intervention by the physician or at-risk person[30]. These data suggest that the cardiovascular examination can be performed at intervals greater than six months without diminishing predictive value.

The committee believes that, in view of epidemiological data, the current policy of medical re-examination every six months for pilots of all ages is unnecessary from a cardiovascular standpoint except for those subsets of persons determined to be at high risk based upon their profiles. One consequence of conducting examinations that are deemed to be unnecessary, is the possibility that they will be done hastily and superficially. Less frequent and more standardized, detailed examinations performed by a specially trained group of physicians are suggested.

Furthermore, while the currently mandated FAA procedures were once considered an adequate cardiovascular examination, we know from medical progress made over the last 20 years that they are not the best predictors of cardiac status. For example, the resting ECG, when used alone, is now recognized as a relatively insensitive method of screening for cardiovascular disease[29]. Better testing procedures are now available to detect latent disease and should be employed. In addition, accumulated knowledge of the natural history of cardiac disease points to the usefulness of risk factor assessment in limiting more frequent and in-depth screening and study procedures to those subgroups at highest risk of disease[15,31-33].

Table 11 outlines one possible stratification by age that could be used to determine choice and frequency of cardiovascular evaluation procedures. The present entry exam would be modified to include a 5-minute ECG rhythm strip to detect arrhythmias, a risk-factor profile to detect hypertension, hypercholesterolemia, abnormalities in selected lipoproteins, elevated blood sugar, and a history of smoking. The use of echocardiography as part of entry exams provides a useful screen for valvular, congenital, and cardiomyopathic disorders. A more comprehensive evaluation would begin at age 50. Prior to age 50, the yield from extensive cardiovascular testing will be low and false-positive results numerous. At about age 50, the gradually increasing cardiac disease prevalence reaches a point where the ratio of true positives to false positives is more favorable for screening purposes.

Screening tests for latent cardiac disease have been developed and improved (see Appendix A). Their sensitivity and specificity are generally known and the tests are very reproducible. The required standard evaluation should be modified if a person's risk-factor profile and/or routine test results--at any age--suggest the need for additional tests. Appendix B presents possible guidelines for decisions about more extensive testing.

Follow-up of persons with defined risk-factor profiles would involve an exercise stress test. The criteria for a positive stress test should include: the occurrence and magnitude of ST displacement, the occurrence of frequent and complex ventricular arrhythmias, the failure to elevate the blood pressure effectively, and the failure to increase the heart rate appropriately. Repeat testing will also improve the specificity of stress testing. Radionuclide or thallium perfusion imaging and angiography can be used to follow up stress testing to help differentiate true and false positives.

If an arrhythmia is detected clinically or by ECG screening or stress testing, further evaluation is indicated. Ambulatory ECG monitoring for 24 hours is the test of choice with a quantitative analysis of the tapes. Spontaneous occurrence of ventricular premature depolarizations (VPDs) is seen in normal, healthy individuals, but those occurring with high frequency (greater than 60 per hour) and in complex forms (ventricular tachycardia, R on T, multiformed) generally indicate a higher risk for ventricular fibrillation[34,35].

Coronary angiography is both the most invasive and most definitive test to exclude significant coronary artery disease or quantify its severity. It is therefore indicated in high-risk subjects after repeated positive stress tests, ventricular arrhythmias, or positive thallium scans. It is important to state, however, that although following these procedures will pick up the vast majority of those at high risk, no test or series of tests will detect all such persons. Furthermore, there is no certainty that any individual, once cardiovascular disease is detected, will experience a sudden cardiac event.

Table 11. Suggested Schedule for Cardiovascular Disease Screening*

On Entry:

(1) Complete history and cardiovascular examination

(2) Resting ECG with five-minute rhythm strip

(3) Risk-factor profile - blood pressure, cholesterol, smoking history, blood sugar, lipoprotein class, triglycerides

(4) Echocardiography

Until Age 50:

(1) Interval history and cardiovascular exam every two years

(2) Risk-factor profile, as above, every two years

At Age 50:

(1) An exercise stress ECG to be used as a baseline for comparisons if subsequent exercise stess tests are necessary

After Age 50:

(1) Interval history and cardiovascular exam every year

(2) Risk-factor profile, as above, every year

(3) Resting ECG with rhythm strip every two years

After Age 60:

(1) Interval history and cardiovascular exam every year

(2) Risk-factor profile, as above, every year

(3) Stress ECG at age 60 and every two years as long as Class I flight status renewal is sought

*Abnormalities or high-risk profiles should be followed up in the manner outlined in Appendix B and in the text.

Table 12. Summary of Chapter 6, Cardiovascular Health Status

Disorder	Age-Related Increase in Frequency	FAA Tests Now Required	Possible Additional Tests	Possible Complications or Increased Risk for Other Disorders
Cardiac Events: myocardial infarction cardiomyopathy valvular heart disease atrial or ventricular arrhythmias angina	Yes	Medical history and annual resting ECG for those age 40 and over; overt cardiac disease is disqualifying.	Risk-factor profile and echocardiography on entry; interval exams using risk-factor profile to determine frequency and extent of further testing (e.g., exercise ECG), every two years to age 50 and annually thereafter (see Table 11).	Sudden incapacitation or death.
Subclinical Cardiovascular Disease	Yes	As above.	As above.	Decrements in reaction time and speed of processing of perceptual information.

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CHAPTER 7

EVALUATION OF ENDOCRINE, RENAL, PULMONARY, HEMATOLOGIC, AND GASTROINTESTINAL HEALTH STATUS

Disorders of major organ systems have clinical manifestations that could logically be expected to affect pilot performance. The identification of these disorders by routine examinations should be followed by more complete evaluations. The high likelihood of appropriate therapy correcting many abnormalities and returning the pilot to normal function should make detection of disorders beneficial for pilot health and performance. Identification of endocrine, renal, pulmonary, hematologic, or gastrointestinal disorders would not necessarily be a means of discontinuing certification, except in selected instances.

Endocrine System

The pancreas, thyroid, gonads, adrenals, parathyroids, and pituitary are considered.

Pancreas

Relation to Pilot Performance

Diabetes mellitus in middle-age and older people is commonly asymptomatic. Obesity is present in 80 percent of such persons. The diabetes usually can be controlled by diet alone and in such persons the risk of hypoglycemia (low blood sugar), which could affect pilot performance, is so small as to not warrant any special screening. Uncontrolled hyperglycemia (high blood sugar) progressing to dehydration and/or metabolic acidosis would affect pilot performance, but would manifest itself by obvious symptoms and signs of serious illness[1].

There is increasing evidence that good control will delay or minimize the development of such complications as retinopathy, nephropathy, and neuropathy[2]. The presence of diabetes was shown to be an additional risk factor in the development of cardiovascular disease in the Framingham study and elsewhere[3,4]. Controlling the diabetes through diet and exercise (and usually simultaneously controlling the associated obesity) may help minimize cardiovascular risk, but this has not yet been proved by clinical field trials.

The risk of a hypoglycemic reaction as a result of insulin or oral hypoglycemic drug use is unacceptable; persons requiring either type of drug regimen for control of diabetes are automatically disqualified as airline pilots[5].

Relation to Age

Carbohydrate metabolism changes with age, with, on the average, a gradually declining ability to dispose of a standard glucose load[6-8]. The decline in glucose tolerance with age is due, in part, to the increasing percentage of body composition that is fat tissue (even in the absence of gross obesity) and the declining amount of muscular tissue. It probably also is related to a diminished response of body cells to the effect of insulin[9]. Glucose tolerance decline is highly associated with obesity, and in most affected persons may be controlled by weight reduction through diet and exercise[9].

These normal changes in glucose tolerance with aging must be differentiated from diabetes mellitus. Diabetes mellitus is a disorder in which there is an absolute or relative insufficiency of insulin. From middle age to the older years, the most common form of diabetes mellitus is that which does not require insulin and is controllable by diet and exercise. The annual incidence of new cases of diabetes in the United States is 3 to 7 per 1000, but the incidence begins to rise in the fourth decade and continues at least into the seventh decade, with an annual rate of 1 to 2 new cases per 100 persons in the later decades[9]. It has been estimated that one in every six persons reaching the age of 65 and one in every four persons reaching the age of 85 will have diabetes[10]. The prevalence of diabetes is greater among women compared with men at all ages above 17. Standards have been developed to differentiate diabetes from normal glucose tolerance changes with age[8].

FAA Medical Examination

If diabetes is suggested by the pilot's medical history or physical examination, or by sugar in the urine, a diagnostic work-up with glucose tolerance test is called for in the Guide to Aviation Medical Examiners[5]. The values to be used as diagnostic for diabetes are not given. FAA form 8500-8 requires only that the determination of urine sugar be reported.

Preferred Screening/Examination

For detection of diabetes, a plasma or serum glucose determination two hours after a standard glucose load of 75 or 100g. is the most sensitive screening test. A value of 200 mg/dl or higher would indicate diabetes and call for further evaluation. Many persons with diabetes may have a negative urine test for sugar on a random urine test[9].

A careful ophthalmoscopic examination of the lens (for cataracts) and the retina (for retinopathy), as well as the tests of vision already required by the FAA, will establish the presence of diabetic complications of the eyes. This also will be a good indicator of renal complications, inasmuch as retinal and renal microvascular complications are highly correlated. Tonometer screening for glaucoma, a complete urinalysis, and serum creatinine determination also should be performed after a diagnosis of diabetes mellitus is made. Diabetic neuropathy would be detected by a careful neurologic examination including testing of the sensory modalities of light touch, pinprick, deep pain, position and vibration sensation in the feet and hands, deep tendon reflexes, cranial nerve function, and muscular strength.

Follow-up Evaluation

In pilots diagnosed as diabetic and controllable on diet and exercise, periodic follow-up tests of plasma/serum glucose (fasting values and two hours after usual meals) should be obtained. There also should be regular periodic re-examination of the ocular, cardiovascular, neurologic, and renal status.

Thyroid

Relation to Pilot Performance

Both hyper- and hypothyroidism may interfere with neuromuscular reflexes and response time[11] and thus may affect performance. Furthermore, hypothyroidism may significantly impair judgment and thinking processes[12].

Relation to Age

Decreased activity of the thyroid gland (hypothyroidism) increases with age. This increase is predominantly in women[14]. Hyperthyroidism is less prevalent in older persons, but its manifestations may be more subtle (so-called apathetic hyperthyroidism).

FAA Medical Examination

The present FAA regulations require an examination of the head, face, neck, and scalp as well as recording pulses in order to determine thyroid disease (FAA form 8500-8).

The Guide for Aviation Medical Examiners recommends specific tests to confirm the diagnosis and degree of severity of thyroid disease if the examiner suspects this disease on the basis of the physical examination.

Hyperthyroidism, if symptomatic or under treatment, and hypothyroidism, if symptomatic, presently require denial or deferral of medical certification[5].

Preferred Screening/Examination

Measurement of serum thyroxine (T4) is the best single test for screening for occult thyroid disease[14]. This test should be performed periodically on pilots over age 60 because of the increased prevalence of hypothyroidism with age.

Follow-up Evaluation

Medical documentation of euthyroid condition should be required at each periodic medical certification examination once a diagnosis of thyroid disease has been made.

Ovaries and Testes

Relation to Pilot Performance

About 65-75 percent of postmenopausal women age 45-55 experience vasomotor flushes at some time, with the symptoms adversely affecting performance for about 10 percent of the symptomatic women[15]. Hormone replacement has been shown to decrease these symptoms markedly. There is currently a debate concerning the advisability of hormone replacement to ameliorate these and other effects associated with menopause, such as an increase in the incidence of cardiovascular disease, osteoporosis, and reactive depression, because of the potential risk of uterine cancer in women taking estrogens for long periods.

There is little evidence to date of an analogue to menopause in aging males.

Relation to Age

Most women cease producing estrogen and progestins by age 45 to 50, depending upon genetic predisposition.

FAA Medical Evaluation

There are presently no FAA regulations pertaining to menopause and this condition is not mentioned in the Guide for Aviation Medical Examiners[5].

Preferred Screening/Examination

Because of the likelihood of increased numbers of women pilots, the Aviation Medical Examiner should include in the history for female pilots over age 45 questions concerning the history of vasomotor flushes, and appropriate treatment should be recommended. There should be some medical documentation that the vasomotor flushes are under control, if they were affecting performance.

Adrenals

Relation to Pilot Performance

Primary or secondary adrenal disorders of importance to pilot performance include Cushing's syndrome, Addison's disease, and pheochromocytoma. Cushing's syndrome may alter behavior and judgment as well as produce glucose intolerance, hypertension, and susceptibility to infection[11]. Addison's disease has the potential to produce hypotension, impaired response to stress and infection, and significant biochemical abnormalities[11]. Pheochromocytoma may produce episodic or sustained hypertension and may produce episodic tachycardia and sweating[11]. Although these conditions represent a major risk to pilot health and performance, their prevalence is low.

Relation to Age

There does not appear to be a clinically important change in adrenal function with age[16].

FAA Medical Examination

The Guide for Aviation Medical Examiners[5] indicates that pilots with Cushing's syndrome and Addison's disease are disqualified, but does not mention pheochromocytoma. The FAA form 8500-8 does not mention any of these disorders.

Preferred Screening/Examination

A well-done history and physical examination should be adequate.

Follow-up Evaluation

All three of the adrenal dysfunctions described can be treated successfully[12,17,18]. Regular monitoring and documentation that normal adrenal function has been maintained should be required.

Parathyroids

Relation to Pilot Performance

Hypoparathyroidism may produce symptoms as serious as tetany, seizures, or laryngospasm[11]. It is associated with an increased incidence of cataracts[11]. Hyperparathyroidism may produce symptoms as mild as polyuria and polydipsia or as severe as confusion and coma[11]. Hyperparathyroidism also is associated with hypertension and with renal stones and colic[11].

Relation to Age

There appears to be an increase in the level of serum immunoreactive parathyroid hormone with age[19] and an increased incidence of parathyroid adenoma in women over 70 years old[20]. Hypo- and hyperparathyroidism are uncommon, however.

FAA Medical Examination

Neither the Guide for Aviation Medical Examiners[5] nor the FAA form 8500-8 comments on parathyroid disease.

Preferred Screening/Examination

More than half the cases of hyperparathyroidism in an elderly population were discovered in asymptomatic persons by biochemical screening for serum calcium concentration[20]. A serum calcium level might be justifiable as a screening chemistry, although less frequently than every six months.

Follow-up Evaluation

Documentation of an eucalcemic state is indicated in persons with treated hypo- or hyperparathyroidism.

Pituitary

Pituitary disease, which may present as a mass lesion or as evidence of either hormonal deficiency or hormonal excess, is uncommon, representing about 10 percent of intracranial tumors and a small percentage of endocrine disorders. Hormonal excess or deficiency would, with the exception of abnormal production of growth hormone, present as abnormal function of other endocrine organs (e.g. the adrenal--hypoadrenalism or Cushing's syndrome) or of other non-endocrine organs (e.g, kidney—diabetes insipidus). Because of the low incidence of pituitary disease and the absence of strong evidence of clinically important changes with age, evaluation of pituitary function *per se* is not justifiable as part of a routine evaluation of pilots. The *Guide for Aviation Medical Examiners*[5] and the FAA form 8500-8 do not deal with pituitary disease, and the committee believes that is appropriate.

Renal System

Relation to Pilot Performance

Any disease with renal failure (uremia) as a potential complication would be a major risk to pilot health and performance. Renal stones and colic may produce acute incapacity in pilots. Chronic renal failure is frequently associated with an increased incidence of hypertension and cardiovascular disease as well as with neurologic dysfunction and anemia[11].

Relation to Age

There ia a mild to moderate loss of renal function with age, but in the absence of renal disease the margin of reserve is adequate for normal function. With age, particularly beyond age 60, the incidence of prostatic hypertrophy increases so that eventually the majority of men are affected. This can lead to obstructive uropathy and in some instances may require surgery[21].

FAA Medical Examination

The *Guide for Aviation Medical Examiners*[5] disqualifies pilots with nephritis, nephrosis, renal infection, and renal failure. It recommends determination of urine protein and glucose. FAA form 8500-8 requires reporting of urinary protein and glucose.

Preferred Screening/Examination

A complete urinalysis with measurement of specific gravity, protein, glucose, occult blood, and an examination of the urine sediment would be a far better screening examination than that presently required by FAA. The presence of proteinuria, glycosuria, or hematuria, or the loss of concentrating ability would be an indication for follow-up evaluation. Rectal examination to evaluate the prostate should be routine in men over 50.

Follow-up Evaluation

Follow-up documentation of adequate treatment would depend on the results of detailed evaluation and diagnosis.

Pulmonary System

Relation to Pilot Performance

Any form of severe pulmonary disease would be a significant risk to pilot performance. With advancing pulmonary insufficiency, hypoxemia might impair neurologic function and threaten cardiac function. The retention of carbon dioxide that may accompany pulmonary insufficiency can further impair cerebral function. Methods for detecting or recognizing significant degrees of pulmonary insufficiency are discussed below.

Relation to Age

There is, on average, a gradual decline in pulmonary function with age[11,22] and an accompanying gradual decline in the partial pressure of oxygen in the arterial blood, from 90-95 mm Hg in younger adults to levels of 70-75 mm Hg in persons in the age group of 65 and older[23]. These changes are not sufficient to cause any measurable decline in overall function, for a pressure of 70-75 mm Hg will maintain oxygen saturation of hemoglobin at 90 percent or better[11]. However, in the face of this decreased pulmonary reserve, additional stresses such as any pulmonary disease or damage produced by smoking become critical.

FAA Medical Examination

The Guide for Aviation Medical Examiners[5] and FAA form 8500-8 provide no specific guidelines for examination of lungs or pulmonary function status. A number of pulmonary conditions are listed that, if present, would disqualify a pilot.

Preferred Screening/Examination

In addition to taking a history about pulmonary disorders and smoking, and conducting a regular physical examination of the chest and airways, it is recommended that a timed vital capacity measurement (1 second and 3 second) be made a routine part of the aviation medical examination. This test would provide simple, adequate information about one form of pulmonary insufficiency that would be likely to affect pilot performance and also would be valuable to help guide the pilot's preventive health practices. It requires minimal time and equipment, and would have to be reported only every two to three years, with an increasing frequency with age. A level of impairment, indicated by this test, that would call for referral for expert pulmonary consultation should be established.

Follow-up Evaluation

If pulmonary functional impairment requiring remedial action or treatment is found, more frequent follow-up tests of pulmonary function would be indicated.

Hematologic System

Relation to Pilot Performance

Anemia from any cause would be likely to interfere with pilot performance, as would be true of other major disorders of the hematologic system such as polycythemia, leukemia, or coagulation defects. Heritable disorders of hemoglobin are not in themselves risk factors if they do not produce anemia; i.e., sickle cell trait without anemia would not impair pilot performance[24].

Relation to Age

There is a slight decline in average hemoglobin concentration with age that has little functional effect[25]. The incidence of pernicious anemia increases in middle to late years, especially in whites of Northern European ancestry[26].

FAA Medical Examination

The <u>Guide for Aviation Medical Examiners</u> lists as disqualifying an anemia with hemoglobin lower than 12 mg/100 cc blood, but FAA form 8500-8 does not provide for reporting a hemoglobin value; the <u>Guide</u> also lists other major hematologic diseases as disqualifying[5].

Preferred Screening/Examination

A determination of hematocrit or hemoglobin should be a part of the regular aviation medical examination and should be reported on the form. A frequency of two to three years should be adequate for younger persons, but an increased frequency is suggested for older persons.

Follow-up Evaluation

If significant anemia is found, regular reports of the results of measures to correct the anemia should be required.

Gastrointestinal System

Relation to Pilot Performance

Gastrointestinal disorders that would be likely to impair pilot performance include acute gastroenteritis of any cause and acute gastrointestinal hemorrhage, such as from gastritis or peptic ulcer.

