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Review of the Scientific Basis for the Mandatory Separation of an Air Traffic Control Specialist at Age 56

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16. Abstract

Under Public Law 92-297, air traffic control specialists (ATCS or controller) are required to retire at age 56. A review of the literature relevant to the mandatory retirement of controllers was conducted. The scope of the review was limited to studies relevant to the specific rationales proferred in support of mandatory separation of controllers at age 56. The review was *not* a comprehensive examination of the extensive literature on aging, health, stress, shiftwork, cognitive abilities, or job performance, including errors, as related to the air traffic control specialist (ATCS) occupation. The testimony offered in 1971 before the U.S. Congress did not explicitly describe why age 56 was chosen.The argument for mandatory retirement appears to have been that (a) the mid-50s were the ages in which "burnout" was likely to occur among controllers as a result of job stress, (b) age 56 would allow a controller to accumulate 25 years or more of creditable service if hired at the proposed maximum entry age of 31, and (c) age 56 was a young enough age to allow a "burned out" controller to pursue an alternative career, if desired. Studies of self-reported symptoms of stress, biochemical markers or indicators linked to stress, medical disorders, and disability retirements among controllers were cited in testimony as evidence of the need for the early retirement of controllers. Overall, the evidence available in 1971, when carefully reviewed, was not as strong as characterized in testimony. The studies and statistics cited suffered from various defects that, in retrospect, make them less persuasive as the scientific foundation for the "ATCS Age 56 Law." Moreover, research since 1971 does *not* support the inherent stress rationale articulated in 1971 for the "ATCS Age 56 Law." However, the available studies also do not offer a "firm foundation" for either supporting or rejecting the mandatory separation of controllers at age 56. Although cross-sectional in design, age and performance studies suggest that performance may decline with age and that variability in performance between controllers is likely to increase with age. Additional research is suggested to assess changes in knowledge, skills, and abilities with age and to determine the impact of those changes on ATCS job performance.

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Scope of review

The scope of this review is limited to studies relevant to the specific rationales proferred in support of mandatory separation of controllers at age 56. The review is *not* a comprehensive examination of the extensive literature on aging, health, stress, shiftwork, cognitive abilities, or job performance, including errors, as related to the air traffic control specialist (ATCS) occupation.

Why Age 56?

The testimony offered in 1971 before U.S. Congress did not explicitly describe why age 56 was chosen. No scientific data definitively demonstrating a remarkable decline or change at that specific age were presented. Rather, the argument appears to have been that (a) the mid-50s were the ages in which "burnout" was likely to occur among controllers, (b) age 56 would allow a controller to accumulate 25 years or more of creditable service if hired prior to the proposed maximum entry age of 31, and (c) age 56 was a young enough age to allow a "burned out" controller to pursue an alternative career, if desired.

Scientific evidence offered in support of the "ATCS Age 56 Law"

Studies of self-reported symptoms of stress, biochemical markers or indicators linked to stress, medical disorders, and disability retirements among controllers were cited in testimony as evidence in support of the need for an early retirement rule for controllers.

Evaluation of evidence available in 1971

Overall, the evidence available in 1971, when carefully reviewed, was not as strong as characterized in testimony. The studies and statistics cited suffered from various defects that, in retrospect, make them less persuasive as the scientific foundation for the "ATCS Age 56 Law."

Scientific data developed since 1971

Research since 1971 has investigated (a) physiological indicators of job-related stress, (b) anxiety, personality, attitudes, and stress, (c) shiftwork and fatigue, and (d) age and performance. Moreover, the research since 1971 must be considered within the context of advances in the understanding of stress, the etiology of disorders such as hypertension, the role of genetics, personality, and lifestyle choices, and changes in the environment and working conditions of the job.

Physiological indicators of stress

Melton (1982) reviewed 10 years of research on ATCS stress and concluded that objective evidence did not support the popular perception of the occupation as being unusually stressful.

Anxiety, personality, attitudes, and stress

Smith (1980) reviewed previous research and concluded that controllers were less anxious than the general population. Subsequent research has confirmed Smith's conclusion.

(Continued)

EXECUTIVE SUMMARY (Continued)

Shiftwork and fatigue

Melton et al. (1973) found no differences in physiological and biochemical indicators of stress after introduction of the counter-clockwise rotating 2-2-1 shift pattern. Cruz and Della Rocco (1995) reported no significant differences in subjective ratings of sleep quality or sleepiness for persons age 30-35 and 50-55 in a laboratory study of two shift rotations (2-2-1 versus 2-1-2). A national survey of controllers conducted at the direction of Congress in 1999 provided little evidence that controllers experience any increase in self-reported occupational stress, chronic fatigue, or stress-related symptoms as they age.

Age and performance

While correlations with age are consistently observed on both objective and subjective criterion measures, relationships are very modest. However, all studies currently available are cross-sectional. No long-term longitudinal studies of changes in performance are available, so no conclusions can be drawn to support or refute the hypothesis that ATCS proficiency is lost with age.

Medical disability retirements

Analysis of FY1997-2003 disability retirements shows that younger (age 44 and younger) controllers retire at a rate proportionate to their representation in the FAA workforce, in contrast to the 1971 testimony.

Conclusions

The scientific evidence available in 1971 provided only weak objective support for the rationale given for the "ATCS Age 56 Law."

Research since 1971 does *not* support the inherent stress rationale articulated in 1971 for the "ATCS Age 56 Law." However, the available studies also do not offer a "firm foundation" for either supporting or rejecting the mandatory separation of controllers at age 56 in view of the age and performance results. Although cross-sectional in design, the age and performance studies suggest that performance may decline with age and that variability in performance between controllers is likely to increase. Additional research is suggested to assess changes in knowledge, skills, and abilities with age and to determine the impact of any changes on job performance.

Review of the Scientific Basis for the Mandatory Separation of an Air Traffic Control Specialist at Age 56

INTRODUCTION

The U.S. Congress amended Section 8335 of Title 5 of the United States Code (USC) in 1972 (Public Law 92-297) to provide for the mandatory separation of an air traffic controller from employment at age 56 unless otherwise exempted by the Secretary of Transportation as "having exceptional skills and abilities as a controller." Passed on the heels of the 1970 report of the Air Traffic Controller Career Committee and two public hearings in 1971, the law was based on the argument that declines in skill with age and cumulative stress in the controller workforce will result in diminished safety and efficiency in the air traffic control system ("Hearings"; U.S. House of Representatives, 1971, p. 3, testimony of John Volpe, Secretary of Transportation). The testimony by John Shaffer, FAA Administrator, made the case that:

> From the thrust of these proposals, you can see that your principal concern is with the use of older personnel in the controller positions. This is the basis for a specific maximum retention age provision. We believe that an individual should embark on a career as a controller while in his twenties, and in the usual case, retire or change to another line of work before he reaches 56 years of age. This makes him available during his most productive stage and while his interest, stamina, and general health are at their highest level.
>
> As a general rule, we find that our controllers simply do not maintain their proficiency as they progress through the second half of the normal period of service of a career employee.
>
> In some cases, the work becomes too stressful. In other cases, conditions of health force the controller to leave the work altogether. The maximum retention age level, with the early retirement and retraining provisions in our proposal, would give the controller the assurance of eventual relief from a long span of control work. He will have the opportunity to turn to a new career at a time when he otherwise might find it necessary to remain in controller work under conditions that he finds nearly intolerable. The bill will also allow the Secretary to maintain a safer, more proficient controller work force, and to operate a safer, more efficient national airspace system (Hearings, p. 9).

This testimony was presented against the backdrop of tremendous expansion of the aviation industry with the concomitant perception of ever greater burdens being placed upon controllers by the work (Kent, 1980). Three principal lines of evidence in support of mandatory separation of controllers at age 56 were articulated in 1971 hearings before the Post Office and Civil Service Committees of the U.S. House of Representatives and Senate:

(a) the inherent stress of the job;
(b) loss of proficiency with age; and
(c) medical retirements.

This review will consider these major lines of evidence first, from the perspective of the scientific data available in 1971, and second, from the perspective of relevant scientific research since the passage of P.L. 92-297. The review closes with an assessment of the degree to which current scientific evidence supports the hypothesis that a controller may no longer perform the core and essential functions of the job without hazard to others or self at or beyond age 56, and recommendations are presented for continued research on the questions of stress, shift work, performance and age, and disability retirements.

Evidence Available in 1971

Inherent Stress of the ATCS Job

Testimony

The premise of an inherently stressful job was presented in the testimony of Don Leyden, the President of the Professional Air Traffic Controller Organization (PATCO) as follows:

> We believe that the intense pressure which attaches to practically every working minute the controller is on the job merits special consideration. The controller does, literally, hold in his hands the lives of the people on those airplanes.
>
> Thus he must not only be constantly – every minute – on the alert, he is also working under severe stress and strain – to an extent that is equaled in few, if any, other jobs or professions (Hearings, p. 59).

The consequences of an error in control judgment were highlighted as an important component of that inherent stress and strain:

> I have encountered experiences where I have handled up to 20 and 25 jet aircraft at one particular time on a scope. There is no room for error for that individual.
> The person working the scope is fully cognizant of that, which adds to the stressful nature of the work (Hearings, p. 72).

The testimony of Donald Francke, Executive Director of the Air Traffic Control Association (ATCA), reinforced the theme of inherent stress to the ATCS job. Describing the job as "arduous," Mr. Francke began his testimony by noting that the need to provide controllers with an opportunity for "relief" was well documented (Hearings, p. 95). He went on to testify:

> The undisputably [sic] valid basis for early retirement for controllers rests upon the provable fact that the business of assuring expeditious and orderly movement of air traffic, safeguarding against midair collision, is a highly stressful occupation which lays a heavy toll on the mental and physical capacity of the controller and which limits his productive life. There must be an orderly phasing out of the older controllers when they can no longer make the rapid and accurate decisions essential to the preservation of human life. This calls for recognition of the highly important fact that early retirement is not solely a matter of fairness to the controller, it is primarily a safety measure (Hearings, p. 97–8).

At this point, Mr. Francke identified several reports "proving" that the business of air traffic control was highly stressful. He first contrasted the description of the pilot occupation as "hours of boredom intermixed with moments of sheer terror" to a description of the ATCS occupation:

> The controller has no such hours of boredom; he must frequently work for 8 hours at a stretch without rest periods and gulping his lunch at his position. Because of shortages of personnel, many of them have been on 6-day weeks for several years. This situation is further worsened by the fact that air traffic control is a 3 shift per day, 7-day a week operation, and each controller must take his turn standing midwatches. This is usually not too onerous on the younger man, but older men usually have difficulty in changing the rhythm of their life, and in sleeping during the daytime in the periods that they are on midwatches (Hearings, p. 98).

Next, Francke asserted that "Unrelieved pressure and tension will ultimately take its toll of even the hardiest constitution" based on a summary of studies finding that an "overwhelming majority" of coronary patients had been subjected to unusual occupationally-related stress (Hearings, p. 98). Francke highlighted the conclusions of the summary study author that "the results clearly demonstrated a striking correlation of coronary heart disease prevalence and emotion [sic] stress." Francke also testified that "Of course, it is well proven that stress and mental illnesses result from stress…" and even suggested that the medical profession had come to believe that diabetes resulted from stress (p. 98).

To buttress his characterization of the ATCS occupation as inherently stressful, Francke then summarized several studies that were "conducted by responsible bodies over the years." The first study he cited was published by the U.S. Air Force in 1963:

> The second important point which merits special attention is the fatigue and feelings of tension that were reported time after time in interviews with both individuals and groups.… The job is not physically demanding and yet operators talked about spending an unusual amount of time sleeping, particularly after a day of heavy traffic.… However, it was pointed out in interview situations that even experienced men develop tenseness and irritability.

Francke also cited an even earlier study, conducted by the Royal Norwegian Air Force Aeromedical Institute in 1949, as evidence of the inherent stress and strain of the ATCS job:

> If one thinks of the concentration and strain which the air traffic controller goes through during rush periods and the constant anxiety in view of the serious consequences which may result from a mistake, these are typical psychological factors which have proved to be contributory causes of digestive disorders (dyspepsia) and gastric ulcer. To this is added the fact that the work is carried out in watches at widely differing hours which has a very disturbing effect upon the bodily functions.
>
> (Quoted by Francke, Hearings, p. 99.)

These two studies cited by Francke explicitly pointed to three factors contributing to the inherent stress and strain of the job: (a) workload (especially during rush periods); (b) the inherent responsibility of the position; and (c) shiftwork. The primary evidence for stress among controllers consisted of observed and self-reports of tension, anxiety, trouble sleeping, and the incidence of "digestive disorders."

Francke next cited a joint Flight Safety Foundation (FSF)-FAA (1959) study as providing evidence that the "major air traffic control problem lay in the area of subjective" rather than objective fatigue (Hearings, p. 99). In his view, the FSF/FAA study showed "that the controller's job carried inherent mental stresses and that the psychological and emotional factors were the major ones governing controller fatigue." Moreover, Francke testified that

> The foundation found that the almost continuous responsibility for the proper separation of aircraft, accompanied by the fear of the consequences of mistakes was the major underlying cause of controller fatigue. "Without laboring the point," the FSF concluded, "there is a growing body of evidence in the medical and scientific literature that such anxieties or fears are producing reactions similar to what has been defined here as subjective fatigue, and furthermore will lead to real psychological impairment of individuals over periods of time" (Hearings, p. 99-100).

To further support his argument, Francke next cited an FAA Office of Aviation Medicine (OAM) study of the self-reported symptoms often associated with stress (Hauty, Trites, & Berkley, 1965a,b). In his testimony, Francke characterized the FAA study as having found "a startling increase in the incidents of stress-related symptoms with an increase in ATC experience" (Hearings, p. 100). He concluded that the study results showed that the pressures of the ATCS job began "to affect a controller's health significantly after the age of 40, and to a steadily increasing degree as his years of service as a controller increase" (p. 100).

His testimony continued in this vein with a lengthy excerpt from an unidentified 1969 Office of Aviation Medicine report on controller stress. The quote asserted that as traffic density increased, the stress level rose correspondingly and that ultimately, the stress level that controllers could tolerate would become the "limiting factor on the workload that the system can handle with safety" (Hearings, p. 101). The report suggested that the point in time at which a controller's traffic handling capabilities began to decline depended, at least in part, on two factors: (a) "the type of management" that had been exercised over the controller; and (b) "the amount of stress" experienced by the controller up to that point.

Evidence for Inherent Stress

While much of the testimony offered in 1971 was anecdotal or personal, objective studies were available. Francke cited four specific studies in his testimony as supporting the hypothesis that the air traffic controller job was inherently stressful: a 1963 U.S. Air Force study; the 1949 study for the Royal Norwegian Air Force; an unidentified 1969 OAM report; and the 1965 studies by Hauty et al. The 1963 U.S. Air Force and 1965 Hauty et al. studies were located and reviewed; the cited 1949 Norwegian and 1969 OAM reports could not be located due to a lack of identifying information in the testimony.

Other primary sources of information available to the agency in 1971, but not cited in testimony, included:

- a study of controller performance measures (Nagay, 1949);
- a National Research Council report (Fitts, 1951);
- the Congressionally-mandated FSF studies of controllers (FSF, 1958, 1959);
- the Air Traffic Controller Career Committee (1970) report;
- a study of physiological indicators of stress (Hale, Williams, Smith, & Melton, 1971); and
- a study of self-reported symptoms (Dougherty, Trites, & Dille, 1965).

The FSF studies led directly to the establishment of the Controller Health Program. Each of these primary sources, including the U.S. Air Force and the Hauty et al. (1965a,b) studies cited by Francke in his testimony, and the Controller Health Program, will be summarized below.

Nagay (1949). The American Institutes for Research (AIR) contracted with the Civil Aeronautics Administration for the development of measures to assess the proficiency of en route air traffic controllers. In the first phase of the work, the research team made observations every 15 seconds of the activity of controllers during three watches at two air route traffic control centers. Nagay noted that less time was spent in the 2nd half of the watch on interphone activities than in the 1st half; no other differences in activities were noted. However, apparently on the basis of this decline in interphone activities across the watch, Nagay's study was cited by the 1963 U.S. Air Force study as evidence of the fatiguing nature of the controller job.

National Research Council. The National Research Council (NRC) Committee on Aviation Psychology prepared a report "on the application of the principles and techniques of human engineering to the improvement of the air-navigation and traffic-control systems" (Fitts, 1951, p. iv). The report was not a direct study of age, stress, or performance but described what are now termed human factors concerns and issues in the design, development, and operation of the air traffic control system. The report cited the perception that younger men were more suited to the demands of air traffic control without attribution or supporting data (p. 10). The committee conducted site visits and interviews with controllers at a number of facilities as part of the fact-finding process. Inquiries were made as to the personnel and personal problems controllers experienced as a consequence of the job. Only 3 of 35 center controllers mentioned a concern relevant to the rationales given for age 56, and that was phrased as "early disability requiring semi-retirement" (Table II, p. 70). None of the 25 tower controllers interviewed mentioned any personnel or personal factor relevant to the rationales articulated in support of mandatory separation at age 56 in the 1971 testimony.

FSF study of controllers. In 1956, the U.S. Congress appropriated funds "to provide for an objective evaluation of current medical standards and their administration" (Flight Safety Foundation, 1958, p. xi). The Civil Aeronautics Administration contracted with the Flight Safety Foundation (FSF) to conduct the investigation, with particular attention to air traffic controllers. The FSF produced two reports in the course of the investigation: (a) *Physical Qualifications for Air Traffic Control Personnel* (FSF, 1958); and *FSF/FAA Air Traffic Control Personnel Study: Effects of Activity and Environment* (FSF, 1959). Data relevant to shiftwork, fatigue, and performance were collected by both on-site observation and a survey. Over 4,000 controllers completed the FSF survey.

The first FSF report (1958) focused on medical qualification standards for the controller occupation. Recommendations in that report included (a) establishing medical qualification standards at hire for all controllers, (b) periodic (annual) medical evaluation of controllers, and (c) establishment of a general health maintenance and protection program for controllers. The second report (FSF, 1959) considered in more detail the work performed by controllers, the environment in which the work was performed, and the impact of the work on the controllers. The FSF considered controller fatigue from three perspectives. First, the FSF did not find evidence for "objective fatigue" defined as observable decrements in job performance. However, that negative finding was attributed to the lack of sensitive, reliable, and interpretable measures of job performance. (p. 120). Second, FSF considered evidence of "physiological" fatigue. Evidence for visual fatigue, particularly for radar controllers, was found in the form of changes in visual test scores pre- and post-shift (p. 122). However, findings of "physiological" fatigue "from blood pressure and pulse rates were negative" (p. 122). Finally, the FSF considered evidence for "subjective" or "psychological" fatigue. In a rational analysis, the FSF researchers constructed the case for "psychological" fatigue among controllers (pp. 123-125). First, they noted the difficult environmental conditions, including noise, temperature, and illumination problems as a likely source of subjective fatigue among controllers. Personnel practices, as highlighted in the survey, were next cited as factors contributing to controller fatigue. These factors included dissatisfaction with working schedules, supervisory practices, pay and retirement provisions, and "a feeling of being 'let down' by superiors in cases of disputes between ATC and others" (p. 124). The FSF concluded that "the overall work situation is one that is conducive to 'Subjective Fatigue'" (p. 124).

U.S. Air Force (1963). The U.S. Air Force air traffic control tower operator (CTO) was the focus of a field survey conducted in the midst of a significant expansion of the Air Force. An investigation of the adequacy of controller training methods in use at the time was requested in order to increase the effectiveness of the CTO program (U.S. Air Force, p. 1). A six-item open-ended questionnaire was administered to 99 Air Force controllers as part of the data collection effort to identify CTO job requirements. Other data sources included interviews, published reports, and observations of the CTO job. Drawing on these data, the study authors highlighted fatigue and tension among the controllers as an area of concern (p. 11). There appeared to be no obvious physical explanation for the fatigue and tension reported by controllers in both individual and group interviews. The authors recommended further study of these feelings of fatigue and tension in relation to job proficiency, time on the job, and age (p. 13).

Controller Health Program. The FSF studies were the impetus for the establishment of the Controller Health Program. The FSF concluded that medical qualification standards were needed for the occupation and should be tailored to the particular demands of the position (Holbrook, 1974). In addition, periodic (annual) examinations were recommended to ensure that controllers were fit for duty as part of a health maintenance program. The Controller Health Program was implemented in October 1965 to provide continuing medical observation of controllers "oriented toward the maintenance of both employee health and system safety" (FAA, 1965, 1966). The medical examination for controllers given under the auspices of the CHP ensured that controllers at any age met minimum physical and medical standards.

Air Traffic Controller Career Committee. One of the tasks of the Air Traffic Controller Career Committee was to determine the "true nature and extent" of occupational stress among controllers and assess its importance relative to other problems in the occupation (Air Traffic Controller Career Committee, 1970, Appendix XVII). The operational question was, "Is there evidence that job-related stress has a significant effect on the psychophysiological condition of the FAA air traffic controller?" Three classes of data were considered by the Committee as evidence of job-related stress among controllers: (a) anecdotal, personal experiences of incumbent controllers; (b) statistical data on the incidence of medical disorders and retirement; and (c) preliminary data from an assessment of biochemical markers of the stress response of controllers under actual working conditions.

The Committee described two kinds or sources of job-related stress among controllers, based on anecdotal reports and discussions with controllers. The first source was sudden emergency events that occurred while controlling traffic. The second source appeared to be a sense of personal inadequacy "to cope with the overall demands of the job" (Air Traffic Controller Career Committee, Appendix XVII, p. 2). Controllers described both acute and chronic anxiety reactions. While acknowledging that there may have been instances of exaggeration or embellishment, the Committee felt that the reports made by controllers were credible, valid, and candid. The Committee concluded that the controller self-reports were "impressive evidence that the air traffic controller job imposes, at least on occasion, conditions which are highly stressful to the employees" (*ibid*).

The second class of evidence considered by the Air Traffic Controller Career Committee was medical statistics. The Committee considered two sets of data: (a) the incidence rate of specific disorders among controllers compared to other occupational groups; and (b) medical disability retirements. The disorders of interest to the Committee were coronary artery disease, coronary thrombosis, hypertension, and peptic ulcer, which were then "all generally regarded as more or less stress-related illnesses" (p. 3). The Committee reported that the incidence rate for these disorders among controllers was 1.5 to 4 times higher than comparable rates for civil airmen and up to 8 times higher than rates for Air Force pilots age 35 to 39. The Committee noted that comparisons may have not been statistically valid since identical medical diagnostic criteria and examination techniques were not used for the comparison groups. However, the Committee went on to reason that the higher incidence rate, compared with groups subject to similar annual examinations, was "in keeping with the expected findings, if one postulates the presence of a high degree of occupational stress among air traffic controllers" (*ibid*). In other words, if one accepted two premises – (1) the air traffic controller occupation was stressful, and (2) the disorders such as coronary artery disease, coronary thrombosis, hypertension, and peptic ulcer were "caused" by stress – then the finding of a higher incidence of "stress-related" disorders among controllers is evidence that the occupation is highly stressful.

Medical disability retirement data for calendar years 1967 through 1969 were also examined by the Air Traffic Controller Career Committee in an appendix titled "Review of Medical Information Regarding Occupational Stress Among FAA Air Traffic Controllers." On one hand, controllers accounted for 45% of the agency workforce in those three years and 45% of all the medical disability retirements. In other words, the rate of medical disability retirement for controllers was proportionate to their representation in the workforce. On the other hand, air traffic controllers accounted for 67% of all medical disability retirements among employees under age 45. In other words, the rate of medical disability retirement for younger controllers appeared to be disproportionate to their representation in the workforce. The Committee concluded, in view of the anecdotal reports, the higher incidence rate for "stress-related" disorders among controllers, and the disproportionate rate of medical disability retirement for younger controllers, that there was "a significant degree of stress associated with the air traffic control occupation" (p. 3-4).