Relation to Age

Though diverticular disease, gastrointestinal malignancy, and hiatal hernia are more common with advancing age, there is no good evidence that gastroenteritis or likelihood of bleeding from gastritis or peptic ulcer is related to age; peptic ulcer disease is more common in men than women[27].

FAA Medical Examination

The Guide for Aviation Medical Examiners[5] requires evidence for adequate treatment of peptic ulcer or gastrointestinal bleeding; FAA form 8500-8 does not provide for reporting of hemoglobin or hematocrit or stool for occult blood.

Preferred Screening/Evaluation

There is no current means to anticipate or screen for acute gastroenteritis or a previously unsuspected disorder that might cause acute gastrointestinal hemorrhage. Regular testing for and reporting of hematocrit or hemoglobin, as called for in the hematologic section, and test of stool for occult blood, are desirable. Follow-up of recognized gastrointestinal disease, as called for in the Guide for Aviation Medical Examiners[5], including regular reporting of hematocrit/hemoglobin and stool for occult blood, is justifiable.

Miscellaneous Disorders

Obesity

Relation to Pilot Performance

Excess weight may physically interfere with the pilot's ability to reach and handle the airplane's controls. Obesity may be a complicating factor in other conditions such as diabetes[28], hypertension[11], and cardiovascular disease[11].

Relation to Age

Obesity increases slightly with age in both males and females[16].

FAA Medical Examination

The present FAA regulations do not stipulate standards or limitations for body weight. Weight, to the nearest pound, is recorded by the pilot on FAA form 8500-8.

The Guide for Aviation Medical Examiners states that height and weight recorded by the applicant will be checked by the examiner in the course of the examination[5]. It further states in relation to body build that any congenital or acquired defect that would adversely affect flying safety or endanger the individual's well-being if permitted to fly would be disqualifying for medical certification.

Preferred Screening/Examination

Since obesity alone is important medically only in relation to other diseases that already are being screened for, no additional tests are recommended.

Follow-up Evaluation

There is no requirement for any follow-up except to recommend strongly weight reduction to obese pilots.

Gout

Relation to Pilot Performance

Gout is a disorder of purine metabolism, characterized by recurrent episodes of arthritis. Primary gout is an inborn metabolic error; secondary gout occurs in certain diseases such as those involving the kidneys. An acute attack of gout may be incapacitating for a pilot. Chronic gout may be associated with renal injury and colic secondary to formation of kidney stones[11].

Relation to Age

Primary gout is largely a disease of males, usually beginning in early middle age. It is rare in females before menopause[29].

FAA Medical Examination

Neither the Guide for Aviation Medical Examiners[5] nor the FAA form 8500-8 mentions gout.

Preferred Screening/Examination

A measurement of serum uric acid concentration, at intervals of two years or more, would be justifiable only if a general biochemical profile is deemed appropriate to the screening process.

Follow-up Evaluation

If gout is diagnosed, documentation of attack-free status and control of hyperuricemia is indicated.

Table 13. Summary of Chapter 7, Endocrine, Renal, Pulmonary, Hematologic, and Gastrointestinal Health Status

Organ or Problem	Age-related Increase in Frequency	FAA Tests Now Required	Possible Additional Tests	Possible Complications or Increased Risk for Other Disorders*
ADRENAL				
Addison's Disease	No	None; disorder is disqualifying.	Test for normal adrenal function.	Hypotension.
Cushing's Syndrome	No	As above.	As above.	Hypertension.
Pheochromocytoma	No	Not mentioned.	As above.	Hypertension, tachycardia.
GASTROINTESTINAL				
Acute gastroenteritis	No	Evidence of treatment for peptic ulcer or GI bleeding.	Hematocrit or hemoglobin.	
Acute GI hemorrhage	No	As above.	Occult blood in stool.	Hypotension, anemia.
GOUT	No	Not Mentioned.	Serum uric acid concentration.	Coronary artery disease; possible association with renal failure
HEMATOLOGIC				
Anemia	Yes	Disqualifying if hemoglobin is lower than 12gm/100cc.	Hematocrit or hemoglobin.	Additive to pulmonary or cardiac disorder.
MENOPAUSAL PROBLEMS (females)	45-55 yrs.	Not mentioned.	History for vasomotor flushes, other symptoms.	Cardiovascular disease, osteoporosis, reactive depression.
OBESITY	Slight	No standards or limitations.		Diabetes, hypertension, cardiovascular disease.
PANCREAS				
Diabetes mellitus	Yes	Urine sugar.	2 hour postprandial blood sugar; neurologic and ophthalmoscopic exam for complications.	Cardiovascular disease, vision impairment, reduced renal function, impaired neuromuscular function.

Continued

Table 13 Continued

Organ or Problem	Age-related Increase in Frequency	FAA Tests Now Required	Possible Additional Tests	Possible Complications or Increased Risk for Other Disorders*
PARATHYROID				
Hypoparathyroidism		Not mentioned.	Serum calcium concentration.	Cataracts.
Hyperparathyroidism	Yes	Not mentioned.	As above.	Renal calculi, hypertension, polyuria.
PITUITARY		Not mentioned.	Extremely rare. Tests not needed.	Affects other endocrine organs.
PULMONARY	Yes	No specific guidelines; named conditions are disqualifying.	Timed vital capacity measurement.	Cardiac and neurologic dysfunction.
RENAL	Yes	Urinary protein and glucose; named conditions are disqualifying.	Complete urinalysis.	Renal stones and colic, hypertension, cardiovascular disease, neurologic dysfunction, chronic anemia.
THYROID				
Hypothyroidism	Yes	Head, face, and scalp exam; deferral for symptoms.	Serum thyroxine.	Neuromuscular reflex, response time, and judgment are impaired.
Hyperthyroidism	No	As above.	As above.	Neuromuscular reflex and response time are impaired.

*These should be tested as appropriate, based on the primary diagnosis.

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CHAPTER 8

EVALUATION OF NEUROLOGIC HEALTH STATUS

This section of the report includes the central nervous system (CNS) and the peripheral nervous system (PNS). The central nervous system is composed of the brain and spinal cord. The peripheral nervous system is made up of cranial nerves, spinal nerves, and the plexi/peripheral nerves derived therefrom.

The integrity of the CNS is crucial to appreciation of environmental stimuli, consciousness, alertness, selective attention, organized purposeful motor response, judgment, memory, and other capabilities required for the successful operation of an aircraft.

Age-related changes in the CNS may result in impaired functional capacity[1-7]. The rate of change and the ultimate severity are variable. There is no specific age at which there is a predictable impairment and many 60-year-olds have little or no detectable age-related impairment. The CNS and PNS also are subject to pathological processes, not specifically related to aging, that lead to significant functional impairment. A review of some of the more commonly occurring diseases, especially those with a tendency to appear after age 45, will be presented.

Disorders induced by drugs and/or alcohol, the more commonly occurring psychiatric disorders, and age- or disease-related changes in vision and hearing will be discussed in later sections of the report.

Relation to Pilot Performance

There are numerous diseases that can impair central nervous system function and make flying unsafe. An excellent review* of more than 80 such diseases was published in 1979[8]; it is beyond the scope of this report to describe these diseases in detail. However, conditions that by their clinical nature and/or frequency in the population are considered to be relevant to the airline pilot population will be described and discussed.

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*The American Medical Association, at the request of the FAA, in collaboration with the American Academy of Neurology and the American Association of Neurological Surgeons, assembled expert panels to conduct the review.

Neurologic diseases that have special significance for the pilot during flight are characterized by the abrupt onset of significant incapacitation. Some of them are more likely to occur in older persons. They include cerebrovascular accidents (strokes), such as ischemic cerebrovascular disease because of embolism or vascular occlusion and brain hemorrhage; subarachnoid hemorrhage; epileptic seizure; vertiginous attacks; and syncope (fainting).

Other neurologic disorders causing impairment that would impinge on performance in the older pilot have a gradual onset and (frequently) a slow progression. Among those that are common enough to merit consideration are: dementia, Parkinson's disease, essential tremor, and peripheral neuropathy.

Ischemic cerebrovascular disease is usually caused by atherosclerotic changes in cerebral vessels. These changes can result in atherosclerotic plaques, which narrow the lumen of the blood vessels (stenosis). Sometimes this progresses to total occlusion of the vessel. Plaques may ulcerate and be a source of emboli to the brain. The emboli may cause occlusion of a blood vessel in the brain and produce an area of ischemia. The symptom complex is dependent on the area of the CNS rendered ischemic and the duration of the abnormal blood flow. Transient, focal neurological deficits are termed transient ischemic attacks (TIA). They last less than 24 hours. Duration of symptoms beyond that time signals a completed stroke or a reversible ischemic neurologic deficit (RIND)[9,10].

In any case, the nature of the usual deficits would seriously compromise the pilot's ability in-flight. Frequent deficits include hemiparesis, hemi-hyperthesia, visual monocular impairment, visual field homonymous hemianopsia, impaired consciousness, and aphasia. Hypertension is the most definite risk factor associated with this type of lesion. In those cases of embolus (much less common), certain cardiac arrhythmias and valvular disease are associated risk factors[11,12].

Brain hemorrhage is less frequent than ischemic cerebrovascular disease. It has multiple causes, the most common by far associated with hypertension[13]. Hypertension leads to changes in the blood vessel wall[14]; this leads in turn to weakness of the vessels and a tendency to rupture. Typically, deeper areas of the brain are most vulnerable. The patient usually experiences rapid onset of headache, reduction in level of consciousness, and a focal neurologic deficit (dependent on the site of the hemorrhage). There is a severe incapacitation.

Subarachnoid hemorrhage (SAH) is usually caused by the rupture of an aneurysm of a cerebral artery or leakage from an arterio-venous malformation (AVM)[15-17]. The clinical picture is usually one of an abrupt onset of a severe headache, sometimes with major changes in level of consciousness. Cranial nerve palsys (in aneurysms) and focal neurologic cerebral deficit (in AVMs) are not uncommon. Incapacitation is usually severe, abrupt in onset, and incompatible with safe flying. The presence of aneurysm/arterio-venous malformation may first be suspected by the occurrence of an SAH. However, in some cases recurrent headache, transient focal neurological deficits, or the physical finding of a bruit on the skull or eyes may lead to earlier diagnosis and treatment.

Epileptic seizures present a clinical picture that varies with the type of seizure[18-20]. A generalized motor seizure is rather dramatic. The sudden stiffening (tonus) followed by rhythmic muscle jerking (clonus), sometimes with an early cry and incontinence, could be most disruptive to a crew as well as totally incapacitating to the patient. A psychomotor seizure (complex partial seizure) may present with impaired consciousness, motor automatisms, partial disorganized response to environmental stimuli, and other symptoms. The occurrence of any seizure is incompatible with the vigilance and purposeful organized motor behavior of a pilot in-flight. Psychomotor seizures sometimes are subtle and could lead to a temporary incapacitation that would be difficult to detect. Diagnosis may be suspected from a detailed history and the findings of the underlying disease.

Vertiginous attacks can be caused by various diseases, but the symptom complex is rather similar regardless of cause[21,22]. The fairly rapid onset of a sense of dizziness and dysequilibrium is typical. The dizziness may be described as subjective or objective spinning. Nausea and vomiting are common. The patient prefers to remain still because head motion often exaggerates the symptoms. Coordination usually is impaired during the peak of symptomatology. Nystagmus may be seen during the attack. Between attacks there may be no signs or symptoms except those related to an underlying disease process. Even in those cases that are "benign" in causation, the capacity to operate an aircraft safely is compromised. Alternobaric vertigo[23] is related to middle-ear pressure changes and is of special relevance to pilots of any age because of the occupational exposure to atomspheric pressure changes.

Syncope is characterized by loss of consciousness secondary to hypotension[24]. All of the causes of hypotension may be expressed as syncope. The patient may experience lightheadedness and other symptoms just before fainting. History is important in the detection of the underlying cause. The latter may range from "functional" disturbances, such as vasovagal reactions, to blood loss anemia, cardiac arrhythmias, and orthostatic hypotension[25]. Diabetics with autonomic neuropathy may develop orthostatic hypotension and syncope. Syncope is usually brief, lasting only minutes, but sufficiently disruptive to incapacitate a pilot during flight.

Dementia refers to the loss of higher intellectual capacity secondary to organic disease of the brain[26,27]. It is also called organic brain syndrome. Loss of memory, abstract conceptualization, orientation, judgment, and other higher-level capabilities is characteristic. The onset is usually gradual, and early cases are difficult to recognize. The gradual and subtle changes of early dementia could adversely affect the capabilities of the airline pilot in dealing with rapid analysis of complex situations, making decisions based on short-term memory, reaching judgments based on experience, and handling complicated data.

The patient may not recognize and/or may deny the impairment associated with early dementia. Emotional response to the impairment, such as change in personality, irascibility, and inappropriate social behavior may be the presenting symptoms.

Dementia has numerous causes, some of which are correctible. Once dementia is recognized, a detailed neurological work-up is indicated. The presence of severe depression may mimic many of the signs and symptoms of dementia. The underlying cause may have its expression in additional cause-specific symptoms. The list of causes includes but is not limited to endocrine, metabolic, nutritional, toxic, neoplastic, infectious, traumatic, idiopathic, degenerative, and genetically determined degenerative diseases.

Extrapyramidal disease of the Parkinson's type[28] include such symptoms as general motor slowness (bradykinesia), tremor at rest, increased tone (rigidity), increased salivation (sialorrhea), and oiliness of the skin (seborrhea). In a significant percentage, 25 percent or more, there is evidence of an organic brain syndrome[29,30]. This percentage increases with time[31]. The cause of most cases of Parkinson's disease is unknown. Some cases are caused by viral encephalitis and may be seen in the younger adult. Drugs may induce a reversible Parkinsonian syndrome; the phenothiazines are well known in this regard. Early Parkinson's disease is often missed by the physician. Work performance would be most likely affected by the motor disturbance (e.g. slowness of response) and early dementia (e.g. impaired memory). The diagnosis in the well-established case can be made on clinical examination. The treatment is palliative and the course tends to be progressive. The disability is not consistent with the demands for rapid and measured motor response and high intellectual capacity of an airline pilot.

Essential tremor, which is relatively uncommon, is present during movement and usually is considered to be a benign condition[32-34]. It is usually seen in hands initially. It is inclined to be progressive and the tremor is seen in hands, neck, tongue, and other bulbar muscles in more advanced cases. In a minor form it should not intefere with the demands made on the airline pilot. In a more advanced state it would be more likely to reduce the performance level of skills that depend on motor control and accuracy.

Peripheral neuropathy, which has multiple causes, refers to the involvement of the peripheral nerves in a disease process such that the function of the peripheral nerves is compromised[35]. The neuropathy may involve one nerve, e.g. carpal tunnel syndrome with entrapment of median nerve at the wrist, or multiple nerves, e.g. diabetic polyneuropathy. Because the peripheral nerves carry motor, sensory, and autonomic nerves, the symptoms often include weakness, loss of sensation, and disturbances in vasomotor and sweating control in the extremities. It is not difficult as a rule to make the diagnosis on clinical grounds. The presence of a neuropathy could interfere with motor-sensory dependent performance such as instrument control with hands or feet.

Autonomic nervous system involvement is possible in certain forms of neuropathy[35]. Absent or impaired sweating, orthostatic hypotension, disturbances of the gastrointestinal tract (gastric retention, diarrhea, constipation), impotence, and urinary bladder dysfunction are the types of symptoms seen. Most of these would not jeopardize the operation of an aircraft, but the tendency to syncope because of orthostatic hypotension or severe gastrointestinal disturbances could be hazardous in flight.

Relation to Age

There is a definite increase in cerebrovascular disease in the "after 45" group[10]. The best clues related to initial identification of these patients are found in a careful history, examination of carotid arteries (palpation and auscultation), cardiac examination, blood pressure, funduscopic examination, and retinal arterial pressures. More sophisticated studies are available for selected cases. The prevalence of stroke* is estimated at 0.2 percent for the age range 35-44, 0.6 percent for 45-54 years, 1.5 percent for 55-64 years, and 5.1 percent for those 65 and over[36].

Hemorrhage is more likely to occur in older subjects but the correlation with hypertension is more important than with age.

Because most aneurysms and all arterio-venous malformations are thought to be related to the original formation of the vessels, it is not surprising that these cataclysmic events are likely to be seen in young and middle-age adults. Nonetheless, the population above 45 is not spared.

Epileptic seizures in the years after 50 are almost always secondary to an underlying disease process with onset in these years. Cerebrovascular disease and brain tumor (primary or metastatic) are the most common underlying conditions.

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*These numbers exclude stroke due to trauma, infection, and TIAs.

The occurrence of vertiginous attacks is age related when the attacks are secondary to cerebrovascular disease. Those associated with multiple sclerosis affect a younger group of patients. The other causes bear no particular relationship to age.

The most common cause of dementia in the later years is Alzheimer disease[37], often called pre-senile dementia in those younger than age 65 and senile dementia in those age 65 and older. It is widely accepted that these two entities are the same disease expressed at different chronological ages. Senile dementia is considered to be qualitatively different from the mild forgetfulness often seen in elderly patients.

The incidence of Parkinson's disease increases with age. Up to one percent of the population older than 50 years are afflicted[38]. A somewhat lower prevalence is reported in other studies[39,40].

A diagnosis of autonomic nervous system neuropathy usually is suspected from the history. It occurs in diabetics especially. It is not strictly age related but, because it relates to the duration of diabetes, there is a rough correlation. The autonomic nervous system has a central as well as peripheral component. Changes may occur in either or both components. These changes are not in themselves disabling but may bear on the capacity of the aging pilot to respond to stress. An overreaction of an adrenergic type has been reported.

FAA Medical Examination

The present FAA guidelines and the form to be completed by the aviation medical examiner provide rather minimal standards for screening for and reporting of neurological disease in the older pilot.

Preferred Screening/Examination

The medical examinations should be more detailed in relationship to the CNS and PNS. There are standardized forms for reporting neurological examinations, some of which have had long use, e.g. Mayo Clinic examination form[41]. Completion of such an examination would be a major step in improving screening.

In addition, the EEG for the 54-59 age group should be considered as a screening and baseline study because there are age-related changes[42,43]. This would have special relevance if the 60-year-old pilot is being evaluated for continued Class I status. Focal changes or diffuse dysrhythmias could have clinical significance. Other low-cost, non-invasive techniques might include ultrasound studies of the cartoid artery if a bruit is heard in the neck. Similarly, nerve conduction studies would be a helpful, objective, and quantifiable study in the suspected neuropathy case. Other more sophisticated neuroradiological, clinical neurophysiological, nuclear medicine, and cerebrospinal fluid studies should be reserved for the more detailed examination of suspected or proven neurological diseases rather than being used for screening purposes.

Detection of dementia in the aging pilot is important. Careful mental status examination, which could be standardized, should help immeasurably in the screening clincial examination. In the 60-year-old range, more detailed neuropsychological evaluation as a baseline for future comparison would be an excellent step[44-46].

If dementia is detected or suspected, a correctible or treatable condition may be found and an airline pilot could be medically certifiable. An example of the latter is myxedema-induced dementia. It may be that carefully designed performance testing for pilot certification would serve as an additional and sensitive screen for dementia, but this would require further evaluation.

Table 14. Summary of Chapter 8, Neurologic Health Status

Organ or Problem	Age-related Increase in Frequency	FAA Test Now Required	Possible Additional Tests	Possible Symptoms or Complications
General		Minimal general neurologic exam.	Mayo Clinic exam, especially for central and peripheral nervous system function.	
Brain Hemorrhage	Yes			Focal or severe incapacitation.
Dementia	Yes		Neuropsychological evaluation useful above age 60.	Gradual loss of higher intellectual capacity.
Epileptic Seizures	No			Impaired consciousness, motor automatisms, partial disorganized response to environmental stimuli.
Essential Tremor	Yes			Motor disturbance in advanced state.
Ischemic Cerebrovascular Disease	Yes		Careful history, examine carotid arteries, cardiac exam, blood pressure, funduscope, reinal arterial pressures.	Hypertension, cardiovascular disease, visual impairment, muscular weakness, hemihyperthesia, aphasia.
Parkinson's Disease	Yes			Motor disturbance, early dementia.
Peripheral Neuropathy	Yes*			Impaired sensory motor performance.
Subarachnoid Hemorrhage	Yes			Cranial nerve palsy, focal or severe incapacitation.
Syncope (fainting)	Yes+			Loss of consciousness.
Vertiginous Attacks	Yes**			Nausea, vomiting, coordination impairment.

*Associated with diabetes, which is age-related.
+When associated with certain causes.
**When associated with cerebrovascular disease.

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CHAPTER 9

EVALUATION OF MENTAL STATUS

Mental disorders are divided into major categories in the Diagnostic and Statistical Manual of Mental Disorders, Third Edition (DSM III)[1] of the American Psychiatric Association. A wide range of degree of disturbance is found within and among the categories of mental disorders. The accompanying impairment of ability to effectively carry out the responsibilities of a pilot could range from negligible--as in the case of psychosexual disorders--to extensive--as in the case of schizophrenic disorders.

In this chapter, emphasis is placed on disorders that may affect performance but that may not be "obvious" to observers: affective disorders (especially depressive disorders) and substance use disorders (addictions, especially alcoholism). Organic brain disorders, which include dementia, were discussed in Chapter 8.

Relation to Pilot Performance

Depressive Disorders

Among the most common of the affective disorders is the combination of symptoms referred to as depression. Major depressive episodes produce widespread symptoms, including change in mood, appetite disturbance, change in weight, sleep disturbance, psychomotor agitation or retardation, decreased energy, feelings of worthlessness or guilt, difficulty in concentrating, thinking, or remembering, and thoughts of death or suicide[2]. They are sufficiently severe to produce noticeable impairment in occupational functioning.

Other affective disorders, including depressive neurosis, may produce changes in sleep pattern, low energy level, loss of self-esteem, social withdrawal, loss of interest in pleasurable activities, irritability, and decreased effectiveness or productivity. These tend to be more chronic than the severe disorders, and in mild forms can impair performance without producing symptoms apparent to an observer not acquainted with the individual who is depressed.

Alcoholism

The physiological and psychological effects of alcoholism on the various body systems have been documented and reviewed[3-5]. Defects in abstraction ability, memory functions, psychomotor speed, and general intellectual functioning have been found. Age and alcohol have a synergistic deleterious effect on performance on a continuous tracking task, an effect that may originate at the extra-pyramidal level of the central nervous system[6]. Weschsler Adult Intelligence Scale and the Halsted-Reitan neuropsychological test battery responses suggest that alcoholics are more impaired than patients with functional diagnoses, and that they resemble patients with organic brain damage. However, there is disagreement regarding the nature, extent, and permanence of such alcohol derived defects. At least some effects appear to be reversible[4,5,7]. Alcoholic pilots previously diagnosed as having symptomatic organic brain syndrome have recovered normal levels of function--and returned to piloting with FAA approval--after successful treatment of the alcoholism, suggesting that deficits are ameliorated by time and abstinence[8].

Relation to Age

Most mental disorders are either not age-related or tend to begin well before age 60. Schizophrenia onset almost always occurs before age 35. Neurotic disorders typically appear early in adult life, but may become chronic and persist into later life. Psychosexual disorders, if differentiated from normal functional changes during aging, also appear before the age of 60. On the basis of clinical observations, some psychiatrists note an increase in undue suspiciousness with age, but this would be unlikely to occur among airline pilots because it is thought to be linked to declines in sensory perception or to social isolation.

Depressive Disorders

Depressions are common throughout adult life, and may be a cause of impaired performance at any age. Episodes of depression and anxiety are the most common of psychological problems in air traffic controllers aged 25 to 49 years[9], and this finding possibly extends to other occupational groups, including pilots[10]. Depression (or depressive episodes) is the most common psychological problem among older persons[2]. Rates of suicide, which typically is linked to depression, increase with age among white males[11].

Alcoholism

In the United States, a peak incidence of alcoholism is found in the 45-54 age group, with a second, slightly lower peak in the 65-74 group[12]. The exact proportion of aged alcoholics is unknown and knowledge about their characteristics is limited[13-15]. An estimate of the prevalence of alcoholism is given at 2 to 10 percent over age 60. The age distribution for pilots with known alcohol abuse problems is similar to the age distribution for the Airline Pilots Association (ALPA) membership as a whole. Among pilots, the incidence does not appear to increase with age[16,17].

FAA Medical Examination

The Guide to Aviation Medical Examiners[18] specifies that a medical certificate will be denied to an applicant with an established medical history or clinical diagnosis of (1) a character or behavior disorder that is severe enough to have repeatedly mainfested itself by overt acts, (2) a psychotic disorder, (3) chronic alcoholism, and (4) drug addiction. A medical certificate is denied or deferred for psychoneurotic disorders, that render or could render the applicant unable to safely perform the duties of an airman. These disorders include (1) anxiety reaction (acute, chronic, or recurring), (2) obsessive compulsive reaction, (3) conversion hysteria, (4) dissociative reaction, (5) depressive reaction, and (6) phobic reaction. In addition, mental disorders requiring continued or intermittent medication are disqualifying.

The mental status examination suggested in the Guide[18] is based upon observation of behavior, which may be supplemented by questions during the examination. When indications of a possible mental disorder are noted, a more detailed examination may be conducted--often through psychiatric referral. The routine mental status examination ordinarily involves evaluation of general appearance and behavior, state of consciousness, emotional state, pattern of speech and thought, and intellectual functions.

Preferred Screening/Examination

A well performed routine mental status examination is frequently adequate to reveal the presence of major mental disorders. However, unless overt signs of anxiety, depression, or other evidence of emotional distress is noted by the examiner, a brief examination will seldom detect mild anxiety disorders, depressions, or problems in living that may disrupt pilot performance. Mental symptoms may not be disclosed by an intact person who is motivated to conceal them.

The presence of problems typically is discovered when a person confides in another person from whom he or she seeks help, or when signs of emotional distress are noted by peers or physicians who are well acquainted with the patient. A military flight surgeon, for example, who works closely with a group of pilots over an extended period, may be sensitive to emotional problems sufficiently severe to impair performance, but which might be missed by an examiner not well acquainted with the pilot.

A thorough clinical evaluation of behavior involves assessment of personality characteristics, features of the work and living situations that are stressful, the status of significant relationships, important life changes, other problems that may exist, and the coping styles with which problems are customarily handled. A comprehensive evaluation of mental status, of the type made by a flight surgeon or primary care physician who has responsibility for continuing care of a patient, includes a thorough personal history. The examiner will wish to know about the patient's earlier life, including the nature of early family relationships, educa- tion, and occupational history. The examiner will investigate the ease of forming close relationships, outcome of marriage(s), and whether or not there are children. The examiner will ask questions regarding other interests, serious problems, and solutions that appear possible. How does the pilot view life at the present time and the prospects for the future?

The time available for the usual periodic examination does not allow careful investigation of most of these issues. Many of them cannot be effectively assessed unless the pilot is willing to share details of personal life. Some of the indicators of stress and of the milder mental disorders may be observed by a clinician. Others may be suggested by inquiries into change in living habits, eating, sleeping, sexual functioning, and other items that would be covered in a medical history. Family history would be important for bipolar depression.

Screening for subclinical levels of emotional distress--that can influence pilot performance--can be reliably and quantitatively accomplished by use of standardized quantitative psychological screening instruments. The CESD Scale[19], The Beck Depression Scale[20], the Zung Depression and Anxiety Scales[21,22], and the State-trait Anxiety Scale[23] are among the better validated of such scales, but even these can be circumvented by a pilot motivated to hide problems.

It should be emphasized that the changes that might be detected by increasing the thoroughness of the mental status examination are as common in individuals before 60 as after 60. The lack of application of available screening procedure for detecting anxiety disorders, depressions, and even mild organic mental disorders is a problem for certification of all pilots--not only those who are approaching 60.

One promising approach to identifying (and resolving) mental and behavioral problems is seen in The Air Line Pilots Association (ALPA) Occupational Alcoholism Program, operative since 1974. This program includes a Human Intervention and Motivation Study (HIMS). Primarily designed for prevention and rehabilitation, the program was developed as an alternative to the federal and corporate restrictions that made identification of alcoholism tantamount to loss of medical certification and an end to the pilot's flying career.

Based on peer identification, and self-referral, the program offers a nonpunitive tripartite (FAA-airline-ALPA) approach to assisting pilots with substance abuse, depression, and proficiency problems. The self-referral rate has remained stable at approximately 15 percent of those treated over the five years of the project. Detailed histories resulted in the retrospective identification of problems with pilot proficiency in about 30 percent of the total number of cases, although proficiency may not have deteriorated to the point of being labeled by flight training personnel before the referral to the HIMS office[14].

Of approximately 500 pilots seen by the program staff, about 20 percent presented problems other than substance abuse, such as life-events crises. Of the 400 alcohol abuse or dependence cases, multiple substance abuse was documented in less than five percent (with no cases of diagnosed drug dependence). Only one case has been seen for drug abuse (medically prescribed drugs with subsequent abuse). The HIMS experience suggests that drug abuse/dependence is not currently a significant factor in the professional airline pilot population. The United States Air Force data seem to confirm this for military pilots. There were no instances of military aircraft accidents caused by illicit narcotics over a 10 year period, but there was a low and steady rate where alcohol or drugs were associated, not causative, agents[24]. However, cohort differences may prove to be significant here, so that marijuana abuse, for example, may become more important in the future.

In 1976 the FAA established a medical protocol that provides exemptions for pilots who have achieved sobriety and who have no other medical or psychiatric conditions. Since then, over 300 have completed a residential treatment program and are flying again with a valid medical certificate. Relapse (defined as any return to drinking) at two years approximated 20 percent, with no significant difference in mean age between the 20 percent of cases who returned to drinking and the 80 percent who remained abstinent for two or more years[16].

Table 15. Summary of Chapter 9, Mental Status

Disorder	Age-related Increase in Frequency	FAA Test Now Required	Possible Additional Tests	Possible Symptoms or Complications
General	No	Mental status exam based on observation of behavior; named disorders are disqualifying.	Peer and self-referral to employee assistance programs.	Can affect pilot performance, depending upon severity.
Depressive Disorders	No		Quantitative scales, e.g., Beck or Zung.	Change in mood, decreased energy, difficulty concentrating.
Substance Use Disorders (alcoholism)	No? (peak age 45-54 for alcoholism)			Impairs memory, psychomotor speed, general intellectual functioning.

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PART III: BEHAVIORAL ISSUES

Even if one can identify incipient age-related physical and mental disorders that can make it hazardous for a particular person to pilot a commercial airplane, there are other more complex components of behavior that also must be taken into account. Many perceptual and intellectual factors are thought to play a role in the effectiveness with which pilots do their jobs. If a deficit can be demonstrated in a particular factor, will it compromise that pilot's performance enough to constitute an appreciable safety hazard? It is this question that poses the most uncertainty in judging how age affects pilot performance.

This part of the report is a discussion of the age-related perceptual, psychomotor, and intellectual decrements that by direct study, indirect study, or inference are thought to be able to significantly compromise pilot effectiveness in the cockpit. It also is concerned with ways of readily detecting significant decrements of function, especially those that are involved in the judgmental and managerial responsibilities of the captain.

CHAPTER 10

PERCEPTUAL AND PSYCHOMOTOR FUNCTIONS

Information received via sensory perception provides the starting point for decisions and actions. Once the information is perceived, it must be stored in memory, even if only for a short time, and then retrieved for use in solving a problem. Psychomotor function then translates the processed information into action. Mistakes can occur at any point in the chain of events. A pilot may misperceive information provided by the cockpit displays, by a voice on the radio, or by another member of the crew; a pilot may make an inappropriate decision or make a correct decision too slowly; a pilot may unknowingly act at variance with conscious intention. Pilot error was a significant determining factor in a large proportion of airline accidents that occurred during the last 15 years (Table 5).

Research points to a decline with age in the speed and/or quality of many aspects of perceptual and motor functioning[1-4], but much greater research attention needs to be directed to continuously practiced skills. This chapter presents information on age-related alterations in perceptual and psychomotor functioning, and assesses their possible impact on pilot performance.

Vision

The optical media of the eye, which are responsible for the transmission and refraction of light to form a visual image, change with age at a different rate than the photosensitive (retina) and neural mechanisms of the visual system. Changes in refraction and transmission typically appear in the age range 35-45; those in the retina and neural system typically become most evident about age 55-65[3]. Of the age changes in the optic media, those that occur in the pupil and the lens are most significant functionally.

Pupil-Associated Changes

The iris of the eye opens and closes with decreases and increases in light so as to provide the smallest possible pupil opening (and thus the sharpest image and greatest depth of focus) at the prevailing light level. In populations of generally healthy older subjects there is some decline in the response of the pupil to light[5]; reaction to light was present in both pupils in about half of the age group 65-91. The most common and consistently observed age difference in the pupil is a reduction in its resting size under both dark and light conditions (senile miosis)[6,7].

The reduction in resting pupil size lowers the amount of light reaching the retina. This appears to be involved in the elevation with age of the lowest level of light that can be detected (minimum light threshold): pupil size and light threshold are approximately inversely proportional[8]. The decline in pupil size could adversely affect ability to perceive dim objects and to perform tasks carried out under low light levels, especially if the tasks require good visual acuity. This in turn suggests the need to include tests of performance or visual function under low illumination in screening pilots for the effects of age.

The reduction in pupil size does not contribute significantly to the decline in speed of visual perception in older persons. The amount of light reaching the retina is decreased by a factor of three or four[9], but changes in the latent period (the speed of response) of the optic nerve occur only with illumination fluctuations of a thousand-fold or more[10].

Data regarding age differences in the latency of the pupillary reflex are inconsistent[7,11,12]. The differences reported are relatively small and are not likely to be of much practical significance for pilot performance, but studies would be needed to be certain of this.

Lens-Associated Changes

The crystalline lens grows throughout life, adding a new stratum approximately every four years. This leads both to hardening (sclerosis) and yellowing of the lens[13]. The hardening of the lens reduces its ability to change shape to bring near objects into focus (accommodative power)[14]. This diminished ability with age to focus on near objects (presbyopia) has been observed in both longitudinal and cross-sectional studies[15,16]. Although the absolute level of accommodative power is somewhat higher in pilots, an age-associated decline does occur in this population as well[17]. This refractive loss can be compensated for the most part by use of bifocal lenses, which reduce the range over which the eye's lens must alter its shape.

Due to increased lens density and yellowing, the lens transmits less light to the retina in older persons. Loss is greatest for blue-green light because yellow absorbs that short wave-length light[10]. The ability to discriminate color is impaired in the elderly, especially for stimuli at the blue end of the spectrum[18].

There appears to be a significant increase with age, especially past 40, in susceptibility to the deleterious effects of glare[19-21]. This loss in ability to resist glare appears to be due primarily to the increasing opacity of the lens[20]. Although with age there is an increase in the frequency of lens opacities that seriously impair vision (cataracts), the prevalence of cataracts in older persons is not high: nine percent among those 60-69 years old and 18 percent among those 70-79 years old[22]. The degree of impairment is a function of the extent and location of the cataract.

Given the type of lens changes in healthy older persons, their potential impact on pilot performance needs careful evaluation. This might include tests of the older pilot's ability to resist the effects of glare. Flight simulators may prove useful for assessment of operationally significant impact of glare on pilots of various ages.

Retinal Changes

There is some shrinkage in the area that can be seen in a single gaze (the visual field) as people age[23-26]. The loss of visual field is most marked past age 65[26], but the degree of this change is highly variable between individuals. Most of the field is likely to be intact in healthy persons in their 70s. Glaucoma--in which there is reduction in the visual field associated with too high intraocular pressure--increases with age but is not intrinsically related to aging. Glaucoma is found in three percent of those aged 60-69[22]. Visual perimetry testing and regular tonometry should be sufficient to detect glaucoma and associated visual field problems developing in older pilots.

The older retina is slower in recovering from the effect of stimulation. For example, pilots over 40 take longer than those under 40 to recover from the effects of an intense flash[17]. Slowing in the ability to adapt to rapid changes in illumination might be significant in situations such as descent or ascent between a lighted sky and dark ground, as would occur at dawn or dusk.

Other Changes

Age differences in ability to adapt to the dark have been studied extensively[27-29]. Although there is some disagreement regarding possible age differences in the rate of dark adaptation, on average the ability to see effectively after time in low-light conditions is reduced with age, especially past age 55-60 or so. Age-related decrements in retinal metabolism, senile miosis, and yellowing of the lens have all been postulated to be involved in this reduction. Among pilots, age differences in dark adaptation level are relatively small[17].

In the general population the ability to see fine details declines slightly in adulthood to about 60, and more markedly thereafter[30-32]. Although an increase in illumination will improve acuity of persons in their 60s, usually it is not sufficient to eliminate the age difference[33]. However, approximately 35 percent of people aged 65 have a corrected best-eye acuity of 20/20 or better[22,34].

Static visual acuity is an index of the ability to discriminate detail in finely patterned ("busy") stationary targets. (Finely patterned targets are referred to in the research literature as being of high spatial frequency[35].) Displays of this type stimulate primarily the sustained channels of the visual system. However, "real-life" visual targets are frequently in motion and/or of low spatial frequency (for instance, large close objects) and thus are handled by the transient visual channels[35]. There is evidence that these transient visual channels decline more with age than the sustained channels[36]. Older persons require greater contrast to detect stimuli of low spatial frequency, even when matched with young subjects on visual acuity[37]. Further, static acuity does not appear to be a good indicator of the ability to detect moving targets[38] or of the likelihood of such outcomes as automobile accident involvement[39]. Because dynamic visual acuity also declines with age[40,41] an assessment of the transient visual channels should be included in the screening of pilots, especially older ones.

Audition

With age, there is typically some loss in ability to hear effectively; the higher the frequency beyond about 1,000 hertz, (one Hz is one cycle per second), the greater the loss. This age-related loss of ability to hear higher frequency sounds is termed presbycusis. The average change in hearing level for persons aged 60 is about 8 decibels (dB) at 1,000 Hz, 40 dB at 3,000 Hz, and 55 dB at 6,000 Hz[42]. Aging and exposure to noise appear to be involved in these losses. The variability between persons in degree of hearing loss increases with age and the frequency of the sound[2]. A profile of frequency-related loss has also been observed in aging pilots, although overall they hear better than subjects from the general population[17].

The most important aspect of hearing for pilots is the ability to understand speech. This may be impaired by presbycusis[43]. Perception of undisturbed speech was relatively unaffected by age in one study of subjects aged 20-79[44]. However, under "stressful" listening conditions, which include interruption of sentences or the presence of overlapping words, speech intelligibility is significantly impaired for those older than 50[44]. These data strongly suggest that pilots should be screened for ability to hear under the noisy, distracting conditions encountered in an aircraft cockpit.

The Processing of Information

Perception can be regarded as a sequence of neurophysiologically mediated processes that develop and transform representations of environmental stimuli. These processes include the operations of the sensory organs, as well as the mechanisms that interpret, classify, and organize arriving information. Age-related differences in these processes will be discussed, as well as their significance for pilot performance.

Piloting a plane requires efficient extraction of information from the broader array of relevant and irrelevant stimuli in which it is embedded, as well as the necessity for monitoring many sources of information and focusing attention selectively. In the past few years there has been research on the prediction of automobile driving performance according to variables of selective attention, perceptual style, and perceptual motor reaction time[4]. These three variables have been shown to manifest individual differences, to manifest age differences, and to be correlated with automobile accidents[45-47]. The selective attention measure also has been found to be predictive of pilot proficiency[48-50]. Although the research is limited, these three variables, in addition to speed of visual processing and resistance to distracting stimuli, appear to be worth consideration for inclusion in a battery of tests to predict pilot proficiency across the life span, and to give insight into age-related changes in performance.