The third class of supporting evidence examined by the Committee was a study of stress indices among controllers at the Chicago O'Hare terminal. That study was conducted in the summer of 1968 and involved 22 controllers. Several physiological and biochemical measures were collected, including epinephrine, norepinephrine, and 17-hydroxycorticosteroid, a metabolite of cortisol. The Committee compared the relative magnitude of change in excretion of these hormones with that of Mercury astronauts. A direct comparison of concentrations of the hormones could not be made due to differences in assay methods between the two programs. Based on this comparison and the opinion of a medical doctor serving on the Air Traffic Controller Career Committee, the Committee concluded that these data provided "clear-cut evidence of a strong biochemical response by the Air Traffic Controller personnel … to conditions which were perceived within their bodies as acutely stressful" (ibid, p. 5). The results of the Chicago O'Hare study were published as an OAM technical report (Melton, McKenzie, Polis, Funkhouser, & Iampietro, 1971). A parallel study was published in *Aerospace Medicine* (Hale, Williams, Smith, & Melton, 1971) prior to the March 1971 Congressional hearings.

Physiological indicators of stress. While the Air Traffic Controller Career Committee focused on the hormonal indicators related to the stress response, Melton and colleagues (Melton et al., 1971) investigated other measures, including heart-rate, galvanic skin response (GSR), blood pressure, fibrinogen (e.g., blood clotting factors), and phospholipids (e.g., serum fats such as cholesterol, low-density and high-density lipids). The involuntary, physiological response of controllers to their work was "assumed to arise from their concern for the consequences of their instructions" as the actual physical component of the job was relatively light (p. 7). Heart rates were higher during periods of higher workload (upwards of 200 aircraft per hour) in the evening than under lighter workload (< 25 aircraft per hour) in morning shifts. GSR is a nonspecific response to events or stimuli that are attention-getting, arousing, exciting, or emotional. GSR, measured as electrical resistance, decreases in response to stimulating events. GSR increased over the 5-day observation on the morning shift but not on the evening shift. Melton et al. interpreted this as indicating that the controllers were adapting to the workload on the morning shift but not the evening shift. In other words, the controllers were more reactive to stimuli on the evening shift. Average pre- and post-shift blood pressures were not different from each other, and overall, the controllers were not hypertensive. Controllers were normal with respect to the assessment of fibrinogen. However, the controller phospholipid profile was significantly higher than in non-controller occupations. Phospholipids were associated with the sustained action and excretion of catecholamines such as 17-hydroxycorticosteroid. Melton et al. concluded that the measures indicated that the O'Hare controllers were "generally in a state of sympathetic [nervous system] excitation, particularly on the evening shift" (p. 10). Melton et al. found that controllers, particularly under heavier workload, were physiologically aroused or excited, where such arousal is a requirement for performance under demanding conditions.

The work published by Hale, Williams, Smith, and Melton (1971) focused on three hormones. Urinary epinephrine provided evidence of work-associated adreno-medullary hyperactivity, where such hyperactivity is considered a sign of stress (p. 129). This adreno-medullary response was characterized as "early in onset and progressive in intensity" regardless of shift (p. 129). Urinary norepinephrine provided evidence of work-associated hyperactivity in the sympathetic nervous system, where such hyperactivity is considered another sign of stress (p. 130). Hale et al. found that the pattern of norepinephrine excretion corroborated their findings on epinephrine: arousal and hyperactivity of the sympathetic nervous system associated with working traffic. Hale et al. found that 17-hydroxycorticosteroid output "fell during the period of work load decrease (late evening) and rose during the period of work load increase (late morning)" (p. 133).

Hale et al. compared the excretion patterns of controllers in their sample to those of other occupational groups. By one measure (epinephrine), the morning shift "induced a higher degree of stress … than resulted from unusually long or difficult flying operations" (p. 135). However, the authors went on to note that the "stress induced by the early evening work in the O'Hare tower (the heaviest load of the entire day) was of moderate degree, exceeding slightly the levels established for aircrewmembers during flights of unusual length or difficulty" (p. 135). By another measure (17-hydroxycorticosteroid), the authors characterized the morning shift as "fairly stressful," approaching the levels induced by 10-hour transpacific flights in a military aircraft (p. 136). The evening shift produced a level in the same range as the 10-hour transpacific flight.

Self-reported symptoms of stress. Hauty, Trites and Berkley (1965b) obtained data from incumbent controllers from 6 air route control centers and 6 high- and medium-activity terminals. Controllers completed a self-report inventory of symptoms thought of "as being related to or induced by stress" (p. 4). The symptoms were:

- Headache
- Dizziness
- Constipation
- Sweating
- Twitching muscles
- Poor appetite
- Chest pains
- Loose bowels
- Loss of temper
- Difficulty in breathing
- Aching or burning eyes
- Indigestion or heartburn
- Difficulty staying awake
- Stiffness or body tenseness
- Bothered by distracting noise
- Nausea or sick to your stomach
- Asthma
- Insomnia (Pre-shift only)
- Nightmares (Pre-shift only)
- None

There were 300 participants at the start of the study, with data collected over 90 days. By the end of the first 30 days of the study, some subjects had dropped out, leaving 273 participants. At 60 days, there were 250 participants, and by day 90, the number of participants had been reduced by almost a third, to 201 incumbent controllers.

While Francke characterized the participants in his 1971 testimony as having been "*tested* … to ascertain the number of days on which they experienced various incidents of stress" (emphasis added), the data were in fact daily *self-reports* of symptoms experienced pre- and post-shift. The primary measure reported by the study authors was the proportion of days for which at least one symptom was experienced by any controller. Note that data were pooled across both subjects and days for this analysis. Analyses consisted of inspection of graphs of the proportion by facility, pre- and post-shift, by age group, by experience group, and by the combination of age and experience; no formal statistical analyses were reported.

Hauty et al. (1965b) found on visual inspection of the graphs of the proportion of days for which at least one symptom was reported (by any controller) was generally highest "for those symptoms most likely to be judged as being stress-induced or related; further, the incidence of these particular symptoms is generally greater following a work shift" (p. 4). They then grouped the participants into three age groups (20-29, 30-39, 40 and over) and three experience groups (3 years or less, 4-10 years, 11 or greater). They reported that "the percentage of reported physical symptoms increases as air traffic control experience increases, but a similar increase does not appear in the groupings of subjects by age" (p. 4). The researchers regrouped the data into nine age-experience subgroups and re-examined the proportion of days for which at least one symptom was reported (by any controller). The authors concluded that, although age and experience are both related to the incidence of reported symptoms as they are covariants, length of expericnce was the factor "most highly and systematically related to such symptoms."

Another study conducted at about the same time as the Hauty et al. work specifically compared the incidence of new symptoms in controllers with non-controllers in the FAA. This study by Dougherty, Trites, and Dille (1965) was not cited in the 1971 testimony before either the U.S. House of Representatives or the U.S. Senate Post Office and Civil Service Committees in hearings on the controller career legislation. As noted by Dougherty et al., the impact of air traffic control work on the health of the controllers had been of concern to the FAA for some years and led to the establishment of the Controller Health Program. While the belief that the inherent stress of the job had an adverse effect was widely held, there was "little objective evidence on which an evaluation of this belief" could be based (p. 956). This study was an attempt to evaluate the impact of the work of controllers on their health. Dougherty et al. collected survey data from participants in a regional health awareness program, resulting in a sample of 569 controllers and 330 non-controllers. Six symptoms were listed in the questionnaire:

- Frequent or severe headaches
- High blood pressure
- Frequent indigestion or stomach pain requiring antacids or milk over several days period
- Chest pain on exertion relieved by rest
- Taken tranquilizers for more than one week
- A physician's diagnosis of ulcer

The symptoms were listed on the left side of the questionnaire form, with spaces for responses on the right side. Respondents were required to make two responses to each symptom, one indicating the presence or absence of a symptom prior to becoming an FAA employee, and the other indicating presence or absence of a symptom after becoming an FAA employee. The analysis focused on those symptoms for each respondent that were marked as being present after joining the FAA but not present or experienced prior to becoming an employee. The data were analyzed as multi-way contingency tables with the techniques available at the time, where cell entries were expressed as rates (number reporting a symptom per 1,000 persons). The proportion of "new symptoms" was computed for each cell entry as well.

For example, the rate for headaches among controllers was 135 instances per 1,000 controllers, with 74% of those instances being "new symptoms." In comparison, the incidence rate for headache among non-controllers was 61 instances per 1,000 persons, with just 35% of those being "new symptoms." The headache incidence rate for controllers was significantly greater than the rate for non-controllers ($p < .001$; Table III, p. 957). Overall, the incidence rates for headache, indigestion, chest pain, and ulcer were significantly greater for controllers than incidence rates for non-controllers. Subsequent analyses focused on the incidence rate of new symptoms in relation to age and experience. For example, incidence rate were about the same for new symptoms for controllers and non-controllers with 3 years or less experience. However, incidence rates increased with experience for controllers but not for the non-controllers. The incidence rate for new symptoms was stable across age groups for controllers but declined with age for non-controllers. The authors reached essentially the same conclusion as Hauty et al. (1965a,b): the incidence of stress-related symptoms increases with experience for controllers but not necessarily with age. Moreover, by including data from non-controllers, Dougherty et al. were also able to conclude that the incidence rate for controllers of stress-related symptoms was greater than the rate for non-controllers. They concluded that the data supported "the contention of Air Traffic Controllers [sic] that their occupation subjects them to unusual stress" as evidenced by the incidence of symptoms (p. 960).

Evaluation of Evidence for Inherent Stress

To what degree did the scientific data available at the time support or justify the conclusion that the controller job was inherently stressful? There were five classes of data available in 1971 from the studies cited in testimony and the other primary sources described above:

- Controller self-reports, anecdotes, and descriptions of job-related stress;
- Activity analysis data indicating the fatiguing nature of the job;
- Medical disability retirements;
- Self-reported "stress-related" symptoms; and
- Biochemical markers of a stress response.

Self-reports of occupational stress. Clearly, the experience of the incumbent controllers reported by the Air Traffic Controller Career Committee and in the Congressional testimony in 1971 cannot be denied. However, these anecdotes and descriptions were not collected in a systematic fashion, with appropriate controls for response bias, exaggeration, and systematic sampling across facilities, shifts, and positions. Therefore, while informative, they do not constitute scientific data with any great probative value on the question of the inherent stress of the occupation. Rather, they are suggestive, but not definitive.

Activity analysis data. The primary source for job or activity analysis data are the Nagay (1949) and FSF (1958, 1959) reports. Despite the citation by the 1963 U.S. Air Force report as finding evidence for fatigue, Nagay (1949, p. 19) hedged the analysis of the observed differences in activities across shifts: "Whether the difference is also partly the result of fatigue, of errors due to sampling or some other factor not readily discernible is not known." Moreover, his report did not speak to any differences in activities or fatigue as a function of age.

The 1958 and 1959 FSF studies of controllers and their working conditions are another primary source for evidence of the fatiguing nature of the controller job. More than 4,000 controllers responded to the survey of job-related factors conducted by FSF. However, the FSF report did not analyze the activity or survey data with respect to controller age. Nor were any conclusions about the relative vulnerability of older controllers to the effects of fatigue presented. The only reference to age was in the recommendations of the first report to conduct further research on "aging and its relationship to proficiency" (p. 87). Overall, the FSF reports presented some data to indicate that the controller job was, unsurprisingly, demanding and tiring. The second FSF report made the argument that the fatigue was psychological in nature, rather than physical, but did so on the basis of a logical chain of reasoning rather than on the basis of empirical data. Neither report presented data about fatigue and age or the cumulative effects of fatigue with reference to older controllers.

Medical disability retirements. The two sources of information about medical disability retirements are the Fitts (1951) report and the report of the Air Traffic Controller Career Committee (1970). The probative value of the reports depends, in part, on acceptance of the assumption that reported disability retirements can be attributed to stress-related disorders rather than to disabilities resulting from accidents or disease.

Considering that just 3 out of 60 respondents mentioned disability, overall, the Fitts (1951) report does not provide substantive empirical or scientific data indicating that controllers took disability retirement as a consequence of job stress at a greater rate than any other group. In fact, no comparisons were made. Moreover, the report does not consider the diagnoses underlying the "semi-retirement" cited by the three controllers. Overall, the Fitts report has little probative value in justifying the argument that job stress results in early disability retirement for controllers at a greater rate than would be expected for the general population.

The Air Traffic Controller Career Committee report (1970) also implicitly linked disability retirements and stress by placing the analysis of retirements in an appendix with the words "occupational stress" in the title. In addition to accepting the assumption that all disability retirements were a consequence of job-related stress rather than accident or disease, the Air Traffic Controller Career Committee analysis depended on a comparison of percentages without knowing the underlying numbers involved. Specifically, the Career Committee asserted that the rate of disability retirement for controllers less than age 45 was disproportionate to their representation in the workforce (Appendix XVII, p. 3). That is, 67% of medical disability retirements between 1967 and 1969 were for controllers less than age 45, compared with their overall 45% representation in the FAA workforce in 1970. This comparison, however, is somewhat misleading for two reasons. First, the appropriate comparison was not to the percentage of the overall FAA workforce represented by controllers (45%) but to the percentage of the overall FAA workforce under age 45. Second, the apparent difference (45% of the overall FAA workforce, 67% of medical disability retirements for employees age 45 and under) may or may not be statistically significant. The actual numbers of persons in each category – controllers under age 45, medically retired controllers under age 45, FAA employees under age 45, medically retired non-controllers under age 45 – are needed to determine if the proportions were significantly different. So, again, while informative, the medical disability retirements data are suggestive but they are not definitive.

Self-reported "stress-related" symptoms. The assumption underlying the OAM studies of self-reported symptoms was that overt symptoms such as headache and tenseness were induced by the job. The credibility of those studies depends upon acceptance of that assumption. However, alternative explanations are possible, including eye-strain due to poor illumination and poor equipment design, as documented in the Fitts (1951) review and the 1959 FSF study of the controller working environment. Another explanation for overt symptoms might be undiagnosed or unreported underlying medical conditions.

Moreover, there are several problems with the analyses reported by Hauty et al. even within the limits of statistical techniques available in the mid-1960s. First, Hauty et al. did not compare the incidence rate for a given symptom with its base rate of occurrence in the general population. It may be the case that the prevalence rate for controllers for any given symptom is no greater (or less) than the "natural" prevalence rate; Hauty et al. simply did not make the comparisons. The second major problem is the lack of appropriate statistical analyses in the comparison of symptom prevalence rates by age and experience groupings, particularly in view of the relatively fewer older controllers. Third, Hauty et al. did not compare the symptom prevalence rate for controllers with the prevalence rate in other shift workers. Fourth, Hauty et al. assumed that the symptoms were stress-related, and made no assessment of the baseline health of the participants. As a consequence, it is not clear to what degree the incidence of a given symptom – say headache – was a function of underlying pathology such as essential hypertension or of exposure to the job. These methodological problems reduce the probative value of the Hauty et al. studies as evidence of the inherent stress associated with air traffic control. In short, the studies by Hauty et al. are descriptive in nature rather than inferential.

The Dougherty et al. study provided at least some measure of control for the base rate of symptoms by comparing the symptom incidence rate for controllers with the rate for non-controllers in the FAA. It also used inferential statistics for comparisons of controllers with non-controllers. However, the Dougherty et al. study is vulnerable to the same criticisms made of the Hauty et al. studies. The Dougherty et al. work appears to assume, as did Hauty, that overt symptoms were "stress-related." While statistical comparisons were made between FAA employee groups (e.g., ATCS and non-ATCS), no comparisons of incidence rates to rates observed in the general population were presented. Moreover, the reference group (non-ATCS FAA and CAA employees) for comparisons did not include employees working rotating shifts similar to those of controllers. Persons working shifts generally have higher prevalence rates of digestive and cardiovascular complaints than persons working traditional day shifts only (Smith, Folkard, & Fuller, 2003). The apparent higher rate for symptoms, therefore, may have been confounded with shiftwork. Overall the Dougherty et al. study is not entirely persuasive as evidence that the controller job is inherently stressful.

Biochemical indicators of stress. The last class of scientific evidence available in 1971 consisted of analyses of biochemical and physiologic measures taken on controllers working at Chicago O'Hare tower. Overall, the biochemical evidence presented by Melton et al. (1971) and Hale et al. (1971) clearly indicated that the work of an air traffic controller had physical consequences in terms of arousal of the adreno-medullary and sympathetic nervous systems. For example, higher heart rates were recorded during evening shifts with as many as 200 operations per hour than on morning shifts with as few as 25 operations per hour. At the time, elevations in specific hormones, heart rate, and other physiological indicators were interpreted as evidence of a stress response. Carefully collected and analyzed, these data are the most persuasive in supporting the conclusion that the work of an air traffic controller was inherently stressful.

Loss of Proficiency With Age

Testimony

Francke's influential testimony takes up the theme that controllers lose proficiency with age by citing a 1967 Office of Aviation Medicine study (Cobb, 1967). Francke characterized the study as finding that "job performance generally tended to increase up to age 41, and up to 11 years of experience, and then steadily deteriorated" (Hearings, p. 100).

Continuing the theme of age and performance, Francke cites "another" FAA study reporting that 40% of controllers age 40 and over were rated as unsatisfactory or barely acceptable while only 11% of those between ages 26 and 30 were rated in the same way. The cited study also reported that failure rates in training increased from a low of 19% for ages 20 to 25 to 86% of trainees age 45 or over.

Evidence for Loss of Proficiency with Age

A primary thrust of testimony offered in 1971 and 1972 was that air traffic control was "a young man's game." This theme had been sounded repeatedly through the years. For example, the National Research Council Committee on Aviation Psychology (Fitts, 1951) reported that:

> Most traffic controllers today believe that their jobs can be done only by fairly young men. Many controllers told us that fifteen years is considered to be a long time to work as a traffic controller (p. 10).

The scientific foundation for this perception was a series of studies conducted by Bart B. Cobb, David K. Trites, and colleagues at the Civil Aeromedical Research Institute (CARI). The principal focus of the research conducted by Cobb and Trites was on the selection of air traffic controllers. Cobb, Trites, and colleagues investigated the validity of aptitude tests as predictors of ATCS training outcomes and job performance. In addition, they also investigated other individual or biographical characteristics such as background, previous experience, and age. Prior to passage of P.L. 92-297, there was no maximum age at entry restriction for the ATCS occupation. As a consequence, applicants as old as about age 45 entered into ATCS training throughout the 1960s.

In the first study, Trites (1961) obtained job performance evaluations made by supervisors of 149 controllers initially trained in 1956. Trites reported a correlation of $r_{xy} = -.23$ ($N = 149$, $p < .01$) between age and average supervisor rating. From this, he inferred that older trainees were not as likely as younger classmates to be considered by supervisors as being among the better controllers. Another study in 1962 (Trites & Cobb) specifically focused on the relationship of age with training and job performance. In five samples of ATCS trainees, the correlation between age and a composite of academic and laboratory grades in training was $r_{xy} = -.38$ for 126 trainees from 1960, and $r_{xy} = -.31$ for 183 trainings from 1961. The researchers pooled the data from 319 trainees in 10 en route and 7 terminal classes conducted in 1960 and 1961, and examined job-related outcomes. Of the 41 persons in the 39-45 age bracket, 48% (or 20) failed ATCS training at some point. Just 15% of these older controllers were considered "satisfactory," compared to 55% of 181 persons in the 21-26 age bracket (Figure 7, p. 9). Trites and Cobb concluded that there was "no doubt" that training failures could be reduced by specifying a maximum age for entry into air traffic controller training. They also recommended, on the basis of their analysis, that an upper age limit (for retention) be established as well (p. 10).

Trites continued this line of work with a 1965 study investigating the interaction of age at entry with intellectual and personality characteristics. A large number of aptitude and personality tests were administered to more than 900 en route and terminal trainees ranging in age from 21 to about 46. The age distribution was bi-modal, with the first peak in the mid-20s and a second, but much lower peak around 40. Based on a correlational analysis, Trites reported that (a) older trainees had lower test scores on measures of immediate memory and non-verbal abstract reasoning, (b) older trainees scored higher on arithmetic and verbal ability than younger trainees, and (c) older trainees did less well on speeded tests. Trites attributed the higher failure rate among older trainees, in part, to "inferior aptitudes for non-verbal abstract reasoning, memory for new material, and by the inability to work as rapidly and accurately as required in training and on the job" (Trites, 1965, p. 1193).

Francke cited Cobb's 1967 study of age and job performance in particular as justifying a maximum retention age. In that study, supervisory performance ratings on a total of 568 en route controllers were collected at four air route traffic control centers (ARTCCs) at least five years after entry into the ATCS occupation. Correlations of chronological age at the time of rating with various alternative combinations of supervisory ratings ranged from $r_{xy} = -.14$ ($N = 525$) to $-.19$ ($N = 568$). The ratings were uncorrelated with "experience," defined as length of service as an ATCS (5 to 11 years); length of experience was correlated ($r_{xy} = .45$, $N = 568$) with chronological age. As 75% of the subjects were between 28 and 35 years, Cobb conducted an analysis of variance (ANOVA) of performance ratings by age. Five age and five experience groups were used. Overall, Cobb found that the mean performance rating declined from youngest to oldest. He reported that the mean performance ratings for the two oldest groups (41-45, 46 and over) were significantly lower than the ratings for the two youngest groups (ages 30 or less, 31-35). However, due to sparseness of data for some of the age-experience combinations, Cobb could not formally examine the statistical interaction of age and experience. However, he did present a graphical analysis contrasting the mean performance ratings for controllers age 41 and older, versus those for controllers age 40 and under, by experience. He found younger controllers consistently had higher mean performance ratings than older controllers across all experience groupings. He concluded that job performance ratings tended to improve with length of ATC experience for journeyman controllers younger than age 41 but not for older controllers. In discussing these results, Cobb pointed out their consistency with previous research indicating that the older a person was at entry into the occupation, the more likely he or she was to separate, change occupations, or be rated less satisfactorily. Cobb noted that additional research into the reasons why older controllers received lower ratings was required. Moreover, he plainly said that, on one hand, it was "possible that the ratings have been biased by attitudes regarding age" but that on the other hand older controllers may have simply been less proficient than younger controllers (p. 9).

Evaluation of Evidence for Loss of Proficiency with Age

Overall, the objective evidence available in 1971 spoke more to the difficulty of acquiring proficiency with age than to the loss of proficiency with age. The studies by Trites and Cobb clearly demonstrated that older trainees were less likely to be successful than younger persons. The studies of job performance are less compelling for two reasons. First, the studies relied solely upon subjective, global assessments of job performance, rather than objective measures of core technical performance. As noted by Cobb (1967, 1968), such subjective ratings are vulnerable to biases. Second, the studies of job performance are cross-sectional in design, not longitudinal. In each case, a measure of job performance was obtained at a single point in time. The traditional correlational and regression analyses, by definition, modeled the effects of the predictors (age, aptitude, other biographical factors) on the mean criterion score. These analyses did not investigate within-individual change (in performance) over time. As a result, these studies do not provide any evidence about at what particular age, if any, controllers begin to lose proficiency. Overall, these studies are not persuasive in making the case that controllers lose proficiency with age.

ATCS Medical Retirements

Testimony

Testimony presented in 1971 also suggested that controllers took medical retirement at an earlier age than "average agency employees." For example, the Federal Air Surgeon testified that between 1966 and 1970, there were 538 medical retirements of controllers in towers, centers, and stations (Hearings, p. 11). The medical retirements data, as presented in the written testimony of the President of the National Association of Air Traffic Specialists (NAATS), is reproduced in Table 1.

The medical specialist for PATCO testified in the same 1971 hearing that there were 65 cases of journeyman controllers in their 30s and early 40s in Chicago that applied for (mostly temporary) disability, blaming tension, physical, and mental problems of the job. The 1970 Air Traffic Controller Career Committee report was cited by the President of the National Association of Government Employees (NAGE) in his 1971 testimony before Congress in support of the perception that controllers were younger than average at medical retirement:

> 3. The average age at which disability retirements are made [are] lower for air traffic controllers than for all other FAA personnel. For example, of those under age fifty, retiring for disability, fifty-four percent are controllers; forty-five percent are other; between the ages of twenty and forty-four, sixty-seven percent are controllers, while only thirty-three percent are other (and here the report notes that controllers approximate forty-five percent of the total FAA work force).
>
> 4. Nervous and psychological reasons accounted for thirty-eight percent of the controller disability retirements during FY67-69, compared to only twenty percent for other FAA employees (Hearings, p. 77).