There is a great deal of interest in determining other attributes and/or abilities necessary for piloting an aircraft. In a study of airline, military, and test pilots for the U.S. Public Health Service, Szafran[51] analyzed specific perceptual and psychophysiological measures to determine whether significant age differences were reflected in their performance. For almost every measure, the pilot's age (from late 20s to early 60s) was irrelevant to performance.

Szafran intended to provide measures for the development of a rational policy on pilot retirement. He analyzed "intrinsic" attributes "essential to flying" (such as high speed decision-making, the detection of low intensity-low probability signals, and the ability to assimilate large amounts of information). Although the expected physiological declines were noted (in visual accommodation, for instance), performance of older pilots in most instances was comparable to that of younger pilots. In older pilots, the efficiency of extracting relevant visual or aural information (signal) from a background of irrelevant information (noise) is reduced at low signal-to-noise ratios. However, differences across individuals within age cohorts exceeded differences between age cohorts. In both auditory and visual discrimination tasks, older pilots tended to select strategies that were optimal for signal detection, negating the overriding limitations incurred by declines in sensory mechanisms (e.g., lens yellowing, declining visual accommodation, and presbycusis). There was also a lack of significant differences with decision-making capacities across age cohorts.

Szafran concluded that routine aspects of a professional pilot's performance would not be affected by the aging process across a normal, working life-span. He suggested cardiovascular diseases as a possible hidden confounding factor in those studies in which dramatic effects with aging were demonstrated; all pilots in his investigation were in excellent health, minimizing the impact of disease processes.

Thus, subject variability, extent of experience, and level of health should be kept in mind in assessing the research on processing of information.

Speed of Visual Processing

One of the most consistently observed age differences in processing of information is a decline in speed. The clearest demonstrations of this slowing have been observed in the studies of age differences in backward visual masking.*

Older persons show a prolonged susceptibility to visual masking effects[52-54]: the interval between the target stimulus and the masking stimulus required to achieve 50 percent correct target identification was significantly greater for older persons (mean = 66 years) than for younger ones (mean = 23 years)[52]. An increase with age in the time required to process a perceptual event implies a reduction in the number of perceptual events that the nervous system in older persons can handle in a given unit of time. The available evidence indicates that the overall slowing in visual information processing with age can be attributed to slowing both in lower level neural operations (beyond the photoreceptors of the eye) and in central brain mechanisms[53-55].

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*In backward masking, a target stimulus, which must be identified by the subject, is presented for a brief duration. After a short time interval, a second "masking" stimulus, is presented. When the second stimulus is very close in time to the first stimulus, it interferes with the "perception" of the first one. As the time separation between the two stimuli is increased, the masking effect of the second stimulus is lost. The time between the two stimuli at which the second masking stimulus no longer has an effect is an estimate of the time required for preliminary processing of the first, or "target," stimulus.

It is not clear to what degree the slowing of information processing occurs specifically in pilots. A choice reaction time task* with younger (mean age = 37) and older (mean age = 48) active pilots, did not provide evidence for a reduction with age in the rate of gain of information until the subject's channel capacity was taxed severely under information overload conditions, and even then the difference was small[51]. Slowing in both peripheral and central perceptual processing with age has been observed in healthy, well-educated subjects screened for visual acuity, therefore it is likely that similar, perhaps smaller, differences with age are present among pilots, especially in high overload situations. However, further research will be needed to demonstrate the extent to which such age differences do occur among airline pilots and to determine their impact on flight performance.

Resistance to Distracting Stimuli

A pilot must be able efficiently to extract task-relevant information from the broader array of irrevelant stimuli in which the information is embedded. There is evidence of an age-related decline in this ability.

Decline in information processing efficiency with age may be caused by an increase in the distracting effects of irrelevant or interfering stimuli[56]. For example, older subjects (mean age 63) have greater difficulty than younger ones (mean age 19) in ignoring irrelevant or redundant information[57]. Air National Guard officers and commercial pilots aged 20-50 were asked to identify partially obscured objects--both relevant (such as a plane or a tower) and "nonsense" (such as geometric shapes). Even though each subject was provided with an exact picture of each object to be identified, a significant inverse relationship was found between identification scores and age in this relatively young select group[58].

However, the "irrelevance" of the nonsense stimuli in such studies has been questioned[59]. For instance, no difference between age groups is found when the stimuli require no processing[59]. Two points should be noted. First, the distinction between stimuli that require processing and those that do not usually cannot be made beforehand in such real-life situations as the operation of aircraft. Consequently, distracting stimuli might well worsen the performance of older observers generally, and possibly that of the older pilots as well. Second, the effect on older perceivers of stimuli that do not need processing is not clear[60].

Interference effects from irrelevant stimuli have been reported in the gerontological literature among even middle-aged subjects. Diverse

*A choice reaction time task is one in which more than one response is possible, and the subject must make a choice, for instance, of which of three buttons to push.

and unpredictable sources of stimulation are likely to be encountered in the operation of aircraft, therefore further research is needed to determine their impact on the aging pilot.

Selective Attention and Vigilance

Botwinick[1] reports widespread impressions that elderly individuals have problems in maintaining attention. This inability would lead to a decrement in performance on many tasks, and might even lead to accidents.

The ability to selectively attend to one message in the presence of other competing messages has been widely investigated[49,61-63]. The dichotic listening procedure is one useful technique. In the traditional dichotic listening task, the subject is presented with simultaneous but different stimuli or messages in each ear, usually at a high rate of speed, and is required to repeat or recall particular stimuli. Studies using a dichotic listening task have shown that older adults as a group perform significantly less well than groups of younger subjects[64-68].

Recently, researchers have demonstrated relationships between individual differences in the ability to selectively attend to relevant stimuli in the presence of irrelevant or distracting stimuli and such "real-world" situations as aircraft flight proficiency and automotive accident involvement[45-48]. Aircraft flight proficiency[48,50], accident involvement of professional bus drivers[49], and accident involvement of commercial drivers for a utility company[45,47] have been predicted successfully.

Conceptually related to the work on selective attention is research concerned with vigilance--the ability to maintain attention to a particular task. To assure the safe and effective operation of the aircraft, the pilot must have the ability to be continuously observant while flying. The types of vigilance required by the pilot will differ as a function of the flying situation. For example, the form of vigilance required on a long-distance routine trip is very different than that requiring multiple decisions under demanding conditions. Investigations of operator vigilance during prolonged motor vehicle driving support the hypothesis that prolonged driving leads to greater automatization of control skills, which increases the time available for the perceptual requirement of the driving task[69-72]. It is assumed that if prolonged driving has any effect at all upon performance, it has the effect of enhancing the vigilance of the operator[69,70].

Overall, older people appear to show greater caution (longer times) than younger ones in monitoring and inspecting signals before responding. This may enable older persons to compensate for increased randomness (or neural noise) and reduced signal strength in the sense organs and central nervous system[73]. Because age differences on vigilance tasks are small when preparation is possible or when the movements required are relatively simple and are made in response to signals well separated in time, age decrements in performance (e.g., of complex activities whose responses cannot be prepared in advance) may represent problems in decision-making rather than vigilance[73].

Perceptual Style

Perceptual style is defined as individual variation in modes of perceiving, remembering, and thinking, or as distinctive ways of apprehending, storing, transforming, and utilizing information[74]. Perceptual style reflects the ability of a person to extract relevant information efficiently from the total array.

A major aspect of perceptual style is the field dependence-independence dimension[74,75]. The ability to resist the effects of distracting stimuli indicates field independence; conversely, the susceptibility to the effects of interfering stimuli is indicative of field dependence. A person's placement along this dimension is usually determined by performance on the Embedded Figures Test* and the Rod-and-Frame Test*.

Extensive cross-sectional data on the field dependence-independence dimension across the life span have been reported[76,77]. Older persons usually show greater field dependence than younger ones[74]. Because decisions are based upon less environmental information, the field dependent person is more likely to make a maladaptive interpretation of a situation, possibly leading to an incorrect decision. Support for this assumption has been received from various research[78]. For example, certain suggested measures of perceptual style were found to be highly related to emergency behavior in a controlled driving simulation[79,80], and these measures have been found to be predictors of accident involvement and/or traffic violations[47,81-84].

Data from two studies indicate that field-dependent subjects require more time to process available visual information and are less effective in their on-the-road visual search behavior[85]. Therefore, the relationship of performance to a pilot's visual processes and perceptual style should receive further experimental investigation. If a relationship is found, then further research on age effects would be advisable.

Perceptual-Motor Reaction Time

Research on age differences consistently shows reaction time increases with age, particularly as the complexity of the task is

*The Embedded Figures Test requires finding an element embedded in a geometrically complex figure. The Rod-and-Frame Test requires accurate adjustment of a luminous rod to the true vertical when it is suspended within a tilted frame.

increased[1,73]. However, the initial age difference in speed of response is largely eliminated by practice[86]. A young subject may start to show improvement immediately, while the older subject may not start to show improvement until after 300 trials.

Slowing in later life cannot be attributed to input or sensory factors alone; central mechanisms appear to be implicated as the mediators of the slowdown[1,87,88]. Therefore, psychomotor slowing with age cannot be attributed to such factors as sensory diminution[89] alone. What emerges from this research is that there are great individual differences at all ages and that practice can have profound effects at all ages. No research has looked at the aging of well-practiced skills over time.

As Welford reports in a review of age differences in reaction time[73], most movements studied in the laboratory and most of those occurring in everyday manipulatory tasks are not limited by muscular factors but by the speed of decisions required to guide movements and the time taken to monitor them. The speed and accuracy of decision-making performance of older pilots appears to be highly dependent upon the cardiovascular-pulmonary status rather than chronological age[51,90].

Table 16. Summary of Chapter 10, Perceptual and Psychomotor Functions

Structure or Function	Usual Changes with Age	FAA Tests Now Required	Possible Additional Tests	Significance to Pilots
VISION				
General	Slower dark adaptation.	None.	*	Possible.
	Decreased dynamic visual acuity (ability to perceive moving or large and close objects).	None.	*	Probable if sufficiently impaired.
Pupil	Decline in resting size: reduced acuity in dim light.	None.	Acuity in dim light.	Possible.
Lens	Less able to change shape: reduced ability to focus on near objects.	Acuity.		Bifocal lenses should be adequate to correct.
	Yellowing: reduced ability to discriminate color, especially at the blue end of the spectrum.	*	*	Possible.
	Increase in opacity (cataracts): less ability to resist the effects of glare.	None.	*	Possible.
Retina	Smaller visual field (may be due to glaucoma).	Perimetry and tonometry.		Unlikely, unless marked reduction in field.
	Slower recovery from stimulation: reduced ability to adapt to rapid changes in illumination.	None.	*	Possible.
HEARING	Decreased ability to understand speech.	Audiometry or whisper test.	Ability to understand speech in noisy, distracting conditions.	Possible.

Continued

Table 16. Continued

Structure or Function	Usual Changes with Age	FAA Tests Now Required	Possible Additional Tests	Significance to Pilots
PERCEPTUAL STYLE	Decreased ability to resist distracting stimuli; increased time to process information.	None.	*	Possible.
VIGILANCE	Decrements small; may reflect decrements in decision making.	None.	*	Possible.
MOTOR REACTION TIME	Increaced response time, especially in new tasks.	None.	*	Possible.

*Development of useful tests, perhaps using a simulator, may be possible. Such tests would have to be validated as relevant to pilot performance.

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CHAPTER 11

INTELLECTUAL FUNCTION

Pilots receive specific training in procedures to be followed during routine flights and during emergencies. They are trained to consult and to follow detailed checklists. However, much additional information unique to each flight or phase of the flight (such as radio frequency or altitude clearance assigned by air traffic control) must be remembered and used in the short term. There also are other circumstances that require high levels of intellectual function by the pilot for which checklists are not applicable. Unusual emergencies and difficult routine situations, such as landing on an icy runway, demand good and sometimes quick decisions by the pilot.

Does aging alter intellectual function? There are many components of intellectual function and they have differential relationships to aging, therefore simple answers are not possible. Effects of age on processes that contribute to intellectual function can be studied to provide partial answers. However, prior training and/or regular practice influence test results[1,2]. Age effects established for the general population by testing "naive" subjects may not apply to airline pilots exercising well-practiced skills. The validity of these tests as predictors of ability to meet the intellectual demands on pilots has not been established.

Memory, intelligence, and problem-solving skills are of prime importance to pilots. Research on the way that age affects these factors is reviewed, but the reader must keep in mind the confounding effects of pilot experience. The effects of fatigue and jet-lag on performance also are reviewed.

Learning and Memory

The ability to perform such tasks as recalling lists of words or digits is related to age, although the age at which performance declines varies with the type and pacing of the task[3]. Few age differences have been reported for tasks that require the retrieval of the most recent information presented[4,5], but age-related decrements are noted in longer term memory capacity[6,7]. The speed with which items are retrieved decreases with age[8]. Age effects are accentuated when the material to be learned (therefore remembered) is unfamiliar[8,9] or consists of non-verbal or spatial figure stimuli[10,11].

More detailed information on memory may be found in recent reviews[5,12] and in the previous chapter as most memory studies are planned in an information processing framework.

Intelligence and Problem Solving

Among pilots, there is no correlation between age and intelligence as assessed by the Raven Progressive Matrices[13], although there is a correlation among the general adult population[6,14]. The primary mental abilities test has five component parts: 1) understanding of ideas expressed in words, 2) rotation of figures in space, 3) solution of logical word problems (inductive reasoning), 4) quantitative problems, and 5) verbal recall, each of which have differential relationships to age and differential sensitivity to practice and repeated testing[1]. Other factors that are known to be correlated with intellectual performance include formal education[15-17], physical fitness[18], cardiovascular health[19,20], blood pressure[21,22], and stress[23].

Studies of problem-solving capacities in relation to age indicate that there are age differences, but these are reduced when the subjects have a high verbal ability. Although there are reports from cross-sectional studies of many deficits occurring among those in their 50s, longitudinal studies of similar constructs suggest better maintenance of function. If the task primarily is a measure of non-verbal or performance intelligence, subjects who are matched for verbal ability show only small or no age differences[24-28].

Pilots as a group appear to have above-average intelligence, scoring in the bright normal range on standard intelligence tests[13,29]. Because health is maintained and levels of formal education are generally in the college range or beyond, an early decline in intelligence in active airline pilots is unlikely. Changes that occur may be related to a specific medical problem.

Jet-Lag and Fatigue

A pilot's flight schedule usually is determined monthly, and is assigned on the basis of a seniority-based preferential bid system. For those pilots whose seniority is too low to hold a regular "bid line", notification of a trip assignment may be as little as one or two hours. Pilots may be required to fly any time of day, any day of the week.

Federal Aviation Regulations provide for certain limits on flight and duty times. The adequacy of the existing regulations is currently under review and they may be modified in the future[30,31].

The effects of related aspects of the pilot's job, including sleep loss and circadian desynchronosis ("jet-lag") are not fully understood[32,33]. There is even less knowledge of the interaction of these factors with age. There is evidence that subjects over age 40 develop desynchronosis in temporal isolation rhythms. In free-running conditions (extended periods in the absence of time cues) there are few age differences in rhythm synchronization/desynchronization, but there are differences in sleep patterns. One very preliminary study in which airline pilots reported subjective assessments of in-flight fatigue and sleepiness, along with information on preceding hours of sleep, work, and recreation, indicated possible age effects[34].

Neuroendocrine aspects of stress, human circadian rhythms, sleep cycles, jet-lag, and similar disturbances and their effect on performance are the subject of much current research. Of related interest is research on prolonged effects of sleeping pills[35]. Residual effects of barbiturates and benzodiazepines on psychomotor and cognitive performance have been observed the day following a single night-time dose. This is of especial interest because of the generally slower metabolism of drugs, changes in sleep patterns, and an increased frequency of sleep complaints among older persons[35].

Table 17. Summary of Chapter 11, Intellectual Functions

Function	Usual Changes with Age	FAA Tests Now Required	Possible Additional Tests	Significance to Pilots
Intelligence	No age-related change detected among pilots through age 60.	None		Unlikely because no change in intelligence is likely.
Memory	Few changes in short-term recall of words or digits; age effects appear with unfamiliar material for long-term memory and as load increases.	None	*	Possible.
Problem solving	Among subjects matched for verbal ability, no age differences for certain tests. (Cross-sectional differences are large.)	None	*	Possible.
Effects of jet-lag, sleep disturbance, fatigue, stress	Research needed.	None	*	Probable.

*Tests need to be developed, and must be shown to be useful for prediciting pilot performance.

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CHAPTER 12

OPERATIONAL ASSESSMENT OF PILOT PROFICIENCY

Programs of training and proficiency evaluation are important to a pilot's continuing ability to perform the complex tasks and meet the mental and physical demands of the job. Research on individual perceptual, psychomotor, and intellectual functions provides measures that might be predictive of performance as a pilot, but the coordination and integration of these functions are the ultimate test of ability. Several small age-related declines may combine to constitute a hazard greater than expected; on the other hand, small declines in one function readily may be compensated for by adjustments in use of other functions. The committee addressed the question of the adequacy of proficiency evaluation programs to detect operationally significant changes; the committee also identified research that might provide information needed to answer this question.

Pilot Training and Proficiency Checking

During the course of their careers, airline pilots receive many different kinds of training, including initial training for the newly hired pilot, transition training for each new type of airplane the pilot is assigned to fly, "upgrade" training for moving from flight engineer (second officer) to co-pilot (first officer) to captain, and various specialized training programs for new systems and operating procedures. In addition, the Federal Aviation Regulations (FARs) specify requirements for recurrent training and proficiency checks that are intended to provide a periodic review of pilot skill maintenance. The committee's focus is upon the recurrent training and checking programs because they provide the most frequent opportunity to assess a pilot's skill during his or her career. However, because the procedures for other training and checking is essentially the same as that for recurrent training, the discussion below applies to most such programs.

As described briefly in Chapter 3, current FARs require that the pilot in command for scheduled airline operations must satisfactorily complete at least one proficiency check every 12 months, and go through either aother proficiency check or an approved simulator training program every six months. The frequency of required proficiency checks or simulator training in lieu of a proficiency check for other pilots (co-pilots and flight engineers) is half that for the pilot-in-command: 24 months for the proficiency check, and 12 months for either a proficiency check or an approved simulator training program (FAR 121.441(a)). In addition, FAR 121.440 requires a pilot in command to pass a check given during regularly scheduled line operations every 12 months.

Program Content

Proficiency Checks

The content of the required proficiency checks is specified in detail in Appendix F of FAR 121. Essentially, Appendix F specifies a series of required maneuvers and procedures that must be accomplished during the course of the proficiency check. Included are normal aircraft operating procedures, such as pre-flight inspections, taxiing, take-offs, area arrival procedures, and instrument approaches and landings. In addition, performance in certain critical situations is required, including a rejected take-off, loss of an engine after passing V_1 speed, approaches and landings with failed engines, and various in-flight maneuvers, including steep turns and approaches to stalls. FAR 121.441 further provides that the entire proficiency check may be conducted in an approved simulator if the pilot being checked makes at least two landings during a required line check.

Training

The content of the approved simulator training course, which may be substituted for alternate proficiency checks, is specified in FAR 121.409. This section of the regulations specifies that the recurrent training program shall provide at least four hours at the controls of a simulator. Two alternatives are offered for the course content: (a) the maneuvers specified in Appendix F (i.e., the same maneuvers required for the proficiency check), or (b) Line Oriented Flight Training (LOFT). LOFT is a relatively recent development that utilizes the capabilities of modern simulation technology to duplicate very nearly the subtle complexities of actual flight operations. LOFT programs require a full crew, and simulate operations as they might occur on the line. Each LOFT program must be approved by the FAA[1]. A detailed description of a LOFT-like scenario[2] and an overview of the LOFT concept and its application in recurrent training programs[3] are available.

One potential advantage provided by LOFT over the maneuver-oriented "Appendix F" training is that LOFT requires all crew members to exercise not only the system operations and manual control skills required of pilots, but also requires them to exercise the cognitive, communications, decision-making, and managerial skills that have been shown to be an important part of the pilot's job (see Resource Management on the Flight Deck, NASA CP-2120)[4]. Next to routine line operations, LOFT provides the most comprehensive exercise of the variety of pilot skills and knowledge.