Evidence for Medical Retirements

Aside from the data offered at testimony and the data presented in the 1970 Air Traffic Controller Career Committee report, there do not appear to have been any published systematic studies of medical retirements available in 1971. Nor were data from annual controller medical examinations analyzed to determine the prevalence or incidence rates for disabling, chronic, or stress-related disorders and diseases.

Evaluation of Evidence for Medical Retirements

The essential argument made in 1971 on the basis of medical retirements data presented in testimony and in the Air Traffic Controller Career Committee report were that (a) disability retirements were a consequence of job-related stress, and (b) younger controllers made up a disproportionate number of medical retirements compared with their representation in the workforce. But as noted in the previous discussion of Fitts (1951) and the Air Traffic Controller Career Committee report, the comparisons offered in testimony and in these reports were misleading. First, disability retirements may have resulted from injury, accident, and chronic diseases unrelated to stress; it was misleading to assume that all disability retirements were stress-related. Second, the raw percentages themselves were uninformative without knowing the actual numbers of persons involved. Therefore, while informative, the medical disability retirements data were suggestive but were not definitive.

Evidence Available After 1971

Substantial research has been conducted on the ATCS and other occupations since passage of P.L. 92-297. Moreover, there have been significant advances in the understanding of the etiology of hypertensive and other cardiovascular disorders. Models of job-related stress, and their linkage to health outcomes, have also been transformed through research. For example, stress is no longer conceptualized as an entirely negative factor (Nelson & Simmons, 2003). Finally, the significant role of genetics, personality, and lifestyle choices such as cigarette smoking and individual differences such as weight in disease etiology have been highlighted. The purpose of this section is to summarize relevant research conducted since 1971 with respect to the three principal themes underlying the

"ATCS Age 56 Law": (a) inherent occupational stress; (b) medical conditions and retirements; and (c) loss of proficiency with age.

Inherent Occupational Stress

Research on physiological or biochemical markers of air traffic controllers continued throughout the 1970s, resulting in multiple OAM technical reports. C. E Melton summarized the ten-years of research on physiological stress in controllers in an OAM technical report published in 1982. In setting the stage, Melton noted that the 1956 mid-air collision over the Grand Canyon aroused substantial concern about the "crowded sky." These concerns increased in the late 1950s by the introduction of jet airliners and questions about the adequacy of the ATC system to provide safe separation for aircraft flying at higher altitudes and ever greater speeds. Controllers felt under intense pressure and complained of task overload and excessive responsibility. The word "stress" began to be more and more closely and frequently associated in the public's mind with air traffic control. In response, the FAA developed a two-pronged research program. The first line of research focused on the assessment and quantification of stress among controllers. The second line of research focused on the assessment of changes in controller health over time as a consequence of the work. Essentially, the two lines of research addressed the questions, "How much stress do controllers experience?" and "What are the consequences of that stress on controller health?"

How Much Stress

Over the period 1968 through 1978, CAMI conducted a series of multidisciplinary studies to investigate the physiological, biochemical and psychological changes associated with the job of the air traffic controller. The overall pattern for the research was similar for each study. Controllers at selected air traffic control facilities were asked to volunteer to participate in a research study that would last for up to 10 days. Controllers were assessed in these studies with a varied battery of physiological, biochemical, and psychological measures including heart rate, galvanic skin response, urinalysis, blood chemistry, personality, anxiety, and job attitudes. Overall, the CAMI research team conducted 22 field studies at air traffic control facilities and 2 laboratory studies. A total of 402 controllers were evaluated during the research across a spectrum of facility types, levels, and workload. Based on the evidence accumulated in numerous studies, Melton (1982) concluded with respect to the physiological and biochemical measures that controllers were *not* subject to excessive or unusual stress (p. 46-47):

> It should not be inferred from these within-group studies that excessive or unusual levels of stress were present in the ATC work force. Studies of non-ATC populations in which exactly comparable measurements were made are almost nonexistent. However, Hale et al. compared O'Hare ATCS's [sic] (the ATCS's who showed the most stress) with various groups previously studied at the U.S. Air Force School of Aerospace Medicine. They found that ORD ATCS's did not uniformly show greater stress levels than did Air Force aircrews, men undergoing altitude chamber tests, or laboratory scientists off duty at home (citation omitted). Smith et al., using an anxiety inventory, showed that psychological measures remained relatively uniform across facilities and suggested that air traffic work, no matter what the nature of the facility, had no dramatic impact on the psychological states of the controllers. Thus, it is clearly inappropriate from the psychological perspective to describe ATC work, as is commonly done in the popular press, as an unusually stressful occupation. Popularized accounts of controller stress deal with the exceptional rather than the typical controller or facility. Further, such accounts tend to assume that physiological and psychological changes associated with simple workload effects are undesirable and invariably have long-term negative consequences. That assumption is highly questionable, particularly in view of the expressed preference of ATCS's for heavy as opposed to light workloads (reference omitted).

Moreover, results from the administration of the State-Trait Anxiety Inventory (STAI), a well-established measure of anxiety, to controllers at these facilities revealed that controllers in general reported *lower* levels of state and trait anxiety than individuals in other occupations. State anxiety scores increased significantly from the start to the close of a shift schedule, much like they did in other occupational groups. They also noted that the increase in state anxiety was greater for difficult than for easy shifts. Further support for the lower anxiety levels in controllers is found in the Rose, Jenkins, and Hurst (1978) study (discussed below) where 80% of the controllers involved in the longitudinal study evidenced scores on the Tension/Anxiety Scale of the Profile of Mood States that were over a standard deviation below the mean for college students. Likewise, in a study involving 22 different occupations, Caplan et al. (1975) found that the average anxiety and depression scores for two groups of controllers from a facility in the Midwest were near the middle of the 22 occupational groups. In conclusion, Smith and colleagues, using the STAI and other attitudinal measures, also found "… little evidence to support the notion that ATCSs are engaged in an unusually stressful occupation. This is not to say that ATCSs never encounter unusual stress on the job; however, it does appear that this is the exception rather than the rule. ATCSs appear both well qualified and well suited for air traffic control work" (Smith, 1985, pg. 106-7).

Smith (1980) summarized a decade of research on controllers, stress, and anxiety by noting that controllers, on average, have lower trait anxiety scores than the normal adult population. Moreover, state anxiety scores increased from the beginning to the end of work shifts for controllers just as they did in non-ATC jobs such as engineers. He concluded that controllers were "well within normal limits on every indicator of psychological states" and appeared to experience less anxiety than is average in other work settings. More recently, Collins, Schroeder, and Nye (1991) investigated psychological measures of anxiety and found that individuals who entered the FAA Academy screen program and moved on to become successful certified professional controllers reported lower levels of state and trait anxiety than those who were unsuccessful. The levels of state and trait anxiety were also lower than that of the average college student. Data from the 16PF also supports the view that individuals entering the profession are generally less anxious and tense than individuals in general (Schroeder & Dollar, 1997).

Other research focused on identifying and quantifying stress as a function of shiftwork and fatigue. From the beginning, shiftwork and fatigue have been cited as sources of controller stress. For example, Hauty, Trites, and Berkley (1965c) investigated self-reported, stress-related symptoms as a function of shifts. They found that controllers reported a higher incidence of symptoms when there were less than 8 hours between successive shifts. However, the study did not compare the symptom incidence rate for controllers with that of other shift workers. In the 1970s, CAMI researchers investigated changes in physiological and biochemical measures after the introduction of the counter-clockwise rapidly rotating 2-2-1 shift pattern in 1973 (Melton et al., 1973). They found no significant differences on the physiological measures between the shift patterns (straight 5-day and 2-2-1). Moreover, they found that the stress measures did not vary greatly from those found in the general population. More recently, in a field study, Cruz and Della Rocco (1995) compared the sleep quantity and quality for controllers on the 2-2-1 pattern with those of controllers on a 2-1-2 variation. They observed a characteristic decline in sleep quantity through both rotations from about 8 hours to less than 3 hours before the midnight shift. They also reported no significant differences between shift patterns with respect to sleep quality or sleepiness. A laboratory study by Della Rocco and Cruz (1996) compared sleep quantity and quality for two age groups (30-35 and 50-55) on the 2-2-1 rotation. They reported no significant differences by age group. A subsequent study comparing the 2-2-1 rotation with straight days found significant performance decrements on a synthetic work task (the Multiple Task Performance Battery) for both age groups on the night shift. Schroeder, Rosa, Witt and Banks (1995) examined the effects of an alternative work schedule (four 10-hour shifts) with the more common 2-2-1 rotation. In their field study, they found that performance on the National Institute of Occupational Safety and Health fatigue test battery did not differ by shift pattern with the exception of the single midnight shift on the 2-2-1 schedule. Lower performance was observed on the fatigue test battery in the early morning hours at the end of the midnight shift. Controllers on the four 10-hour shifts did not work a midnight shift.

Most recently, CAMI conducted a large-scale survey-based study of controller shiftwork and fatigue in response to a 1999 Congressional directive (Ramos, McCloy & Burnfield, 2001). Occupational stress was assessed in the survey with a single, but straightforward, question: "In general, how stressed do you feel at work?" with responses on a 5-point Likert scale ranging from "Not at All" to "Extremely." This item has been used for several years as part of a nationwide telephone survey of the American workforce conducted by the Harris Interactive (the Harris Poll), thus allowing responses from air traffic controllers to be compared to a statistically representative sample of U.S. employees. The responses of terminal and en route Certified Professional Controllers (CPCs) and Flight Service Station controllers (FSS) are illustrated in Figure 1.

On one hand, just 3% of CPCs and FSS controllers indicated that they felt "Extremely" stressed at work, compared with 6 to 8% of the national sample of employees. On the other hand, comparable percentages of controllers and employees indicated feeling some stress. About 52 to 55% of the national sample and the controllers indicated feeling "Extremely," "Somewhat" or "Quite a Bit" of stress at work. The proportion of FSS controllers indicating feeling "Somewhat" to "Extremely" stressed at work was slightly lower (46%). In other words, controllers appear to feel about as stressed at work as representative national samples of U.S. employees. The results also indicate that smaller percentage of controllers reported that they were "Not at all" stressed at work than the national sample of employees.

Responses to the stress question are broken out by age for terminal and en route controllers in Figure 2 and for FSS controllers in Figure 3. The percentage of CPCs who said they felt that their work was "Somewhat" to "Extremely" stressful increased from around 42% at age 26-30 to nearly 60% at ages 41- 45, after which there was a gradual decline to a little over 40% for those in the 56-60 age category. Age-related changes in the FSS respondents was not as clear cut as for CPCs and may peak at an earlier age. However, there was a general decline in the last two age categories. These differences may be, in part, because FSS respondents were slightly older than their CPC colleagues. These results suggest that there is little evidence that the oldest controllers (ages 51 and greater) are more stressed than middle-aged controllers.

Controllers were also asked in the survey about the degree to which they experienced chronic fatigue and symptoms often linked to fatigue and/or stress. There did not appear to be any increase in chronic fatigue or gastrointestinal and cardiopulmonary symptoms among older controllers (over age 50). Older controllers in this sample reported lower levels of chronic fatigue than middle-aged controllers. This may be attributable, in part, to the greater flexibility in shift rotation schedules for older controllers as a consequence of their seniority. It is also possible that individuals with poorer health and other medical problems may have been screened out by the annual medical examinations or may have retired.

The Consequences of Stress

Health changes. While Melton and colleagues were conducting field and laboratory studies in the mid-1970s, the Boston University School of Medicine was conducting, under contract to the FAA, a "prospective study to determine the kinds and degrees of health changes occurring in air traffic controllers and the extent to which these health changes might be predicted by other factors" (Rose, Jenkins, & Hurst, 1978). Beginning in 1973, the five year longitudinal "Controller Health Change" study was designed to gather psychological, physiological, and organizational data from controllers at two en route centers, a major terminal, and the common IFR room in the eastern U.S.

Earlier research by Dougherty, Trites, and Dille (1965) and Hauty, Trites, and Berkley (1965a,b) revealed a higher incidence of gastrointestinal disorders and hypertension. In an investigation involving 22 occupations (including controllers at a large and a small facility) Caplan et al. (1975) found that controllers expressed more somatic complaints than employees in most of the other occupations; however, the average blood pressures and heart rates for the two groups of controllers were comparable to averages noted in the other occupational groups.

A total of 416 controllers participated in the Controller Health Change study. Only 5% of the initial group were not available for the final testing session. The results were complex and contradictory. Overall, Rose, Jenkins, and Hurst (1978) reported that:

(a) Stress, as evident in the physiological and behavioral measurements, was most likely to occur in individuals who were more vulnerable;
(b) Air traffic control work, per se, was not the sole factor associated with the appearance of a stress response in some controllers, with job dissatisfaction and other organizational factors contributing significantly to the emergence of individual health changes, burnout, and other physiological problems;
(c) There was a higher incidence of hypertension and ulcers in this group of controllers than in the general population; and
(d) Controllers, in general, were heavier drinkers than the general population.

These researchers initially concluded that:

> …the relationships that were found between our selected indicators of stress and some few outcomes may implicate work difficulty as having some partial role, when combined with other biological and psychological factors, toward ultimate illness. Specifically, the physiological measures at work did significantly predict hypertension and mild and moderate illness (p. 626).

In other words, with some caveats, the Controller Health Change study can be interpreted as providing some support for the hypothesis that the "stressful" nature of the controller's work resulted in adverse health outcomes. However, in a subsequent report, they demonstrated that hypertension was most closely linked with obesity and alcohol intake (DeFrank, Jenkins, & Rose, 1987).

Controller morbidity. Other studies conducted at about the same time also cast doubt on the hypothesis that the stress of the job and shiftwork resulted in adverse health consequences for controllers. For example, in an assessment of hypertensive diagnoses in some 25,000 air traffic controllers, Booze (1978) reported that the incidence rate for hypertension was below the expected rate based on national averages. In a follow-on analysis of aeromedical certification data, Booze and Simcox (1984) compared the distribution of blood pressure by age for all airmen, airline pilots, and a sample of air traffic controllers who were pilots. The prevalence of borderline and definite hypertension increased with age for all groups studied. Overall, the prevalence of hypertension was lowest in airline pilots and highest among controllers. However, when compared to other national databases, air traffic controllers had a lower prevalence rate for definite hypertension and a comparable level for borderline hypertension. Booze and Simox cautioned that differences between airmen and controllers could be attributed to the more liberal waiver and retention criteria for controllers.

In a 1978 report, Booze analyzed the morbidity experience of 28,086 ATCS personnel for the 1967 to 1977 time period. Once again, the rate of hypertension experienced by this group of controllers during the course of the study was significantly lower than that of the well-known Framingham and National Health Survey studies. The incidence of cardiovascular disorders was also lower than rates reported in other large scale studies. Over age 50, the incidence of coronary heart disease in controllers was lower than that evident in either pilots or reported in the Framingham study. Booze also reported that there was no association or correlation of disease occurrence with length of service and age. Booze concluded that "While some isolated trends found in these data are supportive of an occupation/disease relationship, they are neither--as would be expected if the association were a strong one--impressive nor consistent" (p. 1).

Booze (1978, p. 13) also reported that "substantial increases were seen for most all diseases" after implementation of P.L. 92-297 with its provisions for retraining of controllers in alternative careers at the government's expense. The largest increases were found for neuropsychiatric and cardiovascular disorders. Staten and Umbeck, (1982) analyzed the effects of changes in the federal Workers' Compensation Program requiring identification of a specific job-related event precipitating the claimed injury and allowance of stress-related claims. They found that system error (e.g., operational error) reporting rates increased after the change. In their analysis, they attributed the increase to the need for objective evidence linking the disability to a stressful event on the job and that, perhaps, the financial benefits available under these programs served as incentives for some controllers to report stress-related disorders. As a consequence, the overall rates for psychological and cardiovascular disorders might have been inflated by this reporting bias.

Organizational consequences. The 1978 Controller Health Change study reflected the widespread concern in the agency and in public opinion about the consequences of job-related stress in terms of the individual controller's health. Yet job-related stress may have wider consequences for the organization as a whole. For example, job-related stress appears to have played a role in the 1981 PATCO strike as one of many complaints raised by controllers about working conditions, equipment, the job, and management. Post-strike investigations conducted by a special task force (the "Jones Committee"; see Jones, Bowers, & Fuller, 1982) found that an individual's decision to strike or stay on the job was influenced substantially by five major factors, including the frequency of acutely stressful episodes or incidents experienced on the job and the degree of job burnout felt by the person. Other factors included the organizational climate experienced in the workplace, the degree of alienation or goal integration felt by the person, and the frequency of equipment outages experienced on the job. The Jones Committee analyzed survey data from controllers who struck and those who remained on the job shortly after the August 1981 strike. The questionnaire included items focused on the frequency of stressful incidents in the past three years, recovery time, helpfulness of other employees and supervisors/managers, whether the stress associated with air traffic control work was chronic/situational/acute episodic or a mixture, and the level of burnout in the respondents.

Using a modified version of the burnout index developed by Rose, Jenkins, and Hurst (1978; see Figure 4 for items), the Jones Committee found 85 (19 working and 66 striking) controllers that exceeded their cutoff score. The percentage of controllers age 41 and older who exceeded the burnout criteria was 21%. For those with 19 or more years of service, the percentage was much higher (69%). Four factors were found to contribute to burnout: (a) frequency of occurrence of acutely stressful incidents; (b) length of service in the job; (c) perceived lack of concern for people by the FAA; and (d) dissatisfaction. One consequence of this report was an extensive effort to improve the quality of supervision and management within the FAA through programs such as the Supervisory Identification and Development Program.

To assess progress in addressing issues associated with the strike, the FAA initiated a biennial employee survey in 1984. In 1986, the content of the employee survey was expanded to include items assessing employee perceptions of stress associated with aspects of their work. In addition, the modified Burnout Index used by the Jones Committee was used to assess burnout among all FAA employees. An average score of 3.75 on the Burnout Index was established as the criterion for determining the percent of the workforce that would be considered to be "burned-out." Responses were received from 63% of the FAA workforce.

Overall, just 6.8% of all responding FAA employees reached or exceeded the 3.75 criterion, that is, would be characterized as possibly experiencing "burnout." The proportion of Air Traffic respondents reaching or exceeding the criterion for "burnout" was 6.5%, compared to 8.5% of the Airway Facilities and Aeronautical Center respondents. A slightly greater proportion of Air Traffic manager and supervisors (7.5%) exceeded the criterion for "burnout," compared with 6.6% of the Air Traffic specialists. Within the various air traffic control options, en route specialists had the highest percentage exceeding the criterion (8.1% versus 5.9% for terminal and 5.7% for FSS specialists). The 1986 percentages were lower than those noted in 1984 (Figure 5). In 1984, 22% of en route managers and supervisors exceeded the criterion for "burnout," compared with 9.8% in 1986. The proportion of en route specialists exceeding the "burnout" criterion in 1984 was 15% compared with 8.1% in 1986.

The 1986 survey also included 14 items that assessed potential sources of stress. Respondents indicated how often each item had been a source of stress during the past six months on a "Never" to "Always" scale. The proportions of respondents marking "Frequently" or "Always" for each item were reported, as shown in Figure 6 for all respondents ("FAA") and for non-supervisory ATC employees ("ATC Non-supv"). There are similarities and some differences in response patterns of the ATC employees and the FAA as a whole that are worth noting. For example, less than 20% of both groups (non-supervisory ATC and all FAA employees) marked "Unwanted overtime," "Increased automation," "Personal concerns," "Accountable for others," and "Delays in automation" as "Frequently" or "Always" sources of stress in the last six months. It is somewhat surprising, in view of the complaints about equipment inadequacies and mandatory overtime in testimony supporting the mandatory retirement age and in the complaints preceding the 1981 strike, that "delays in automation" and "unwanted overtime" were not endorsed as sources of stress by a larger proportion of ATC employees. More of the non-supervisory ATC employees (27.1%) than all FAA employees (21.5%) indicated that "Decisions about safety" was frequently or always a source of stress. While one would hope that ATC employees are concerned about decisions about safety, compared to the FAA as a whole, the proportion indicating that the decisions were a source of stress was surprisingly low, at just over a quarter of the non-supervisory ATC employees. Even more surprisingly, in view of the wide-spread perception of the ATC job as being "stressful," smaller proportions of the non-supervisory ATC employees than of all FAA employees indicated that factors such as "Extended periods with too much work to do," "Too much work to do in an ordinary day," "Amount of time to meet job demands," "Amount of resources available" were "Frequently" or "Always" sources of stress in the last six months. Feelings of being overwhelmed with too much to do, not enough time, and of being "stretched too thin" are common hallmarks of job-related stress. Yet in this instance, less than 25% of non-supervisory ATC employees (presumably, primarily working controllers) indicated that these factors were sources of stress. However, "Opportunity for advancement" and "Supervisory/management practices" were "Frequently" or "Always" sources of stress for non-supervisory ATC employees (42.7% and 48.6% respectively). In contrast, the proportions of all FAA employees indicated "Opportunity for advancement" and "Supervisory/management practices" as sources of stress were slightly lower (38.6% and 44.2%). These two factors represent more about the organizational culture and climate in which the work of controlling is done than the inherent nature of the work itself. Finally, the proportion of controllers indicating that "Federal issues" such as pay and retirement were a source of stress (47.7%) was slightly less than the proportion of all FAA employees indicating the topic as a source of frequent stress (51.3%).

It is surprising that those factors reflecting the nature of the work itself (such as decisions about safety, the complexity of the job, and the amount of work) appear not to have been major sources of job-related stress for the majority of controllers in 1986. Moreover, factors reflecting the conditions under which the work was performed (e.g., unwanted overtime, time to meet the job demands, and resources to do the work) also seem *not* to have been major sources of stress for the non-supervisory ATC employees. Taken together, these survey data tend to undercut the hypothesis underlying the mandatory retirement age that controllers are subject to extraordinary stress and strain.

SUMMARY

Overall, the results of scientific research since 1971 designed to quantify the stress purportedly experienced by controllers and to assess the impact or consequences of that stress on controller health do not support the popular image of the ATCS occupation as being among the most stressful in the U.S. Nor do the results strongly support the perception that, as a consequence of the job, controllers experience adverse health consequences at a higher rate than might be expected in the general population.

Disability Retirements

The second major class of data cited in support of the "ATCS Age 56 Law" was disability retirements. In this section of the review, data on disability retirements among controllers for the period FY1997 through 2003 will be analyzed to determine to what extent the "ATCS Age 56 Law" is still supported by this line of evidence.

Data

As part of continuing research in support of human capital management for Air Traffic Services, CAMI receives quarterly extracts of personnel actions and on-board data from the FAA Consolidated Personnel Management Information System (CPMIS). A Notice of Action (NOA) is generated for each personnel action for an employee, such as hiring, promotion, pay change, and retirement, and recorded in CPMIS. For this analysis, all NOAs for disability retirement (code = 301) generated between October 1, 1996 and September 30, 2003 for controllers and non-controllers were analyzed in relation to on-board staffing numbers at the end of each fiscal year. In keeping with the 1971 testimony, retirees and employees were grouped into two age groups: age 44 and younger; age 45 and older.

Analysis

The testimony in 1971 was that the proportion of disability retirements represented by controllers under age 45 was disproportionate to their representation in the FAA workforce. To test this hypothesis, we compared the proportion of disability retirements that were for controllers under age 45 with the proportion of FAA employees less than age 45 (e.g., "younger controllers") in each fiscal year 1997 through 2003 using a conventional Z-test of proportions.