Performance Standards

Are judgments of satisfactory performance made by methods adequate to assure detection of those subtle changes in performance that are of operational significance and that may be age-related? FAR 121.409 and 121.441 require "satisfactory completion" of the simulator training or proficiency checking program. In addition, 121.441(e) allows the check airman who administers the proficiency check to give additional training to the pilot being checked if he fails any of the required maneuvers.

A pilot's fitness to fly is mostly a subjective judgment (of the quality of the pilot's performance of specific maneuvers and activities) made by an instructor or check airman. The standards that are used in this assessment are qualitative, not quantitative. For example, FAR 121 Appendix F states "good judgment ...must be demonstrated. In determining whether such judgment has been shown, the person conducting the check considers adherence to approved procedures, actions based on analysis of situations for which there is no prescribed procedure or recommended practice, and qualities of prudence and care in selecting a course of action." Similar guidelines appear in other sections of the FARs and in various Flight Test Guides published as Advisory Circulars[5]. In some cases, these qualitative standards are supplemented by quantitative "Acceptable Performance Guidelines," for instance, "The applicant shall maintain an airspeed within +/-5 knots of the best rate-of-climb speed, and a heading within +/-10 degrees of the assigned heading while controlling the airplane in various configurations"[6].

Factors that may affect the subjective rating of pilot performance include[7]:

1. Judgments are made without reference to a definite standard because the same maneuver may be flown satisfactorily in a number of different ways.

2. Different standards of performance are employed by different examiners, because of differences in their knowledge, experience, and proficiency.

3. The examiners differ in personal bias toward the student or pilot to be tested.

4. Raters have different concepts of the specific grading system in regard to the flight variables involved, the knowledge tested, weights to be assigned, and the range of the qualitative categories.

5. It is difficult to compare actual performance with the conceptual performance and with what the average proficiency level should be at the time of the check ride.

In a recent study of the feasibility of conducting transition training totally in a simulator, it was confirmed that there are wide variations in the interpretation and application of pass/fail criteria by individual check airmen[8].

Most pilot proficiency ratings are scored on a "pass/fail" basis. Although this may be quite acceptable for the purposes of pilot certification, a passing grade only indicates that performance meets minimal acceptable standards, and provides no data on the quality of performance above those standards. It is therefore impossible to generate any empirical, age-related functional index of pilot performance based on these data. The use of a finer scale, perhaps a five-point grading system, could offer more information but its development and implementation and the accumulation of an adequate data base will require several years to accomplish[9].

Gerathewohl[9] has provided the most recent, comprehensive review of the state-of-the-art of pilot performance measurement and assessment, including various experimental programs undertaken to develop objective, automated pilot performance measurement techniques. Although the many shortcomings of subjective performance assessment have been widely recognized, the method is "generally accepted and operationally rather effective"[9]. Objective recording and analysis of performance data would provide a high degree of objectivity and reliability, but the verification and validation of this more advanced method of measuring pilot performance are "still a matter of future research"[9].

The mandatory retirement rule precludes systematic, objective airline pilot safety or performance data that extend beyond the age of 60. Furthermore, airlines do not generally retain pilot training and proficiency checking records or data (other than the required "pass/fail" grade) in sufficient detail or for long enough periods to allow any longitudinal analysis of performance as a function of pilot age.

Assessing Age-related Effects

The magnitude of age-related differences in performance seen in laboratory studies is such that effects at the operational level, if present, might be masked by the variance resulting from the subjective evaluation of pilot performance by check airmen, might be compensated for by experience or by the actions of other crew members, or might simply not be measurable. The feasibility of detecting operationally significant changes with present methods of checking pilot performance has not been demonstrated.

The point at which demonstrable or measurable change in the performance of pilot tasks becomes "operationally significant" needs to be determined. For example, is a change in choice reaction time of a few hundred milliseconds "operationally significant?" There are very few situations in airline operations where a few hundred milliseconds are operationally significant. These few, however, are very important: to reject a takeoff requires complex decision-making and, a very short reaction time. For example, NTSB Aircraft Accident Report NTSB-AAR-79-1[10] describes an accident in which a pilot had to reject a takeoff with only one second remaining before reaching critical speed (V_1). Guidelines for acceptable performance, which relate performance on laboratory tasks or in simulated line operations to acceptable actual line performance, should be developed and validated.

Simulation technology is advancing rapidly[11,12], and is being fostered by recent changes in the FARs (FAR 121 Appendix H: Advanced Simulation Plan) which, ultimately, will permit all pilot training and checking to be performed in a simulator[11,12]. Furthermore, recent developments such as LOFT suggest that pilot skills other than system operation and manual control skills may be taught and/or assessed using simulation. The FARs presently in effect are only permissive, and no simulators have been approved for total simulation training, nor is any such approval likely in the immediate future. The practicability, reliability, and validity of more specific testing of age-related factors in the flight simulator has yet to be ascertained. Objective, automated techniques for measuring pilot performance in the airplane and the simulator do show promise, but before these can be introduced, much remains to be done, particularly in the area of developing performance standards or acceptable criteria.

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CHAPTER 13

OVERVIEW OF THE SCIENTIFIC AND MEDICAL EVIDENCE

Public Law 96-171 asks whether the age-60 rule is medically warranted, whether any particular age for airline pilot retirement is medically warranted, and whether the current content and frequency of medical certification examinations are adequate to insure medical fitness for the demands of a pilot's job. In addition the law inquires about the general question of the effect of age on pilot performance.

In this chapter, the scientific evidence that bears on these questions will be summarized. In Parts II and III of this report, the committee has considered age-related effects in health and performance, and has assessed the availability and adequacy of tests of individual level of function and fitness. The reader is cautioned that the committee has dealt only with biomedical and behavioral considerations that should help to determine retirement policy and the adequacy of the present FAA system for assessment of medical fitness. During its deliberations, the committee identified a number of other issues that also will have to be taken into consideration by those determining policy.

The question of quality control of testing inevitably arises during discussions of the adequacy of medical testing. A test that potentially is able to detect a health problem will not do so unless it is actually and accurately administered. Other concerns, which are not as closely tied to questions of science, include the financial and safety-margin costs of adding or deleting a particular test, the acceptable margin of safety for airlines, and the effect that changes in FAA policy would have on airline retirement programs, seniority systems, and financial positions.

The charge to the committee was limited to a consideration of airline pilots, but the committee noted that the adequacy of the medical examination for other pilots could be questioned as well. This report summarizes and assesses scientific evidence that should be considered in the deliberations on alteration of FAA-mandated medical testing and mandatory age-60 retirement for airline pilots.

Is Mandatory Retirement at Age 60 or at Any Age Medically Warranted?

The medical concerns that led to the age-60 rule fall into two categories: 1) increased probability of sudden death or acute incapacitation, which would greatly compromise flight safety were they to occur while the pilot was at the controls of an airplane; and 2) increased probability of subtle incapacitation that would lead to errors or slowing in perceptual, cognitive, and psychomotor function, and thus compromise safe pilot performance.

In its assessment of relevant biomedical and behavioral research, the committee found that variability within an age group is often nearly as great as variability among age groups, and that usually no single age emerges as a point of sharp decline in function.

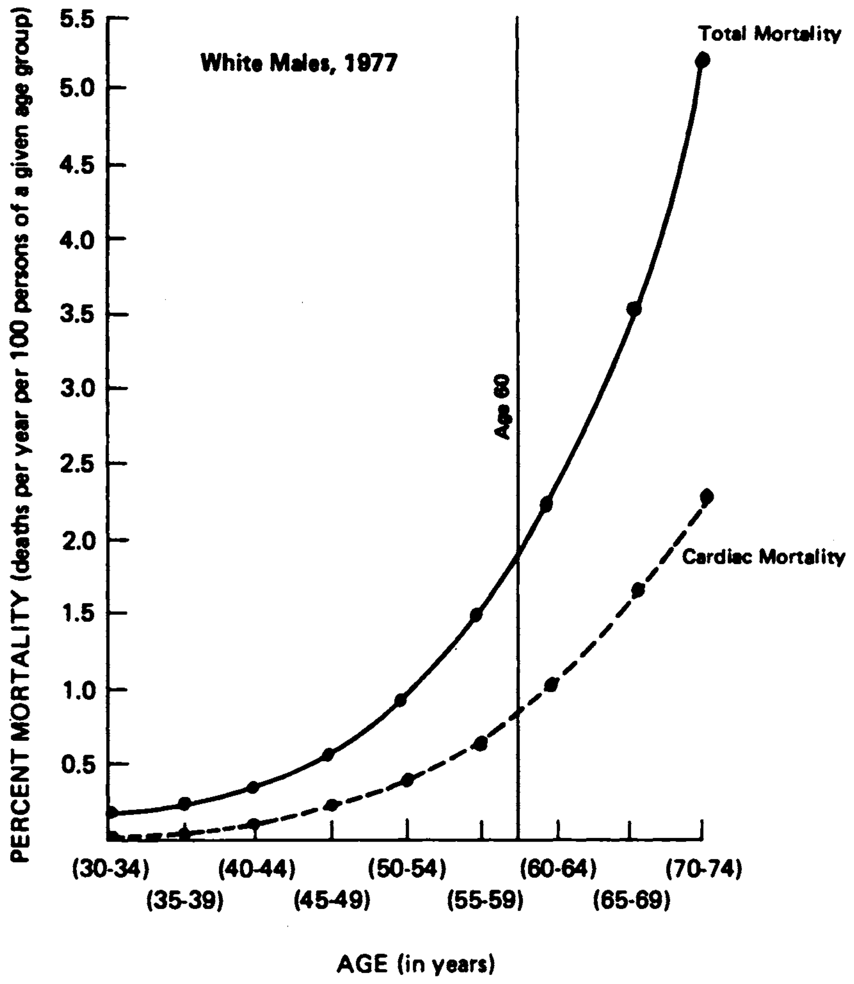
Acute Incapacitation

With regard to acute incapacitation, cardiovascular events (sudden cardiac death, myocardial infarction, and arrhythmias), stroke, and some neurologic and renal disorders linked to hypertension, diabetes, or cerebrovascular disease were identified as those disabling disorders whose frequency is great enough to be of concern and whose frequency increases with age. Figure 3 shows, for 1977, the percent of white males in a given five-year age cluster who died, irrespective of cause. (Because the great majority of pilots are white males, these data were used, but as the demography of the pilot population changes in the future, it would become less and less advisable to use white male mortality figures for assessment of risk of mortality among pilots.) On the basis of overall mortality, age 60 is not a time of special risk, although that age, or any other specific age, carries with it greater risk, on the average, than younger ages.

Cardiac death increases with age in a manner similar to total mortality (Figure 3). While the probability of cardiovascular disease within eight years does increase sixteen-fold (from 0.6 percent to 10.0 percent) between age 35 and 70 for low risk men, age alone is not the best predictor of risk. At any age, those with a high risk profile (on the basis of such factors as blood pressure, cholesterol, and cigarette smoking) have a much greater risk than a "low-risk" 70 year old (Figure 4).

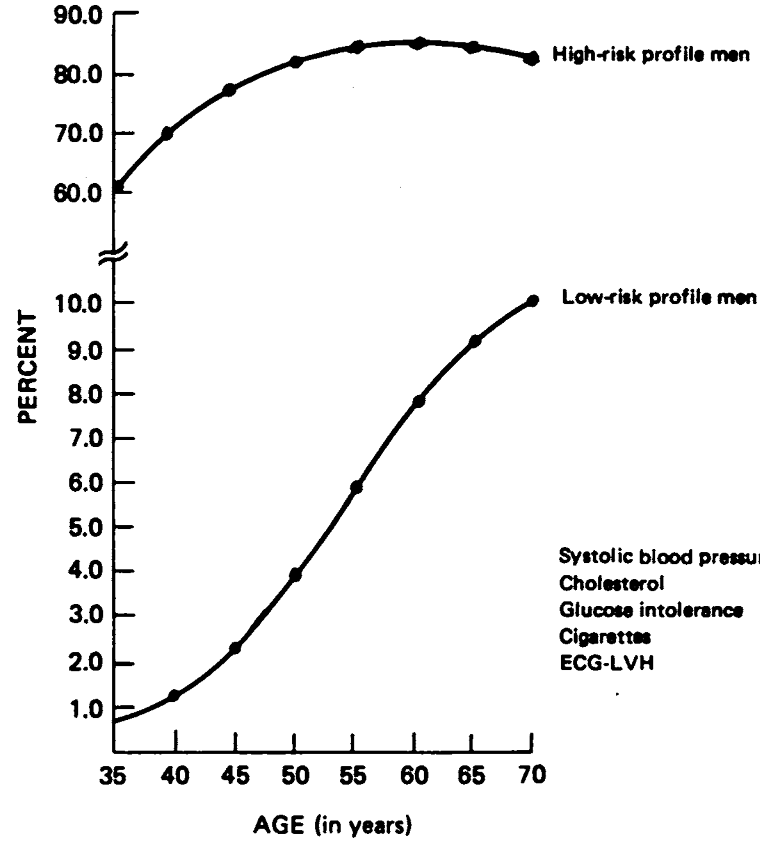
Stroke, epileptic seizures, syncope, and vertiginous attacks are possible neurologic causes of age-related increasing rates of acute incapacitation. The link with age is often due to increased rates of hypertension, atherosclerosis, or diabetes, rather than because of age *per se*. The incidence of stroke rises from about 0.2 percent at age 50 to 0.35 percent at age 60 and 0.65 percent at age 70, for men. Data on the frequency by age of the other possible neurologic causes of acute incapacitation are not available.

Figure 3. Total mortality and cardiac mortality for white males in the United States by age, 1977.



Source: Figures derived from data in Health United States, 1979, DHEW Publication No. (PHS) 80-1232.

Figure 4. Probability of developing cardiovascular disease within eight years by age and by risk-profile.*



	Risk Group	
	High	Low
Systolic blood pressure	195	105
Cholesterol	335	185
Glucose intolerance	+	0
Cigarettes	+	0
ECG-LVH	+	0

*NOTE: In the figure, the percent scale for the high-risk data is not the same as that for the low-risk data.

Source: Figures derived from data in W.B. Kannel. "Cardiovascular Risk Factors in the Aged: The Framingham Study" In Epidemiology of Aging, Publication No. NIH 80-969.

Subtle Incapacitation

Cardiovascular disease and hypertension, which increase with age as indicated above, may be responsible for decrements in the level of cognitive and psychomotor function, but definitive data on actual or potential impact on performance are lacking.

Neurologic disorders with a gradual course that increase in frequency with age and that might contribute to subtle incapacitation include dementia, Parkinson's disease, essential tremor, and neuropathy. Good data on the incidence of pre-senile dementia (younger than 65) and senile dementia (older than 65) at various ages are not available, but it is likely that the annual incidence rises with age. A prevalence of less than 0.1 percent has been estimated for pre-senile dementia, while the prevalence rate for senile dementia may be five percent. The prevalence of Parkinson's disease is about one percent among those over the age of 50.

Age-related changes in perceptual function include decreased visual acuity in general and especially decreased dynamic acuity and acuity under conditions of dim illumination, diminished accommodation and visual field, and greater susceptibility to the deleterious effects of glare. Hearing acuity, especially the ability to understand speech under stressful listening conditions, also decreases with age. The age-related slowing in the ability to process and respond to information also is most evident under stressful or high-overload conditions. Many of these changes begin well before age 60, and any age group will show great variability in level of these functions.

Aspects of attention, psychomotor performance, memory, and problem-solving ability show altered speed, capacity, or accuracy with age. However, as was noted for perceptual function, there is great variability among individuals. In addition, performance decrements are far less apparent for well-practiced skills.

The question of whether individual testing is technically feasible at the present time, so that those individuals over 60 who are still able to safely perform the duties of a pilot may be identified, will be considered in the next section.

Is the Content and the Frequency of the Current FAA Medical Examination Adequate?

The committee considered the overall adequacy of the current FAA medical examination. The assessment emphasized conditions of particular concern with regard to older pilots but was not confined to these. Although the airline safety record does not indicate that medical problems have been documented to be a major cause of airline accidents, there is no information on airline pilots over age 60 and the relationship between health status and pilot error (at any age) is not well understood.

In general, the current examination would be improved by taking advantage of advances in medical knowledge and technology. This is true of both the content and the frequency of the exam. Rates of decline in function or change in risk usually are not so rapid that checking every six months is productive. The committee recommends less frequent but more careful and comprehensive medical examinations, with the content and frequency modified to match changing risks with age.

Cardiovascular Testing

The current FAA examination for Class I certification requires a semi-annual medical history and an annual resting electrocardiograph for those applicants past 40 years of age. Echocardiography at entry would be useful to identify valvular heart disease, congenital heart disease, and cardiomyopathies. Detection of ischemic heart disease is more difficult. Because resting ECGs are relatively insensitive when used alone, and because risk of cardiovascular disease does not change rapidly, an annual resting ECG (as required by the FAA for those over age 40) should not be necessary for all ages. The committee suggests a 5-minute rhythm strip at entry, and routine resting ECG with rhythm strip every two years for those past the age of 50. The committee suggests a stress ECG every two years for pilots 60 years and older, if they are permitted to fly. As outlined in Table 11, instead of routine annual resting ECG for all applicants, the committee suggests use of a risk factor profile that includes blood pressure, cholesterol, objective determination of cigarette smoking, blood sugar, and lipoprotein class to select candidates for treadmill exercise ECGs. The profile would be determined every two years until age 50, and annually thereafter. If the treadmill exercise ECG is confirmed positive for those high risk profile individuals tested, coronary heart disease would be presumed to be present, until the pilot could provide evidence to the contrary by having a thallium perfusion test during exercise and, if necessary, angiography. The committee also suggests a baseline treadmill exercise ECG at age 50, to be used for comparisons if subsequent exercise ECGs are performed.

Endocrine Testing

If diabetes mellitus is suggested by the history or physical findings, a diagnostic work-up including a glucose tolerance test (to include blood and urine glucose determinations at hourly intervals up to 3 hours following a loading dose of no more than 100 g) is called for in the Guide to Aviation Medical Examiners.

The committee suggests that as a routine screening measure plasma or serum glucose be determined two hours after a specified standard glucose load (75-100 g). The committee also suggests that values to be used as diagnostic for diabetes be provided to examiners in order to increase comparability of diagnoses. For follow-up of diet controlled diabetes, in addition to the tests specified by the Guide, the commitee recommends tonometer screening for glaucoma, a complete urinalysis, serum creatinine determinations, and addition to the neurologic follow-up of examination for deep tendon reflexes, cranial nerve function, and muscular strength.

Other endocrine disorders whose diagnosis is to be confirmed by specific tests include hyper- or hypothyroidism, Addison's disease, diabetes insipidus, hypoglycemia, and Cushing's syndrome. The committee suggests addition of thyroxine and serum calcium determinations for those over 60, if they are permitted to fly as airline pilots.

Renal, Pulmonary, Hematologic, and Gastrointestinal Testing

The present renal testing relies on history and determination of urine protein and glucose. The committee suggests a complete urinalysis, to include specific gravity, protein, glucose, occult blood, and examination of the sediment.

The present pulmonary "testing" relies on history. In addition to a history and a physical examination of the chest and airways, the committee suggests timed vital capacity measurements every two years.

Anemia with hemoglobin lower than 12 mg/100 cc blood is disqualifying, but the level need not be reported routinely to the FAA. The committee recommends determination and reporting of hematocrit or hemoglobin--every two or three years for younger persons and more frequently for older pilots. In addition to the hematocrit and hemoglobin, the committee suggests testing of the stool for occult blood, to confirm adequate treatment of peptic ulcer or gastrointestinal bleeding.