Results

The results of the analysis are presented in Table 2. In FY1997, there were 108 disability retirements, 40 of which were for controllers less than age 45. "Younger" controllers accounted for 37% of all disability retirements from the FAA in FY1997. There were 16,407 controllers on-board in FY1997 less than age 45, representing 33% of all FAA employees. As shown in the table, these two proportions – 37% of disability retirements, 33% of all employees – were not significantly different. That is, the proportion of disability retirements represented by "younger" controllers was about the same as their representation in the FAA workforce in FY1997. The same pattern of results was obtained for each fiscal year through FY2003 – the proportion of disability retirements represented by "younger" controllers was about the same as their representation in the workforce. Note also that the proportion of FAA employees who were "younger" controllers declined from .33 in FY1997 to .25 in FY2003, and the proportion of disability retirements represented by "younger" controllers also declined.

Conclusion

In contrast to the testimony of 1971, younger controllers do not seem to be taking disability retirement in numbers disproportionate to their representation in the workforce. Therefore, current disability retirement data do not support the assertions made in 1971 to justify mandatory retirement at age 56.

Age and Performance

The third major class of evidence supporting the "ATCS Age 56 Law" was the argument that controller proficiency declined with age. The purpose of this section is to review more recent studies of controller performance and age and to summarize research that might be relevant.

Training Outcomes

Recent studies of the post-strike generation of controllers, in general, find the same association between chronological age at entry into the occupation and performance in initial and subsequent field training as found in the older scientific research literature. For example, Collins, Nye, and Manning (1990) found a negative correlation (-.31) between age and performance in the FAA Academy ATCS Nonradar Screen. Schroeder, Broach, and Farmer (1998) analyzed the relationships of age to outcomes such as training for the post-strike generation of controllers. They found that the older a new controller was at the time of entry into the occupation, the more likely he or she was to attrite from training either at the Academy or in the field. However, as noted before, these studies do not directly speak to the issue of age and on-the-job performance.

Operational Errors

Broach (1999) investigated the relationship of age to involvement in en route operational errors based on data for 3,724 controllers for the period 1991 through 1995. The prevalence rate for errors was computed as the ratio of the total number of errors for controllers of a given age group to the total number of controllers in that age group, as measures of exposure (e.g., hours worked on position) were not available. There was a curvilinear relationship between age and the error prevalence rate (Figure 7) and some evidence that experience moderated the relationship. However, the study was not definitive due to the lack of an appropriate measure of exposure or controls for workload and sector characteristics.

Job Performance

Heil (1999) investigated the relationship of age to a measure of core technical job performance in the en route environment. The data were collected in the course of validating a computerized controller selection test battery. Overall, data were available for 838 incumbent CPCs. Almost half (391, or 47.6%) were between the ages of 32 and 37; there were 89 CPCs age 44 and greater (10.9%). The criterion measures were peer and supervisor rating scales and a computer-based assessment of core technical job skills in the en route environment known as the Computer-based Performance Measure (CBPM; Hanson et al., 1999). The peer and supervisor ratings consisted of behavior-based scales for 10 dimensions and an overall effectiveness scale. The CBPM was a 38-item, 2-hour assessment in which controllers were presented with a series of realistic air traffic scenarios and several multiple choice questions about each scenario.

Heil (1999) found a curvilinear relationship between current age (at the time of data collection) and the scores on the CBPM. However, the relationship was very modest ($R^2 = .04$, $p < .01$). Comparisons by age group also suggested differences in performance by age, with controllers age 50 and greater earning lower scores on the CBPM than controllers in the other age groups. Overall, mean CBPM scores increased with age, reaching their highest for controllers between ages 38 to 43. CBPM scores then declined, dropping significantly for controllers age 50 and older. The ratings data followed a similar pattern. Heil concluded that, when viewed as a group, older controllers were found to have lower levels of performance. However, as with the previous studies by Trites and Cobb, the Heil study is cross-sectional in design and does not address change within an individual. He recommended that longitudinal studies of age and performance be conducted to better understand the age-performance relationship.

Changes in Cognitive Abilities

Interpretation of the studies comparing the performance of younger with middle age and older workers is complicated by some of the issues raised regarding the use of cross-sectional research. Younger cohorts are more likely than older cohorts to have a higher overall level of education and greater experience with computers and other new technologies. In addition, the composition of the workforce changes as employees age. Some productive and involved employees may have been selected to become managers. Less productive employees may have moved on to other jobs or they may have been dismissed. Thus, additional selective processes may complicate interpretation of any age-related changes in performance.

Substantial research has been conducted on changes in cognitive abilities with age. There are three substantive findings relevant to age 56: (1) speed of central processing declines with age; (2) sensory and perceptual abilities decline with age; and (3) variability in cognitive abilities measures increases with age (Corso, 1981; Park & Hedden, 2001; Salthouse, 1996; Welford, 1985). The research suggests that from year to year, age-related changes in cognitive functioning occur at a relatively predictable rate (except for changes involving the overall health of the individual). The rate of decline in cognitive functioning is not dramatic (again, absent a major change in health). Salthouse (2000) suggested that there is an age-related decline in cognitive abilities of between one and two standard deviations across a range in age from about 18 to 80, or something on the order of less than 1% per year. Changes in perceptual ability appear to follow a similar course up until middle age, although some evidence suggests that declines in vision and hearing, particularly, may accelerate slightly, on average, after about age 50 (Corso, 1981).

It is important to note that the observed declines in cognitive and sensory abilities are based on the mean or average performance for each age level and may or may not reflect the performance of any given individual. Moreover, within each age group, there are those individuals whose performance is superior to the group, as well as some who perform worse than the average for the group. Thus, some older persons may perform better on a given measure than their younger colleagues. Because of this variability, the scientific merit of basing retirement solely upon chronological age rather than demonstrated ability to continue performing the job is debatable (Landy, 1992; Mavor, 2001; Schneider, 1996).

However, the implications of age-related changes in cognitive abilities for job performance are not well understood, and the available evidence is equivocal. Theoretical models linking changes in fundamental cognitive abilities to changes in knowledge, skill, and performance are lacking. Davies and Sparrow (1985) cited studies in non-controller jobs where performance declines with age in situations where the work demand is most closely aligned with changes in sensory/perceptual and cognitive processes. They determined that the inverted U-shaped relationship between age and work performance was most evident in production records for skilled and semi-skilled jobs. Supervisory ratings, on the other hand, suggested that older employees were rated similarly to their younger colleagues on overall efficiency but were viewed less positively with respect to speed of work and learning ability. However, later studies involving meta-analyses of the literature suggest that there is little evidence of any age-related changes in either actual job performance or in supervisor ratings. In their meta analysis of age differences in job performance, Waldman and Avolio (1986) found a pattern of increased performance as age increased. Supervisory ratings, on the other hand, tended to show a slight decline in the older age groups. McEvoy and Cascio (1989) found little evidence of age-related differences in performance measures (ratings or production records) across types of jobs. Interviews with working controllers in Europe (European Air Traffic Management Programme, 2003) suggested concerns about adaptation to changes in equipment and procedures as well as "keeping up with traffic" among older controllers. A number of the interviewees mentioned that night shifts were more demanding with age. Yet 20 of the 76 controllers interviewed felt that age itself had little or no effect on performance, while 17 felt age negatively impacted job performance.

Moreover, as noted by the European controllers, compensatory strategies may be developed and used to off-set subtle declines in fundamental cognitive abilities with age. For example, a large number of the European controllers (42 of 76) referred to having better situational awareness as a function of their experience. Research on pilots also suggests that experience may compensate for age-related changes (Morrow et al., 1994; Tsang, 2003). Research is needed to assess how, and under what circumstances, controllers develop and use compensatory strategies to offset age-related changes in factors such as speed of processing.

The differing findings with respect to age and performance highlight the fact that changes in cognitive abilities, as assessed by measures of specific abilities, do not necessarily result in observed changes in job performance. On one hand, perhaps changes in some cognitive abilities do not matter, fundamentally, to the performance of a controller. On the other hand, changes in a cognitive ability such as short-term memory might have a substantial impact on job performance. However, because there has been relatively little research to develop models linking specific abilities with specific performance dimensions, we are unable at present to make and test predictions about the effects of age. In addition, most controller performance measures currently available are relatively coarse (Broach & Manning, 1998), with the exception of the CBPM. CBPM items are linked to specific, important controller tasks (Hanson et al., 1999). However, the CBPM is restricted to the en route radar environment, and assesses how well a controller can identify a problem rather than how well he or she can resolve a problem. Research is needed to develop similar measures for the tower cab, TRACON, and FSS environments and to extend the assessment beyond problem identification.

CONCLUSIONS

The scientific basis for the "ATCS Age 56 Law" consisted of three lines of evidence: (a) the inherent stress of the job; (b) disability retirements; and (c) loss of proficiency with age. Overall, the evidence available in 1971, when carefully reviewed, was not as strong as characterized in testimony. Moreover, research conducted since 1972 also does not provide a firm foundation to either support or reject the mandatory separation of controllers at age 56. On one hand, the research on physiological measures of stress since passage of P.L. 92-297, as summarized by Melton (1982) and Smith (1980), does not support the public myth that the controller job is among the most stressful in the U.S. Analysis of seven years of CPMIS data indicates that younger controllers take medical disability retirements at a rate proportionate to their representation in the overall FAA workforce. On the other hand, available research on performance and age in the controller occupation, as well as in other occupations, suggests that differences in performance have been observed in cross-sectional designs. While older individuals, on average, exhibit lower performance, there are older persons who out-perform some of their younger colleagues due to increasing variability in performance with age. Additional research is needed to provide more definitive answers to the questions raised in this review. As a part of those efforts, longitudinal research is suggested to assess age-related changes in cognitive abilities and their possible relationship to changes in performance of complex jobs. Such studies might provide a reasonable basis for determining if the statutory requirement to separate controllers at age 56 should be changed.

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FIGURES

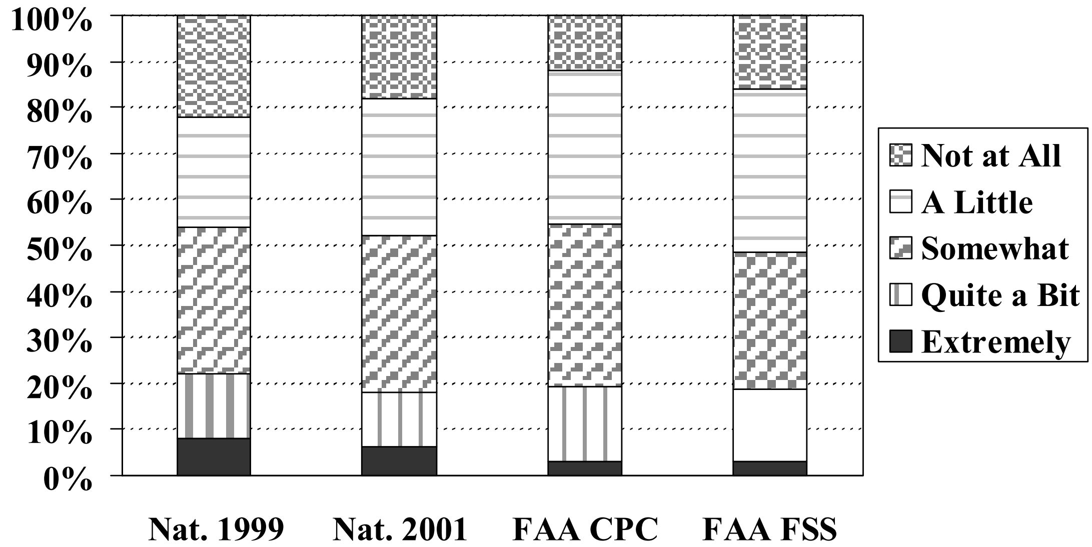

Figure 1: ATCS responses to "In general, how stressed do you feel at work" compared to responses from national samples in 1999 and 2001

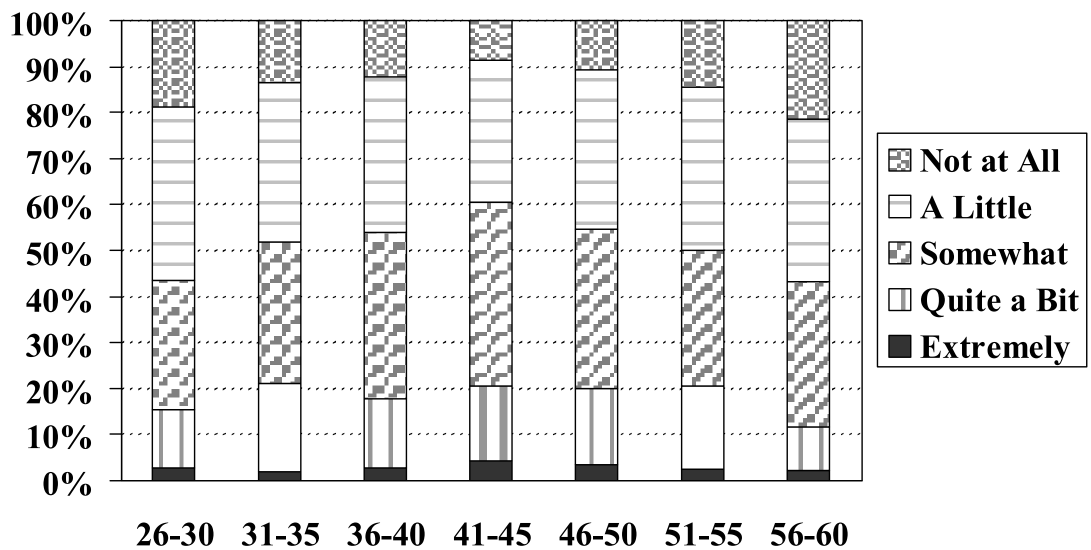

Figure 2: Responses of terminal and en route CPCs by age group to 1999 survey question, "In general, how stressed do you feel at work?"

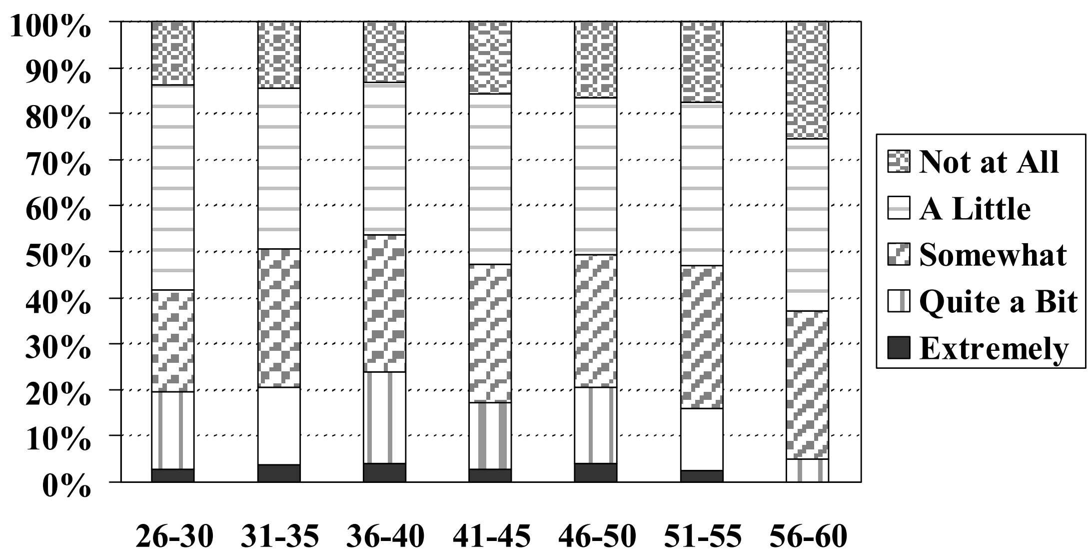

Figure 3: Responses of FSS controllers by age group to 1999 survey question, "In general, how stressed do you feel at work?"

In the last six months at work, how difficult has it been for you to bounce back to peak performance when you have been away from the boards?

In the last six months of work, how difficult have you found it to shift between peak and slow periods?

1	2	3	4	5
Extremely difficult	Fairly difficult	Somewhat difficult	Fairly easy	Extremely easy

How often have you found yourself worrying about your own "burnout?"

1	2	3	4	5
Practically never	Rarely	Sometimes	Often	Almost constantly

At the present time (last time you worked), how close to "burnout" do you (did you) feel?

1	2	3	4	5
Not close at all	Not very close	Somewhat close	Fairly close	Very close

Figure 4: Burnout Index items and responses from Jones, Bowers, & Fuller (1982)

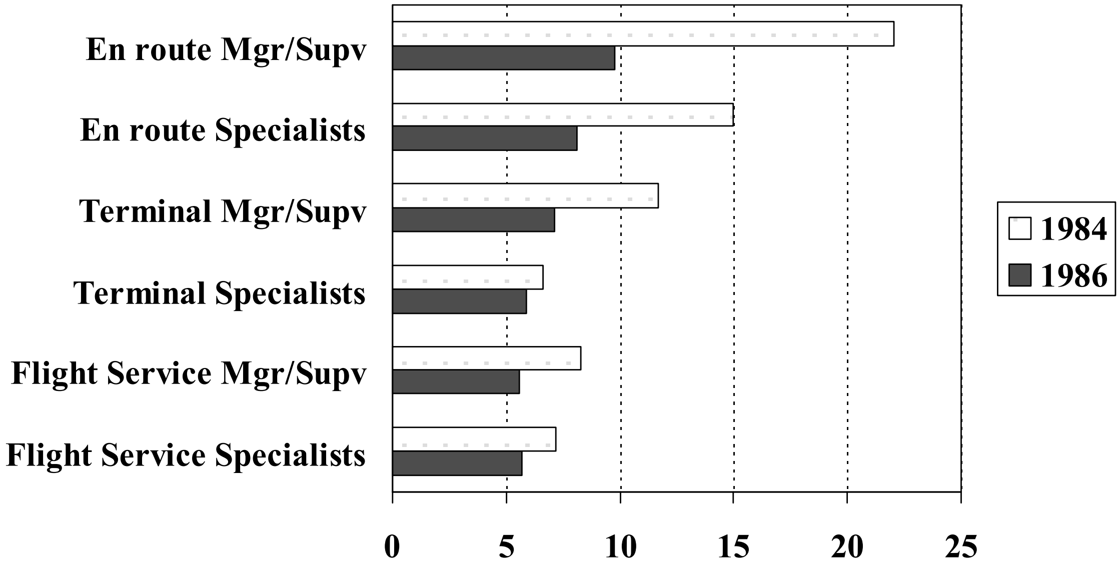

Figure 5: Comparison of percent (%) of Air Traffic employees exceeding 3.75 criterion score on "Burnout Index" in 1984 and 1986 FAA surveys

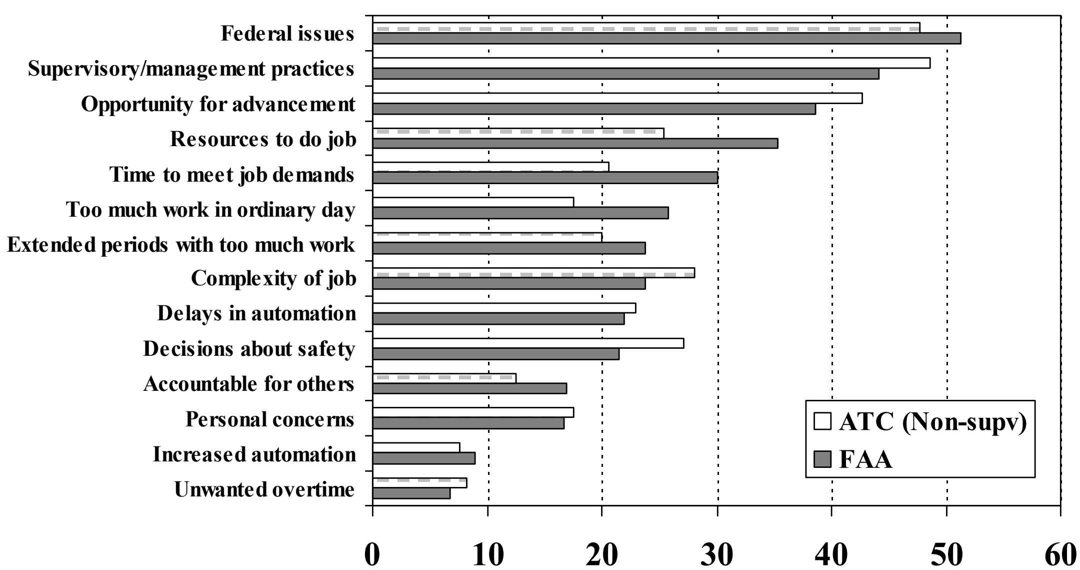

Figure 6: Comparison of proportions of non-supervisory ATC employees and all FAA employees indicating the factors as "frequently" or "always" a source of stress in the 1986 survey

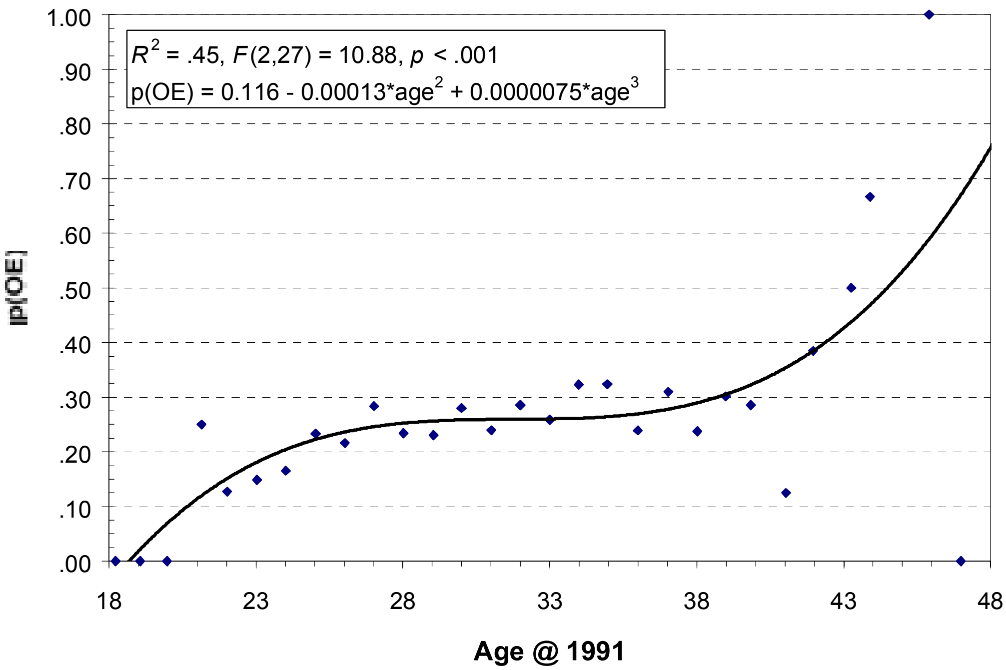

Figure 7: Cubic regression of likelihood of OE (p(OE)) on controller age at beginning of 5 year observation period (1991-1995) from Broach (1999)

TABLES

Table 1: Medical retirements data presented in 1971 testimony

Type of Facility	N ATCS (as of Dec 31 1970)	Total medical retirements (1966-1970)	% of ATCS medically retired (1966-1970)
Centers (ARTCCs)	10,848	160	1.5
Towers (Terminals)	8,713	229	2.6
Stations (Flight Service)	4,217	134	3.1

Table 2: Disability retirements for controllers less than age 45 compared to their representation in the FAA workforce

	Disability Retirements			N Employees				
Year	"Younger" ATCS	FAA Total	p_1	"Younger" ATCS	FAA Total	p_2	Z	Sig
1997	40	108	.37	16,407	49,690	.33	0.86	.39
1998	39	119	.33	16,011	50,381	.32	0.23	.82
1999	30	104	.29	14,729	48,940	.30	-0.28	.78
2000	22	79	.28	15,351	49,662	.31	-0.61	.54
2001	23	75	.31	13,668	50,683	.27	0.69	.49
2002	26	86	.30	13,157	55,218	.24	1.29	.20
2003	19	93	.20	12,569	49,434	.25	-1.19	.23

Notes: "Younger" ATCS = ATCS less than age 45