Neurologic Testing

The Guide to Aviation Medical Examiners and Part 67 stipulate that a Class I medical certificate will be deferred for a "history or findings suggesting" head injury with 30 minutes loss of consciousness, brain surgery, subarachnoid hemorrhage, cerebral aneurysm, cerebrovascular disease, epilepsy, or an unexplained disturbance of consciousness. No instructions are provided for even a minimal neurologic exam. The committee suggests use of a standardized reporting form--such as the Mayo Clinic Examination form--to guide the aviation medical examiner in the screening for "findings." A carefully administered mental status exam would be a useful addition as a screen for dementia.

Mental Status Testing

The routine mental status examination presently required is adequate--if well performed--to reveal major mental disorders. However, it is unlikely to detect less severe mental disorders, with subtle manifestations, that potentially may have a detrimental effect on pilot performance. The committee thus encourages the FAA, the airlines, and the pilots' unions to continue to seek ways to foster both self-referral and peer-referral to "troubled employee" programs. To assist in the referral process, validated screening techniques (such as the Beck Depression Scale) for less than disabling subjective distress, impulse control problems, alcohol abuse, and interference with daily life role functions might be instituted on a trial basis and evaluated.

Vision and Hearing Testing

Currently, the aviation medical examiner is required to test color vision, distant vision, field of vision, heterophoria, intraocular tension, and near vision. The committee suggests that, in addition, dynamic acuity and acuity under dim illumination be tested. The operational effects of age-related alterations in response to glare should be determined, perhaps through simulator-aided research. If significant effects are found, then the vision testing should be modified appropriately, either as part of the medical examination or as part of proficiency checking.

Hearing is currently tested by audiometry or a whispered voice test. Speech intelligibility should be tested, but the committee believes that the whispered voice of the aviation medical examiner does not provide adequate standardization of the test. The committee suggests that speech intelligibility testing by the aviation medical examiner be more rigorous or that it be incorporated into the routine proficiency checks carried out in simulators.

Cognitive Testing

Testing of cognitive function (information processing and intellectual functioning) does not fall within the domain of the aviation medical examiner, but it should be addressed in the determination of whether the FAA-mandated examination is adequate to detect decrements in functioning past age 60. Component processes that may influence function include attention, memory, problem solving, and decision making. Some of these are tested implicitly in proficiency checks, but there is no basis for stating that such testing is adequate to detect subtle decrements. Decision-making ability, for instance, is not really tested in the proficiency check. The check consists of known routines and maneuvers, and the pilots have been extensively drilled during their preparation for the test. Nor has item-by-item assessment of components of cognitive function been validated as a predictor of pilot performance. The committee considers the opportunities for testing in a LOFT-type simulation the most promising avenue to pursue. Research would be required to validate the predictive worth of testing, using laboratory tasks or LOFT-type simulation.

In summary, institution of a more rigorous and comprehensive medical examination is recommended, especially if the age-60 rule is removed. The content and frequency of the examination should be tailored to age-related and/or risk-factor-related alterations in probability of particular health problems.

What is the Effect of Age on Pilot Performance?

As indicated earlier in this report and in this chapter, there are two areas of concern: acute incapacitation and subtle incapacitation. There is no question but that average risk of acute incapacitation increases with age, but the committee has noted the great variability that exists among older individuals. Cardiovascular disease is the most significant disorder in this context, and the committee believes that risk-factor profiles and a more thorough testing of high risk individuals are adequate to identify those pilots whose health status would represent a threat to safety because of possible acute incapacitation.

In addition, subtle decrements such as hearing and vision losses; decreases in the capacity, speed, and/or accuracy of attention, memory, and intellectual skills, and perhaps susceptibility to fatigue and jet-lag, become more frequent with age. There is great variability among individuals. Furthermore, there is reason to believe that well-practiced skills would show little if any age-related decline. However, this has not been proved by appropriate research.

The appeal of an age limit as a determinant of occupational eligibility is that it is inexpensive, unequivocal, and easily applied. As a substitute for specific individual criteria, its disadvantage is that able pilots will have to retire while less able pilots younger than 60 will continue flying.

Is assessment of individual level of function possible? A number of age-related decrements in health or level of function have been established for the general population, on average. Those changes that are well established as being present among the pilot population and as being relevant to the safe performance of a pilot's job can be adequately assessed by individual tests. However, there are other possible changes about which many unanswered questions remain. Age-related changes in speed or accuracy of a number of perceptual, psychomotor, and intellectual functions have been observed, but the particular relevance of these changes to pilots and to the demands of a pilot's job is not yet established. Tests of these functions in individuals are not yet validated as predictive of level of function as a pilot.

CHAPTER 14

NEEDS AND OPPORTUNITIES FOR RESEARCH

The most obvious need for research is also the most obvious opportunity, and that is research on the pilot population. One of the principal sources of uncertainty in responses to questions of P.L. 96-171 is the unknown applicability to airline pilots of findings for the general population.

About 35,000 airline pilots undergo medical examinations and proficiency checks twice a year. Some of the data routinely generated by these testing and monitoring systems are gathered for adminstrative reasons--and are systematically discarded after a period of time. Other data are stored, unanalyzed, in computers and files of the FAA, the airlines, and individual aviation medical examiners.

These data on airline pilots under age 60 represent an invaluable store of knowledge that researchers could bring to bear on the unanswered questions on age, health, and pilot performance. As with any such data, it would be necessary to protect the identity of individuals, but the value of the potential research findings warrant efforts to develop the data base and to extend it beyond age 60.

In addition to this general point, the committee found certain specific research needs.

Biomedical Research

1) Sequential longitudinal data on biomedical status, collected on airline pilots of all ages, should be systematically retained and analyzed to determine age-related changes among pilots (as opposed to other population groups). Simultaneous collection of measures of variables of potential use in a risk-factor profile would improve the ability to predict, on an individual basis, probability of acute or subtle incapacitation.

2) A number of studies have indicated potential detrimental effects of stress. These detrimental effects may be on physical health, cognitive function, and on performance in general. The recent Institute of Medicine

study Research on Stress in Health and Disease[1] concluded that stressors potentially can affect a wide range of physiological and psychological processes and that major advances in research methodologies now allow investigators to study many of these processes in humans in relatively natural settings. Information is minimal on the impact of fatigue, jet-lag, sleep disruption, emotional conflict, and flight emergencies on pilot health and performance. Not only is definitive information on the impact of these stressors lacking, but the interaction with age also is unknown. A cross-sectional study of groups of pilots of different ages, in which performance variables are observed and quantified in a simulator situation in conjunction with minimally invasive physiological, biological, and psychological observations and measures, would allow evaluation of the behavioral and biological effects of age and various stresses and their interactions. Useful longitudinal data would accumulate within a decade, if cross-sectional data were taken repeatedly for the same persons over the years.

Behavioral Research

1) Research should be directed toward development of effective screening criteria for pilot performance. Tasks that are representative of type, complexity, and pacing of flight conditions or which, alternatively, tap the components of the complex skills involved should be identified. Current operational procedures for training and for periodic proficiency checks--in simulators--provide an excellent opportunity for such research. Development of indices of number, type, and class of errors would allow collection of data to guide the selection of screening tests. Developing and validating these criteria to be reliable predictors of actual performance would be facilitated by incorporating the full-simulation study design into the research program. These converging lines of research should enable prediction of in-flight performance ability.

2) Slower processing of perceptual information has been observed in healthy, well-educated subjects as they age. Similar, perhaps smaller, changes might occur in older pilots, particularly in high information load situations. Research is needed to assess the extent to which such age-related changes occur among pilots. Such research should assess information processing speed under task conditions as demanding, numerous, and distracting as might be expected to occur in flight operations. LOFT-type simulations would be able to provide such conditions. If age-related effects are found, and research also establishes that there is an effect on operational performance, then screening tests and performance criteria would have to be developed and validated.

3) Research on cognitive and intellectual functions and any changes with age among pilots, employing tests shown to be relevant to actual flight performance, is suggested. Age-related decrements in short-term memory, long-term memory, and speed and quality of decision-making and problem-

solving have been found, primarily in studies of "naive" subjects. Age-related changes in well-practiced skills are found to be much smaller, but there have been very few such studies. More should be carried out because the relevance of the research on naive subjects is questionable--airline pilots have years of experience and are further "drilled" in emergency procedures during their periodic training and proficiency checking.

4) Better methods of evaluating managerial ability should be developed and used to assess the effects of age on such functions. The full mission study design would be especially useful in this context.

Ongoing Review and Evaluation

There are several reasons for developing a mechanism for periodic review of the FAA medical examination and retirement policy in the context of new knowledge. As data emerge from research they may suggest new answers to questions about the adequacy and/or necessity of present retirement policy and tests and criteria for acceptable levels of function. Furthermore, cohort differences can be dramatic; the content and frequency of the medical examination should be assessed periodically, as old cohorts leave and new cohorts enter the "test" population.

As changes in the medical examination are instituted, it would be informative (for future decision-making) to monitor the effectiveness of these changes in identifying cases and, if possible, reducing rates of accidents and incidents attributed to pilot error. Furthermore, introduction of more extensive or more sophisticated testing procedures will raise questions about the optimal coordination and overlap between "medical" testing and "proficiency" checking. It also will raise questions about the consistency and effectiveness with which the medical examination is administered. These questions also should be incorporated into a system for ongoing review, to assure the highest possible level of flight safety.

REFERENCES

1. Institute of Medicine. Research on Stress in Health and Disease. Washington, D.C.: National Academy of Sciences, 1981 (in press).

DEMURRER

March 6, 1981

Robert F. Murray, Jr., M.D., Chairman
Committee to Study Scientific Evidence
Relevant to Mandatory Age Retirement for Airline Pilots
National Academy of Sciences, Institute of Medicine
2101 Constitution Avenue
Washington, D.C. 20418

Dear Dr. Murray:

I have read the February 18, 1981 "review draft". While I have not yet formulated an opinion on several facets of the report which are outside of my areas of expertise, I feel it necessary to express my concern with the apparent willingness of the committee to present a position which is unsubstantiated and has no justification in fact. I refer to those comments in the report which apply to the subject matter of Part II, Chapters 6-9.

Accident statistics pertaining to scheduled U.S. air carrier operations in no way lead to the conclusion that an overhaul of the FAA medical standards is warranted. There is no evidence to indicate that the present standards, as currently applied, are not effective. Inflight incapacitation incidents are uncommon, and have not led to aircraft accidents. Hence, the "screen" has not been proven to be deficient. There is stark contrast in the relatively strong recommendations in Part II as compared with the generally weak or non-existent conclusions in the other sections of the report. The "methodologic issues" discussed in Chapter 5 fail to deal with the very important area of the application of Bayesian theory to the attempt to "milk" pathology from a healthy population of airline pilots. Many pilots' careers will be needlessly ruined by the application of the proposed standards to attempt to find the "needle in the haystack" rare pathological entities.

Because of these and other deficiencies in the report, I am unable to endorse the report as it appears.

I cannot comment on the Chairman's Preface, since I have not seen it as of this date.

Sincerely,

Richard L. Masters, M.D.

RLM:gp

GLOSSARY

ACCIDENT

According to the National Transportation Safety Board, "an aircraft accident is an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which any person suffers death or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or the aircraft receives substantial damage."

ADDISON'S DISEASE

A disease resulting from insufficient function of the adrenal glands. It is characterized by severe prostration, progressive anemia, low blood pressure, diarrhea, digestive disturbance, and bronezelike pigmentation of the skin.

ADRENERGIC

Activated by, characteristic of, or secreting epinephrine or substances with similar activity; the term is applied to those nerve fibers that liberate norepinephrine at a synapse when a nerve impulse passes, i.e., the sympathetic fibers.

AGE-60 RULE

Federal Aviation Regulation 121.383(c) "No certificate holder may use the services of any person as a pilot on an airplane engaged in operations under this part [Part 121] if that person has reached his 60th birthday. No person may serve as a pilot on an airplane engaged in operations under this part if that person has reached his 60th birthday."

AIR CARRIER--"COMMERCIAL AIRLINES"

The National Transportation Safety Board (NTSB) definition of an air carrier is any carrier operating under the Code of Federal Regulations, Title 14, Part 121. This includes operators who have been issued a Certificate of Public Convenience and Necessity by the Civil Aeronautics Board, i.e., certificated route air carriers and supplemental route air carriers. Commercial operators of larger aircraft (more than 12,500 pounds) also are classified as air carriers.

AIRLINE PILOT

The captain or co-pilot of an air carrier.

ALTERNOBARIC VERTIGO

Functional disturbance of the labyrinth (inner ear) secondary to changes in atmospheric pressure. (Also see vertiginous attacks).

ALZHEIMER DISEASE

One of the major causes of dementia, both before age 65 ("pre-senile dementia") and after age 65 ("senile dementia").

ANEURYSM

A bulge, which can become sac-like, in the wall of an artery, vein, or the heart at a point of weakness or increased pressure. The wall may become progressively thinner as the bulge enlarges and may rupture without warning, resulting in hemorrhage that is often severe and sometimes fatal.

ANGINA PECTORIS

Sudden or recurrent chest pain, with a feeling of suffocation and impending death, due, most often, to lack of oxygen to the myocardium and precipitated by effort or excitement.

APHASIA

Defect or loss of the power of expression by speech, writing, or signs, or of comprehending spoken or written language, due to injury or disease of the brain centers.

ARRHYTHMIA

Any variation from normal regular rhythm.

ATHEROSCLEROTIC PLAQUES

Deposits (atheromas) containing cholesterol and other lipids that are formed within the intima and inner media of large and medium sized arteries.

ATRIAL OR VENTRICULAR (CARDIAC) ARRHYTHMIA

Variation from the normal rhythm of the heart beat.

AUSCULTATION

The act of listening for sounds within the body, chiefly for ascertaining the condition of the lungs, heart, or other organs, or for detecting pregnancy.

BICYCLE ERGOMETER

An apparatus for measuring the muscular, metabolic, and respiratory effects of exercise.

BRADYKINESIA

General motor slowness.

BRAIN HEMORRHAGE

Escape of blood from a blood vessel in the brain. This may lead to stroke.

BRUIT
A sound or murmur (especially an abnormal one) heard in auscultation.

BULBAR (MUSCLES)
The six voluntary muscles which move the eyeball.

CARDIOMYOPATHY
Disease of heart muscles.

CAROTID ARTERY
Principal artery of the neck.

CENTRAL NERVOUS SYSTEM (CNS)
Brain and spinal cord.

CEREBRAL ATHEROSCLEROSIS
A form of arteriosclerosis in which plaques are formed in large and medium sized arteries in the cerebrum (main part of the brain).

CHECK AIRMAN
A person who conducts proficiency checks and line checks required of airline pilots by the FAA.

CLONUS
Rhythmic muscle jerking.

COHORT EFFECT
The presumed effects of experience, training, and environmental influences, up to the time of measurement, that are unique to the particular group (or cohort). The group is often defined as those born in the same year (a birth cohort).

COHORT STUDY
Epidemiologic study of an outcome among members of a particular group.

CORONARY ANGIOGRAPHY
A technique for visualizing and photographing the coronary arteries, with x-rays after introduction of a contrast material.

CORONARY ARTERIES
The arteries carrying blood to the muscles of the heart.

CRANIAL NERVE PALSYS
Paralysis of cranial nerves, which are the 12 pairs of nerves connected to the brain.

CUSHING'S SYNDROME
A condition, due to abnormally increased functioning of the adrenal cortex. The symptoms may include obesity, hypertension, polycythemia, and muscular weakness.

DEMENTIA

Chronic impairment of higher intellectual capacity (memory, judgment, abstract thinking) secondary to organic disease of the brain. It may have a slow or fast progression and may be reversible or irreversible.

DIABETES INSIPIDUS

A metabolic disorder that results in a deficient quantity of antidiuretic hormone being released or produced, and thus in failure of tubular reabsorption of water in the kidneys. It is often attended by great thirst, voracious appetite, loss of strength, and emaciation.

DIABETES MELLITUS

A metabolic disorder in which the ability to oxidize carbohydrates is lost to a greater or lesser extent, due to disturbance of insulin function; often due to inadequate release of insulin from the pancreas.

DYSPNEA

Difficult or labored breathing.

DYSRHYTHMIA

A disturbance or irregularity in a rhythm, as in abnormality of brain waves (which may indicate abnormal structure or function).

ECHOCARDIOGRAPHY

A method of graphically recording the position and motion of the heart walls or the internal structures of the heart and neighboring tissue by the echo obtained from beams of ultrasonic waves directed through the chest wall.

EMBOLUS

A clot or other plug brought by the blood from another vessel and forced into a smaller one, thus obstructing the circulation.

EXTRAPYRAMIDAL SYSTEM

A functional, rather than anatomical, unit of the brain involved in control and coordination of motor activities, especially the postural, static, supporting, and locomotor mechanisms.

FLIGHT ENGINEER

The third pilot (or second officer) in the cockpit of a certificated route air carrier.

FUNDUSCOPIC EXAMINATION

Examination of the back of the eye (retina) with an ophthalmoscope, a device for use in routine examination of the interior of the eye through the pupillary opening.

GASTRITIS

Inflammation of the stomach.

GASTROENTERITIS

Inflammation of the stomach and intestines.

GENERAL AVIATION

Refers to the operation of U.S. Civil Aircraft owned and operated by persons, corporations, etc., other than those engaged in U.S. air carrier operations.

GLYCOSURIA

The presence of an abnormal amount of sugar in the urine.

HEMATOCRIT

The percentage (by volume) of red blood cells in whole blood.

HEMATURIA

Blood in the urine.

HETEROPHORIA

Failure of the two eyes to move in conjunction, due to imperfect balance of the ocular muscles.

HEMIPARESIS

Muscular weakness affecting one side of the body.

HYPERGLYCEMIA

Abnormally high concentration of sugar in the blood.

HYPERTROPHIC MYOPATHIC DISORDERS

Disorders characterized by enlargement or overgrowth of muscle cells, such as in the heart.

HYPERURICEMIA

Excess of uric acid in the blood.

HYPOGLYCEMIA

Abnormally low concentration of sugar in the blood.

IDIOPATHIC

Self-originated; of unknown causation.

INCAPACITATION

Inability or unfitness to perform tasks necessary for the safe operation of an aircraft. Causes of incapacitation reported to the NTSB include myocardial infarction, convulsive seizures, gastroenteritis, fainting, and kidney stone attacks; causes reported in a survey conducted by the International Federation of Air Line Pilots Associations include symptoms of food poisoning, earache, headache, and dizziness.

INCIDENT
An occurrence involving an aircraft in which there is only minor damage to the airplane and/or minor injury to an occupant.

ISCHEMIA
Deficiency of blood supply due to constriction or obstruction of arteries.

ISCHEMIC CEREBROVASCULAR DISEASE
Deficiency of blood in the cerebrum of the brain due to constriction or obstruction of a blood vessel.

ISCHEMIC HEART DISEASE
Deficiency of blood supply to the muscles of the heart due to constrictions or obstruction of the coronary arteries.

LINE CHECK
An FAA-required observation of an airline pilot by a check airman during an air carrier flight

LINE-ORIENTED FLIGHT TRAINING (LOFT)
A training process (or concept) designed to place an airline crew in an environment that mimics actual flying conditions as closely as possible. The goal is to provide more meaningful training, including fostering cockpit management and interactive skills while maintaining "stick and rudder" control and training.

LIPOPROTEIN
Complexes of lipids (fats) and proteins. The lipoproteins are major carriers of cholesterol in the blood.

LIPOPROTEIN PROFILE
The pattern of distribution of lipoproteins into classes separated by their density (low density lipoprotein (LDH) and high density lipoprotein (HDL), for example).

LONGITUDINAL STUDY
A study to measure changes over time in test subjects. In general, there are initial measurements made, and then periodic follow-up examinations of the same subjects over the years.

METABOLIC ACIDOSIS
A disturbance in which the acid-base status of the body shifts toward the acid side.

MOTOR AUTOMATISMS
Performance of non-reflex acts without conscious volition.

MYOCARDIAL INFARCTION
Heart attack. Damage to heart muscles as a result of interruption of the blood supply to the area.

MYXEDEMA
A condition characterized by a dry, waxy type of thickening of the skin associated with severe hypothyroidism.

NEPHRITIS
Inflammation of the kidney.

NEPHROPATHY
Disease of the kidneys.

NEPHROSIS
Any disease of the kidney.

NEUROPATHY
A general term denoting functional disturbances and/or pathological changes in the peripheral nervous system.

NYSTAGMUS
An involuntary rapid movement of the eyeball, which may be horizontal, vertical, rotary, or some combination.

ORGANIC BRAIN SYNDROME
Psychological or behavioral abnormality associated with transient or permanent dysfunction of the brain. Dementia is one type or organic brain syndrome.

ORTHOSTATIC HYPOTENSION
A progressive disorder with symptoms of autonomic insufficiency, including weakness or syncope on rising to an erect position.

OTOLARYNGEAL
Ear and/or throat related.

PALPATION
The application of the fingers with light pressure to the surface of the body for the purpose of determining the consistency of the parts beneath.

PERCUSSION
The act of striking a part with short, sharp blows as an aid in diagnosing the condition of the underlying parts by the sound obtained.

PERICARDIAL
Referring to the membranes and fluid that surround the heart and the roots of the large blood vessels emerging from the heart.

PERIMETRY
Determination of the extent of the peripheral visual field.

PERIPHERAL NERVOUS SYSTEM (PNS)
That part of the nervous system consisting of nerves and ganglia outside the brain and spinal cord.

PERIPHERAL NEUROPATHY
General term denoting functional disturbances and/or pathological changes in the peripheral nervous system.

PHENOTHIAZINES
A group of major tranquilizers.

PHEOCHROMOCYTOMA
A tumor of the adrenal medulla or sympathetic paraganglia. The cardinal symptom is hypertension, which may be persistent or intermittent. During severe attacks, there may be headache, palpitation, apprehension tremor, pallor or flushing of the face, nausea and vomiting, pain in the chest and abdomen, and paresthesias of the extremities.

POLYCYTHEMIA
An increase in total red blood cell mass.

POLYDIPSIA
Excessive thirst persisting for long periods of time.

POLYURIA
The passage of a large volume of urine in a given period.

PRECORDIAL INSPECTION
Examination of the region over the heart and lower part of the chest.

PRESBYCUSIS
A progressive bilaterally symmetrical hearing loss occurring with age.

PRESBYOPIA
Diminished ability to focus on near objects associated with advancing age.

PROFICIENCY CHECK
A training exercise described in Federal Aviation Regulation 121 that requires each airline pilot semiannually to carry out successfully specific maneuvers and procedures either in an aircraft or a flight simulator.

PSYCHOSEXUAL
Pertaining to the psychic or emotional aspects of sex.

RENAL
Referring to the kidney.

RETINOPATHY
Any disease of the retina.

SEBORRHEA
Oiliness of the skin.

SIALORRHEA
Increased salivation.

STENOSIS
Narrowing or stricture of a duct or canal.

SCHIZOPHRENIA
Any of a group of severe emotional disorders characterized by onset before age 45, deterioration from a previous level of functioning, and psychotic features which may include misinterpretation and retreat from reality, delusions, hallucinations, ideas of persecution, ambivalence, inappropriate affect, or withdrawn, bizarre, or repressive behavior.

SUBCLINICAL (LATENT) CARDIOVASCULAR DISEASE
Heart disease without clinical manifestations; refers to early stages, or slight degree of the disease.

SYMPTOMATOLOGY
The combined symptoms of a disease.

SYNCOPE
Fainting due to general cerebral ischemia.

TACHYCARDIA
Excessive rapidity in the action of the heart (above 100 beats/minute).

THALLIUM PERFUSION IMAGING
A noninvasive technique, using the radioisotope thallium-201, that allows for evaluation of flow of blood to the muscles of the heart, thus assessing indirectly the status of the coronary arteries.

TONOMETER
An instrument for measuring tension or pressure; usually used specifically to refer to an instrument that measures intraocular pressure.

TONUS
A slight, continuous contraction of muscle, which in skeletal muscles aids in the maintenance of posture and in the return of blood to the heart.

UREMIA

The excessive retention of by-products of protein metabolism in the blood, and the resulting toxic condition. Due to inadequate kidney function.

VASOMOTOR FLUSH

Temporary redness of the face and neck from dilated blood vessels.

VASOVAGAL REACTION

A transient vascular and neurogenic (originating in the nervous system) reaction marked by pallor, nausea, sweating, bradycardia (pulse rate of less than 60), and rapid fall in arterial blood pressure which, when below a critical level, results in loss of consciousness and characteristic electroencephalographic changes. It is most often evoked by emotional stress associated with fear or pain.

VENTRICULAR FIBRILLATION

Arrhythmia characterized by small local involuntary contraction of heart muscle due to rapid repetitive excitation of myocardial fibers without coordinated contraction of the ventricle (lower heart chamber).

VERTIGINOUS ATTACKS

An illusion of movement; a sensation as if revolving in space (subjective vertigo) or as if the external world were revolving around the patient (objective vertigo). The term is sometimes used (erroneously) as a synonym for dizziness.

VISUAL FIELD HOMONYMOUS HEMIANOPSIA

Defective vision in the right halves or left halves of the visual field of the two eyes.

VITAL CAPACITY

The volume of air exhaled from the lungs from the point of maximum inspiration (inhalation) to the point of maximum expiration (exhalation). This is measured by having the subject inhale to the maximum extent possible and then exhale slowly and as completely as possible into a device called a spirometer.

APPENDIX A

TESTS OF CARDIOVASCULAR STATUS

Physical Examination - Blood pressure, pulses (rate, rhythm, and amplitude at different sites), cardiac inspection, palpation, percussion, and auscultation. There is variation in the quality of individual physician examinations and better standardization is needed.

Laboratory Data - Blood sugar, cholesterol, lipoprotein profile. Quality control for biochemical assessment is necessary. Blood sugar determinations are very reproducible, but cholesterol and lipoproten profiles are more difficult procedures. Their measurements should be made in quality-controlled laboratories.

Resting Electrocardiogram (ECG) - The resting ECG is relatively insensitive for detecting latent coronary artery disease[1]. Although the interpretation of standard electrocardiograms varies, there is general agreement about serious abnormalities.

Exercise Stress ECG - Since 1964, exercise stress ECGs ("stress tests") utilizing treadmills and bicycle ergometers have been widely used to screen for latent coronary artery disease. The limitation in interpretation of these tests for screening purposes has been the subject of several recent reviews[2-4]. As the prevalence of disease decreases, the predictive value of a positive test decreases. The number of false positive tests becomes unacceptably high when the prevalance falls below five percent. Selection of a cut-off point is therefore essential for the definition of a positive test. The use of parameters other than the ST segment displacement has improved analysis. Use of such end points as the failure to maintain blood pressure during exercise, the occurrence of frequent and complex atrial and ventricular arrhythmias, and the failure to complete a test standardized to age because of fatigue or dyspnea, improve the specificity. Repeat testing after several weeks, especially after blood pressure control and exercise training also may improve the predictive value of stress testing[3].

Thallium Perfusion Studies - Recently, the radionuclide thallium-201 has been used for determining the perfusion of blood to segments of the myocardium. This technique performed at rest and exercise provides a sensitive and specific method for screening for coronary artery disease[5]. This test is indicated when results of stress testing are equivocal.

Ambulatory ECG Analysis - Several commercially available analog tape units to record the ECG of individuals as they go about their daily activities are available. Computer-based analysis systems that provide high quality data are available. Standardization of data analysis is required.

Coronary Angiography - When performed in excellent laboratories, high quality data can be obtained and quantitation of disease of coronary arteries is possible. Although the safety of coronary angiography has improved, this test is too expensive and retains too high a risk of untoward side effects to recommend it for routine use. It should be used, however, when a pilot desiring clearance for flight cannot be ruled free of disease by less invasive measures.

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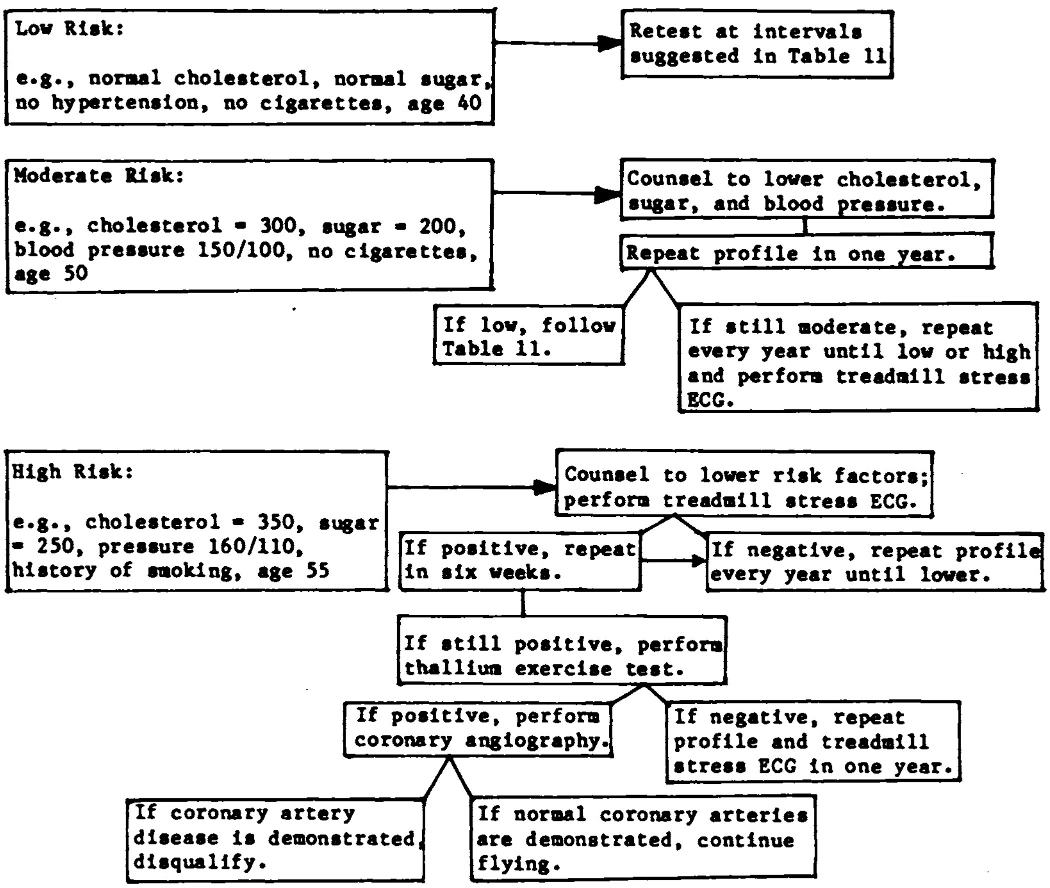
APPENDIX B

EXAMPLES OF CARDIOVASCULAR RISK PROFILES
AND POSSIBLE FOLLOW-UP DECISIONS



PART 67—MEDICAL STANDARDS AND CERTIFICATION

AUTHORITY: Secs. 313(a), 314, 601, 607, 72 Stat. 752; 49 U.S.C. 1354(a), 1355, 1421, and 1427, unless otherwise noted.

SOURCE: Docket No. 1179, 27 FR 7980, Aug. 10, 1962, as amended by Amdt. 67-2, 30 FR 12025, Sept. 21, 1965, unless otherwise noted.

Subpart A—General

§ 67.1 Applicability.

This subpart prescribes the medical standards for issuing medical certificates for airmen.

§ 67.11 Issue.

An applicant who meets the medical standards prescribed in this part, based on medical examination and evaluation of his history and condition is entitled to an appropriate medical certificate.

§ 67.13 First-class medical certificate.

(a) To be eligible for a first-class medical certificate, an applicant must meet the requirements of paragraphs (b) throught (f) of this section.

(b) Eye:

(1) Distant visual acuity of 20/20 or better in each eye separately, without correction; or of at least 20/100 in each eye separately corrected to 20/20 or better with corrective lenses (glasses or contact lenses) in which case the applicant may be qualified only on the condition that he wears those corrective lenses while exercising the privileges of his airman certificate.

(2) Near vision of at least v=1.00 at 18 inches with each eye separately, with or without corrective glasses.

(3) Normal color vision.

(4) Normal fields of vision.

(5) No acute or chronic pathological condition of either eye or adenexae that might interfere with its proper function, might progress to that degree, or might be aggravated by flying.

(6) Bifoveal fixation and vergencephoria relationship sufficient to prevent a break in fusion under conditions that may reasonably occur in performing airman duties.

Tests for the factors named in paragraph (b)(6) of this section are not required except for applicants found to have more than one prism diopter of hyperphoria, six prism diopters of esophoria, or six prism diopters of exophoria. If these values are exceeded, the Federal Air Surgeon may require the applicant to be examined by a qualified eye specialist to determine if there is bifoveal fixation and adequate vergencephoria relationship. However, if the applicant is otherwise qualified, he is entitled to a medical certificate pending the results of the examination.

(c) Ear, nose, throat, and equilibrium:

(1) Ability to—

(i) Hear the whispered voice at a distance of at least 20 feet with each ear separately; or

(ii) Demonstrate a hearing acuity of at least 50 percent of normal in each ear throughout the effective speech and radio range as shown by a standard audiometer.

(2) No acute or chronic disease of the middle or internal ear.

(3) No disease of the mastoid.

(4) No unhealed (unclosed) perforation of the eardrum.

(5) No disease or malformation of the nose or throat that might interfere with, or be aggravated by, flying.

(6) No disturbance in equilibrium.

(d) *Mental and neurologic*—(1) *Mental*. (i) No established medical history or clinical diagnosis of any of the following:

(*a*) A personality disorder that is severe enough to have repeatedly manifested itself by overt acts.

(*b*) A psychosis.

(*c*) Alcoholism. As used in this section, "alcoholism" means a condition in which a person's intake of alcohol is great enough to damage his physical health or personal or social functioning, or when alcohol has become a prerequisite to his normal functioning.

(*d*) Drug dependence. As used in this section, "drug dependence" means a condition in which a person is addicted to or dependent on drugs other than alcohol, tobacco, or ordinary caffeine-containing beverages, as evidenced by habitual use or a clear sense of need for the drug.

(ii) No other personality disorder, neurosis, or mental condition that the Federal Air Surgeon finds—

(*a*) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(*b*) May reasonably be expected, within 2 years after the finding, to make him unable to perform those duties or exercise those privileges;

and the findings are based on the case history and appropriate, qualified, medical judgment relating to the condition involved.

(2) *Neurologic.* (i) No established medical history or clinical diagnosis of either of the following:

(*a*) Epilepsy.

(*b*) A disturbance of consciousness without satisfactory medical explanation of the cause.

(ii) No other convulsive disorder, disturbance of consciousness, or neurologic condition that the Federal Air Surgeon finds—

(*a*) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(*b*) May reasonably be expected, within 2 years after the finding, to make him unable to perform those duties or exercise those privileges;

and the findings are based on the case history and appropriate, qualified, medical judgment relating to the condition involved.

(e) Cardiovascular:

(1) No established medical history or clinical diagnosis of—

(i) Myocardial infarction; or

(ii) Angina pectoris or other evidence of coronary heart disease that the Federal Air Surgeon finds may reasonably be expected to lead to myocardial infarction.

(2) If the applicant has passed his thirty-fifth birthday but not his fortieth, he must, on the first examination after his thirty-fifth birthday, show an absence of myocardial infarction on electrocardiographic examination.

(3) If the applicant has passed his fortieth birthday, he must annually show an absence of myocardial infarction on electrocardiographic examination.

(4) Unless the adjusted maximum readings apply, the applicant's reclining blood pressure may not be more than the maximum reading for his age group in the following table:

Age group	Maximum readings (reclining blood pressure in mm)		Adjusted maximum readings (reclining blood pressure in mm) [1]	
	Systolic	Diastolic	Systolic	Diastolic
20–29	140	88	—	—
30–39	140	92	155	98
40–49	155	96	165	100
50 and over	165	98	170	100

[1] For an applicant at least 30 years of age whose reclining blood pressure is more than the maximum reading for his age group and whose cardiac and kidney conditions, after complete cardiovascular examination, are found to be normal.

(5) If the applicant is at least 40 years of age, he must show a degree of circulatory efficiency that is compatible with the safe operation of aircraft at high altitudes.

An electrocardiogram, made according to acceptable standards and techniques within the 90 days before an examination for a first-class certificate, is accepted at the time of the physical examination as meeting the requirements of paragraphs (e)(2) and (3) of this section.

(f) General medical condition:

(1) No established medical history or clinical diagnosis of diabetes mellitus that requires insulin or any other hypoglycemic drug for control.

(2) No other organic, functional, or structural disease, defect, or limitation that the Federal Air Surgeon finds—

(i) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(ii) May reasonably be expected, within two years after the finding, to make him unable to perform those duties or exercise those privileges; and the findings are based on the case history and appropriate, qualified medical judgment relating to the condition involved.

(Doc. No. 1179, 27 FR 7980, Aug. 10, 1962, as amended by Amdt. 67-3, 30 FR 14562, Nov. 23, 1965; Amdt. 67-9, 37 FR 4071, Feb. 26, 1972; Amdt. 67-10, 41 FR 46433, Oct. 31, 1976)

§ 67.15 Second-class medical certificate.

(a) To be eligible for a second-class medical certificate, an applicant must meet the requirements of paragraphs (b) through (f) of this section.

(b) Eye:

(1) Distant visual acuity of 20/20 or better in each eye separately, without correction; or of at least 20/100 in each eye separately corrected to 20/20 or better with corrective lenses (glasses or contact lenses), in which case the applicant may be qualified only on the condition that he wears those corrective lenses while exercising the privileges of his airman certificate.

(2) Enough accommodation to pass a test prescribed by the Administrator based primarily on ability to read official aeronautical maps.

(3) Normal fields of vision.

(4) No pathology of the eye.

(5) Ability to distinguish aviation signal red, aviation signal green, and white.

(6) Bifoveal fixation and vergencephoria relationship sufficient to prevent a break in fusion under conditions that may reasonably occur in performing airman duties.

Tests for the factors named in paragraph (b)(6) of this section are not required except for applicants found to have more than one prism diopter of hyperphoria, six prism diopters of esophoria, or six prism diopters of exophoria. If these values are exceeded, the Federal Air Surgeon may require the applicant to be examined by a qualified eye specialist to determine if there is bifoveal fixation and adequate vergencephoria relationship. However, if the applicant is otherwise qualified, he is entitled to a medical certificate pending the results of the examination.

(c) Ear, nose, throat, and equilibrium:

(1) Ability to hear the whispered voice at 8 feet with each ear separately.

(2) No acute or chronic disease of the middle or internal ear.

(3) No disease of the mastoid.

(4) No unhealed (unclosed) perforation of the eardrum.

(5) No disease or malformation of the nose or throat that might interfere with or be aggravated by, flying.

(6) No disturbance in equilibrium.

(d) *Mental and neurologic*—(1) *Mental.* (i) No established medical history or clinical diagnosis of any of the following:

(*a*) A personality disorder that is severe enough to have repeatedly manifested itself by overt acts.

(*b*) A psychosis.

(*c*) Alcoholism. As used in this section, "alcoholism" means a condition in which a person's intake of alcohol is great enough to damage his physical health or personal or social functioning, or when alcohol has become a prerequisite to his normal functioning.

(*d*) Drug dependence: As used in this section, "drug dependence" means a condition in which a person is addicted to or dependent on drugs other than alcohol, tobacco, or ordinary caffeine-containing beverages, as evidenced by habitual use or a clear sense of need for the drug.

(ii) No other personality disorder, neurosis, or mental condition that the Federal Air Surgeon finds—

(*a*) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(*b*) May reasonably be expected, within two years after the finding, to make him unable to perform those duties or exercise those privileges;

and the findings are based on the case history and appropriate, qualified, medical judgment relating to the condition involved.

(2) *Neurologic.* (i) No established medical history or clinical diagnosis of either of the following:

(*a*) Epilepsy.

(*b*) A disturbance of consciousness without satisfactory medical explanation of the cause.

(ii) No other convulsive disorder, disturbance of consciousness, or neurologic condition that the Federal Air Surgeon finds—

(*a*) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(*b*) May reasonably be expected, within two years after the finding, to make him unable to perform those duties or exercise those privileges;

and the findings are based on the case history and appropriate, qualified, medical judgment relating to the condition involved.

(e) Cardiovascular:

(1) No established medical history or clinical diagnosis of—

(i) Myocardial infarction; or

(ii) Angina pectoris or other evidence of coronary heart disease that the Federal Air Surgeon finds may reasonably be expected to lead to myocardial infarction.

(f) General medical condition:

(1) No established medical history or clinical diagnosis of diabetes mellitus that requires insulin or any other hypoglycemic drug for control.

(2) No other organic, functional, or structural disease, defect, or limitation that the Federal Air Surgeon finds—

(i) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(ii) May reasonably be expected, within two years after the finding to make him unable to perform those duties or exercise those privileges;

and the findings are based on the case history and appropriate, qualified, medical judgment relating to the condition involved.

[Doc. No. 1179, 27 FR 7980, Aug. 10, 1962, as amended by Amdt. 67-2, 30 FR 12025, Sept. 21, 1965; Amdt. 67-3, 30 FR 14562, Nov. 23, 1965; Amdt. 67-9, 37 FR 4071, Feb. 26, 1972; Amdt. 67-10, 41 FR 46433, Oct. 21, 1976]

§ 67.17 Third-class medical certificate.

(a) To be eligible for a third-class medical certificate, an applicant must meet the requirements of paragraphs (b) through (f) of this section.

(b) Eye:

(1) Distant visual acuity of 20/50 or better in each eye separately, without correction; or if the vision in either or both eyes is poorer than 20/50 and is corrected to 20/30 or better in each eye with corrective lenses (glasses or contact lenses), the applicant may be qualified on the condition that he wears those corrective lenses while exercising the priviledges of his airman certificate.

(2) No serious pathology of the eye.

(3) Ability to distinguish aviation signal red, aviation signal green, and **white.**

(c) Ears, nose, throat, and equilibrium:

(1) Ability to hear the whispered voice at 3 feet.

(2) No acute or chronic disease of the internal ear.

(3) No disease or malformation of the nose or throat that might interfere with, or be aggravated by, flying.

(4) No disturbance in equilibrium.

(d) *Mental and neurologic*—(1) *Mental.* (i) No established medical history or clinical diagnosis of any of the following:

(*a*) A personality disorder that is severe enough to have repeatedly manifested itself by overt acts.

(*b*) A psychosis.

(*c*) Alcoholism: As used in this section, "alcoholism" means a condition in which a person's intake of alcohol is great enough to damage his physical health or personal or social functioning, or when alcohol has become a prerequisite to his normal functioning.

(*d*) Drug dependence: As used in this section, "drug dependence" means a condition in which a person is addicted to or dependent on drugs other than alcohol, tobacco, or ordinary caffeine-containing beverages, as evidenced by habitual use or a clear sense of need for the drug.

(ii) No other personality disorder, neurosis, or mental condition that the Federal Air Surgeon finds—

(*a*) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(*b*) May reasonably be expected, within 2 years after the finding, to make him unable to perform those duties or exercise those privileges;

and the findings are based on the case history and appropriate, qualified, medical judgment relating to the condition involved.

(2) *Neurologic.* (i) No established medical history or clinical diagnosis of either of the following:

(*a*) Epilepsy.

(*b*) A disturbance of consciousness without satisfactory medical explanation of the cause.

(ii) No other convulsive disorder, disturbance of consciousness, or neurologic condition that the Federal Air Surgeon finds—

(*a*) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(*b*) May reasonably be expected, within 2 years after the finding, to make him unable to perform those duties or exercise those privileges; and the findings are based on the case history and appropriate, qualified, medical judgment relating to the condition involved.

(e) Cardiovascular:

(1) No established medical history or clinical diagnosis of—

(i) Myocardial infarction; or

(ii) Angina pectoris or other evidence of coronary heart disease that the Civil Air Surgeon finds may reasonably be expected to lead to myocardial infarction.

(f) General medical condition:

(1) No established medical history or clinical diagnosis of diabetes mellitus that requires insulin or any other hypoglycemic drug for control;

(2) No other organic, functional or structural disease, defect, or limitation that the Federal Air Surgeon finds—

(i) Makes the applicant unable to safely perform the duties or exercise the privileges of the airman certificate that he holds or for which he is applying; or

(ii) May reasonably be expected, within two years after the finding, to make him unable to perform those duties or exercise those privileges;

and the findings are based on the case history and appropriate, qualified, medical judgment relating to the condition involved.

[Doc. No. 1179, 27 FR 7980, Aug. 10, 1962, as amended by Amdt. 67-2, 30 FR 12025, Sept. 21, 1965; Amdt. 67-9, 37 FR 4072, Feb. 26, 1972; Amdt. 67-10, 41 FR 46433, Oct. 21, 1976]

§ 67.19 Special issue: operational limitations.

(a) A medical certificate of the appropriate class may be issued to an applicant who does not meet the medical standards of this Part, under the following procedures:

(1) The Federal Air Surgeon may in his discretion find that a special medical flight or practical test, or special medical evaluation, should be conducted to determine whether the applicant can perform his duties under the airman certificate he holds, or for which he is applying, in a manner that will not endanger safety in air commerce during the period the certificate would be in force. Upon such a finding, the Federal Air Surgeon authorizes the conduct of that test or evaluation. The Federal Air Surgeon may also consider the applicant's operational experience for this purpose.

(2) If the Federal Air Surgeon authorizes a procedure under paragraph (a)(1) of this section, the applicant must show to the satisfaction of the Federal Air Surgeon, by the prescribed procedures, that he can perform those duties in the manner referred to in paragraph (a)(1) of this section. Upon such a showing, the Federal Air Surgeon issues to the applicant a medical certificate of the appropriate class.

(b) Any operational limitation on, or limit on the duration of, a certificate issued under this section that the Federal Air Surgeon determines is needed for safety shall be specified on the airman or medical certificate held by, or issued to, the applicant.

(c) An applicant who has taken a practical or flight test for a medical certificate under this section, and who has had a medical certificate issued to him under this section as a result of that test, need not take the test again during later physical examinations unless the Federal Air Surgeon determines that his physical deficiency has become enough more pronounced to require such an additional test.

(d) Except for air traffic control tower operators, this section does not apply to an applicant who fails to meet the requirements of § 67.13(d)(1)(i), (d)(2)(i), (e)(1), or (f)(1), § 67.15 (d)(1)(i), (d)(2)(i), (e), or (f)(1), or § 67.17 (d)(1)(i), (d)(2)(i), (e), or (f)(1). A medical certificate issued to an air traffic control tower operator who does not meet the requirements of any of those sections is valid only for performing air traffic control tower operator duties.

(e) The authority exercised by the Federal Air Surgeon under paragraphs (a), (b), and (c) of this section is also exercised by the Chief, Aeromedical Certification Branch, Civil Aeromedical Institute, and each Regional Flight Surgeon.

(Secs. 303, 307, 313(a), and 602, Federal Aviation Act of 1958; 49 U.S.C. 1344, 1348, 1354, 1422)

[Doc. No. 1179, 27 FR 7980, Aug. 10, 1962, as amended by Amdt. 67-2, 30 FR 12025, Sept. 21, 1965; Amdt. 67-4, 31 FR 5196, Mar. 31, 1966; Amdt. 67-6, 33 FR 9253, June 22, 1968; Amdt. 67-9, 37 FR 4072, Feb. 26, 1972]

§ 67.20 Applications, certificates, logbooks, reports, and records: falsification, reproduction, or alteration.

(a) No person may make or cause to be made—

(1) Any fraudulent or intentionally false statement on any application for a medical certificate under this part;

(2) Any fraudulent or intentionally false entry in any logbook, record, or report that is required to be kept, made, or used, to show compliance with any requirement for any medical certificate under this part;

(3) Any reproduction, for fraudulent purpose, of any medical certificate under this part;

(4) Any alteration of any medical certificate under this part.

(b) The commission by any person of an act prohibited under paragraph (a) of this section is a basis for suspending or revoking any airman, ground instructor, or medical certificate or rating held by that person.

[Amdt. 67-1, 30 FR 2197, Feb. 18, 1965]

Subpart B—Certification Procedures

§ 67.21 Applicability.

This subpart prescribes the general procedures that apply to the issue of medical certificates for airmen.

§ 67.23 Medical examinations: Who may give.

(a) *First class.* Any aviation medical examiner who is specifically designated for the purpose may give the examination for the first class certificate. Any interested person may obtain a list of these aviation medical examiners, in any area, from the FAA Regional Director of the region in which the areas is located.

(b) *Second class and third class.* Any aviation medical examiner may give the examination for the second or third class certificate. Any interested person may obtain a list of aviation medical examiners, in any area, from the FAA regional Director of the region in which the area is located.

[Doc. No. 1179, 27 FR 7980, Aug. 10, 1962, as amended by Amdt. 67-8, 35 FR 14075, Sept. 4, 1970]

§ 67.25 Delegation of authority.

(a) The authority of the Administrator, under section 602 of the Federal Aviation Act of 1958 (49 U.S.C. 1422), to issue or deny medical certificates is delegated to the Federal Air Surgeon, to the extent necessary to—

(1) Examine applicants for and holders of medical certificates for compliance with applicable medical standards; and

(2) Issue, renew, or deny medical certificates to applicants and holders based upon compliance or noncompliance with applicable medical standards.

Subject to limitations in this chapter, the authority delegated in paragraphs (a) (1) and (2) of this section is also delegated to aviation medical examiners and to authorized representatives of the Federal Air Surgeon within the FAA.

(b) The authority of the Administrator, under subsection 314(b) of the Federal Aviation Act of 1958 (49 U.S.C. 1355(b)), to reconsider the action of an aviation medical examiner is delegated to the Federal Air Surgeon, the Chief, Aeromedical Certification Branch, Civil Aeromedical Institute, and each Regional Flight Surgeon. Except where the applicant does not meet the standards of § 67.13(d)(1)(i), (d)(2)(i), (e)(1), or (f)(1) § 67.15(d)(1)(i), (d)(2)(i), (e), or (f)(1), or § 67.17(d)(1)(i), (d)(2) (i), (e), or (f)(1), any action taken under this paragraph other than by the Federal Air Surgeon is subject to reconsideration by the Federal Air Surgeon. A certificate issued by an aviation medical examiner is considered to be affirmed as issued unless an FAA official named in this paragraph on his own initiative reverses that issuance within 60 days after the date of issuance. However, if within 60 days after the date of issuance that official requests the certificate holder to submit additional medical information, he may on his own initiative reverse the issuance within 60 days after he receives the requested information.

(c) The authority of the Administrator, under section 609 of the Federal Aviation Act of 1958 (49 U.S.C. 1429), to re-examine any civil airman, to the extent necessary to determine an airman's qualification to continue to hold an airman medical certificate, is delegated to the Federal Air Surgeon and his authorized representatives within the FAA.

(Sec. 303, 72 Stat. 747, 49 U.S.C. 1344; sec. 602, 72 Stat. 776, 49 U.S.C. 1422)

[Doc. No. 1179, 27 FR 7980, Aug. 10, 1962, as amended by Amdt. 67-5, 31 FR 8356, June 15, 1966; Amdt. 67-7, 34 FR 348, Jan. 8, 1969; 34 FR 550, Jan. 15, 1969; Amdt. 67-9, 37 FR 4072, Feb. 26, 1972]

§ 67.27 Denial of medical certificate.

(a) Any person who is denied a medical certificate by an aviation medical examiner may, within 30 days after the date of the denial, apply in writing and in duplicate to the Federal Air Surgeon, Attention: Chief, Aeromedical Certification Branch, Civil Aeromedical Institute, Federal Aviation Administration, Post Office Box 25082, Oklahoma City, Okla. 73125, for reconsideration of that denial. If he does not apply for reconsideration during the 30-day period after the date of the denial, he is considered to have withdrawn his application for a medical certificate.

(b) The denial of a medical certificate—

(1) By an aviation medical examiner is not a denial by the Administrator under section 602 of the Federal Aviation Act of 1958 (49 U.S.C. 1422);

(2) By the Federal Air Surgeon is considered to be a denial by the Administrator under that section of the Act; and

(3) By the Chief, Aeromedical Certification Branch, Civil Aeromedical Institute, or a Regional Flight Surgeon is considered to be a denial by the Administrator under that section of the Act where the applicant does not meet the standards of § 67.13 (d)(1)(i), (d)(2)(i), (e)(1), or (f)(1), § 67.15 (d)(1)(i), (d)(2)(i), (e), or (f)(1), or § 67.17 (d)(1)(i), (d)(2)(i), (e), or (f)(1).

Any action taken under § 67.25(b) that wholly or partly reverses the issue of a medical certificate by an aviation medical examiner is the denial of a medical certificate under this paragraph (b).

(c) If the issue of a medical certificate is wholly or partly reversed upon reconsideration by the Federal Air Surgeon, the Chief, Aeromedical Certification Branch, Civil Aeromedical Institute, or a Regional Flight Surgeon, the person holding that certificate shall surrender it, upon request of the FAA.

[Doc. No. 7077, Amdt. 67-5, 31 FR 8357, June 15, 1966, as amended by Doc. No. 8084, 32 FR 5769, Apr. 11, 1967; Amdt. 67-9, 37 FR 4072, Feb. 26, 1972]

§ 67.29 Medical certificates by senior flight surgeons of armed forces.

(a) The FAA has designated senior flight surgeons of the armed forces on specified military posts, stations, and facilities, as aviation medical examiners.

(b) An aviation medical examiner described in paragraph (a) of this section may give physical examinations to applicants for FAA medical certificates who are on active duty or who are, under Department of Defense medical programs, eligible for FAA medical certification as civil airmen. In addition, such an examiner may issue or deny an appropriate FAA medical certificate in accordance with the regulations of this chapter and the policies of the FAA.

(c) Any interested person may obtain a list of the military posts, stations, and facilities at which a senior flight surgeon has been designated as an aviation medical examiner, from the Surgeon General of the armed force concerned or from the Chief, Aeromedical Certification Branch, AC-130, Department of Transportation, Federal Aviation Administration, Civil Aeromedical Institute, Post Office Box 25082, Oklahoma City, Okla. 73125.

[Doc. No. 1179, 27 FR 7980, Aug. 10, 1962, as amended by Doc. No. 8084, 32 FR 5769, Apr. 11, 1967; Amdt. 67-5, 35 FR 14075, Sept. 4, 1970]

§ 67.31 Medical records.

Whenever the Administrator finds that additional medical information or history is necessary to determine whether an applicant for or the holder of a medical certificate meets the medical standards for it, he requests that person to furnish that information or authorize any clinic, hospital, doctor, or other person to release to the Administrator any available information or records concerning that history. If the applicant, or holder, refuses to provide the requested medical information or history or to authorize the release so requested, the Administrator may suspend, modify, or revoke any medical certificate that he holds or may, in the case of an applicant, refuse to issue a medical certificate to him.

(Secs. 303(d), 313(a), 314(b), 601, 602, 609, Federal Aviation Act of 1958 (49 U.S.C. 1344, 1354, 1355(b), 1421, 1422, 1429)

[Amdt. 67-5, 31 FR 8357, June 15, 1966]

APPENDIX D

THE WORK OF THE COMMITTEE

The Institute of Medicine Committee to Study Scientific Evidence Relevant to Mandatory Age Retirement for Airline Pilots met for the first time July 15 and 16, 1980 at the National Academy of Sciences (NAS) in Washington, D.C. The meeting opened with introductory remarks by Dr. David A. Hamburg, then President of the Institute of Medicine (IOM); Dr. Robert F. Murray, Jr., Committee Chairman; and Dr. Robert L. Ringler, Deputy Director of the National Institute on Aging (the contracting agency). The remainder of the first day of the meeting was devoted to briefings on the legislative history of Public Law 96-171, the FAA Class I medical examination and age-60 rule, an airline pilot's activities and responsibilites while flying, and longitudinal study of pilot health status. The speakers included:

Dr. Richard F. Gabriel, Chief Human Factors Engineer, Douglas Aircraft

Dr. Homer R. Reighard, Federal Air Surgeon, Federal Aviation Administration

Mr. David Traynham, Professional Staff Member (Aviation), House Committee on Public Works and Transportation

Captain Jack Young, Legislative Vice-President, Pilots' Rights Association

Captain Elihu York, Head, Medical Sciences Department, and Project Manager, Thousand Aviator Study, U.S. Navy, Pensacola

The second day, committee member Dr. Donald Kline summarized the approach taken by Workgroup 55 of the NAS Committee on Vision, which was conducting a study of pilot age and vision for the Navy. Then a feasible scope and timetable for the IOM committee's study was discussed. Plans for a five-day workshop in August were initiated at the July meeting (and further developed through subsequent conference phone calls).

An eight-member delegation of committee members and study staff visited the American Airlines Flight Academy in Dallas/Fort Worth, Texas on August 1, 1980. They were briefed on pilot selection procedures, retirement statistics, and training and checking procedures. They also observed the operation of a cockpit simulator.

The second meeting of the committee was a workshop help August 20-24, 1980 at the NAS Study Center in Woods Hole, Massachusetts. The committee separated into four task forces:

- o pilot performance
- o cardiovascular issues
- o metabolic and other medical issues
- o neuro-psychological issues

During plenary sessions and task force meetings, the structure and content of the committee's report was developed. Consultants present at the workshop were:

Dr. Gerald Barrett, Professor and Head, Department of Psychology, The University of Akron

Dr. James Fozard, Director, VA Patient Treatment Services, Office of Extended Care

Dr. William Kannel, Framingham Study and Boston University School of Medicine, Section on Preventive Medicine

Dr. Donald Weiner, Assistant Professor of Medicine, Boston University School of Medicine, and Director, Non-invasive and Exercise Laboratory, University Hospital

Dr. Harold Sandler, NASA Ames Research Center

Dr. John Senders, Professor of Industrial Engineering, University of Toronto

Additional resources available to the committee included information provided by organizations and researchers who had responded to a letter or phone call requesting publication reprints or unpublished data and analyses relevant to the work of the committee. The distribution list for the letter included the following organizations and offices:

- o Aerospace Medical Association
- o Airline Passengers Association

- o Airline Medical Directors Association
- o Air Line Pilots Association
- o Air Transport Association of America, Medical Committee
- o American Medical Association
- o American College of Cardiology
- o Association of Aviation Psychologists
- o Civil Aeromedical Institute, FAA
- o Department of the Air Force, Office of Scientific Research
- o Department of Defense, Assistant Secretary of Defense for Health
- o Department of the Navy, Office of the Assistant Secretary of the Navy, Research and Development
- o Federal Aviation Administration, Deputy Administrator
- o International Civil Aviation Organization, Aviation Medicine Section
- o International Civil Aviation Organization, Aviation Medicine Section
- o National Aeronautics and Space Administration, Medical Sciences Division
- o National Air Carriers Association
- o National Council on the Aging
- o National Retired Teachers Association/American Association of Retired Persons
- o National Transportation Board
- o Pilots Rights Association
- o Veterans Administration, Chief Medical Director

Researchers contacted included:

- o Dr. Robert Bruce, Seattle Heart Watch Study

- Dr. William Castelli, Framingham Heart Study
- Dr. Stanley Mohler, Aerospace Medical Director, Wright State University
- Dr. Ed. Podlolak, Georgetown Study
- Dr. Nathan Shock, NIA Gerontology Research Center

The committee held two additional meetings (October 6-7, 1980 and December 15-16, 1980) at the National Academy of Sciences in Washington, D.C. At each meeting the committee reviewed the most recent draft of the report and agreed upon revisions. Final committee review and decisions on revision of the report occurred via mail and telephone.