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# Age 60 Study, Part III: Consolidated Database Experiments Final Report



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**16. Abstract**
This report was a primary deliverable from the research contract with Hilton Systems, Inc. on the FAA's mandatory retirement for pilots operating under Federal Aviation Regulations Part 121, the "Age 60 Rule." The purpose of this study was to examine existing data to assess the relationship between pilot age, accident rate, and experience. Three existing data bases were integrated on a single computer platform: 1) the FAA Airmen Certification file, 2) the FAA Medical History file, and 3) the National Transportation Safety Board (NTSB) Accident data base. The report presents a discussion of the methodological issues with studies in aging and reviews prior research. Limitations of utilizing these data sets are discussed. The methodological approach was developed from these considerations. Hilton Systems replicated and extended analyses from previous studies, including statistical analyses. The report describes outcomes from analyses conducted to answer a series of questions examining the relationship between age and accident rates for pilots holding Class I, Class II and Class III medical certificates. Recent and total flight time are utilized as a measure of risk exposure. The results present a converging body of evidence which fail to support a hypothesis that accident rates increase at or about the age of 60 years.

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## PREFACE

This technical report, entitled "Age 60 Rule Research, Part III: Consolidated Database Experiments Final Report," is the third document in the series of products from Hilton Systems resulting from a two year contract to scientifically examine issues related to the Federal Aviation Administration's (FAA's) mandatory retirement regulations for pilots. The first report, entitled "Age 60 Rule Research, Part I: Bibliographic Database," was published as an Office of Aviation Medicine Technical Report (DOT/FAA/AM-94/20). The second report was published as "Age 60 Rule Research, Part II: Airline Pilot Age and Performance--A Review of the Scientific Literature" (DOT/FAA/AM-94/21).

The Federal Aviation Regulations (FARs), Part 121, prohibit individuals from serving as captain or copilot (1st officer) of an aircraft in air carrier operations if those persons have reached their 60th birthday. Commonly referred to as the "Age 60 Rule", the regulation was implemented in response to concerns about the safety of aging pilots as the airline industry transitioned into the jet age. Although the rule has withstood legal and legislative challenges, little scientific evidence has been available to either support the rule or to guide the FAA to an appropriate alternative.

In 1990, the FAA's Associate Administrator for Certification and Regulation (AVR-1), Mr. Anthony Broderick, requested and sponsored a two year research contract to examine the relationship between age, experience, and accident rates. The Civil Aeromedical Institute (CAMI) was assigned the task of developing and monitoring the contract. In September 1990, the contract was awarded to Hilton Systems Inc., of Cherry Hill, New Jersey. Hilton Systems collaborated with Lehigh University faculty to supplement technical expertise. The FAA requested that the contractor engage in a fresh, innovative approach to the issues involved in the Age 60 Rule. No direction was given by the FAA to the contractor on whether the Agency desired to maintain a position either for or against the rule.

This report was a major focus of the research project. Since 1983, a primary source of the defense of the Age 60 Rule was a study by Richard Golaszewski entitled "The Influence of Total Flight Time, Recent Flight Time and Age on Pilot Accident Rates." The purpose of this phase of the contract was to replicate and extend the analyses conducted in the Golaszewski study, resolving methodological problems in the process. To accomplish this, Hilton systems integrated three existing data sources on a single computer platform: 1) the FAA Airmen Certification file, 2) the FAA Medical History file, and 3) the National Transportation Safety Board (NTSB) Accident data base. The integrated data, the Consolidated Data Base (CDB), was a major project deliverable and survives the contract as a significant research tool. The CDB currently resides in the Civil Aeromedical Institute's (CAMI) Accident Investigation Research Section (AAM-610).

The data in this report represent merely a selection from the myriad analyses conducted by Hilton Systems to address the Age 60 issues. In total, approximately 181 separate models of pilot age, accidents and flight time were examined by Hilton in the course of preparation of this report. The analyses which Hilton and Lehigh felt most directly addressed the Age 60 Rule for Part 121 pilots are presented here.

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## 1.0 INTRODUCTION

### 1.1 Background

Part 121 of the Federal Aviation Regulations (121.383c) contains a provision for mandatory retirement at age 60 of commercial airline pilots-in-command and co-pilots. The Age 60 rule was established in 1959 with the objective of reducing aircraft accidents attributable to the effects of pilot aging. The rationale behind the rule was that the increased speeds and passenger loads of commercial airliners placed greater demands on pilots with respect to their physical fitness and piloting skills. In addition, existing studies reinforced a belief that progressive deterioration of physiological and psychological functions regularly accompanied increasing age. Other studies raised the concern that sudden incapacitation could be brought on by such events as heart attacks or strokes, which occur with greater frequency among older members of the general population. Although not all individuals experience equivalent age-related deterioration in health and performance, it was nevertheless concluded that an age 60 limitation was prudent on the grounds that performance decrements could not be reliably and objectively measured or predicted on an individual pilot basis.

In 1979, the U.S. Congress enacted P.L. 96-171, an Act to require a study of the desirability of mandatory age retirement for certain pilots and for other purposes. The legislation required the Director of the National Institutt , of Health, in consultation with the Secretary of Transportation, to conduct a study to determine the effect of aging on the ability of individuals to perform the duties of pilots with the highest level of safety. The National Institute on Aging was assigned the primary responsibility for implementing the legislation and formed an inter-institute committee to prepare the federally-mandated report. The committee decided in favor of awarding a contract to the Institute of Medicine (IOM) of the National Academy of Sciences to provide an objective examination, summary, and assessment of existing scientific knowledge relevant to the questions posed in P.L. 96-171.

The National Institute on Aging established a Panel on the Experienced Pilots Study in 1981 to assist in reviewing the IOM report (Institute of Medicine, 1981). The panel held three public meetings to receive comments on the IOM report and to hear oral statements from several organizations. The panel was unable to identify a medical or performance assessment system that could determine which pilots would pose a safety hazard because of early or impending deterioration in health or performance. It recommended that the Age 60 rule be retained, while at the same time recommending that a systematic collection of medical and performance data be carried out for future consideration of the Age 60 rule. This recommendation formed the basis for this project.

In 1990, Hilton Systems, Inc. (HSI) began a two-year contract to provide support to the Civil Aeromedical Institute (CAMI) of the FAA for studies of existing data contained in several databases concerning aging and pilot performance. This project included an exhaustive review of the scientific literature (Hyland, Kay, Deimler, & Gurman, 1992). A principal goal of the project was to develop a Consolidated Database (CDB) from several pertinent FAA and NTSB databases in order to facilitate analyses that explore relationships between age and performance and identify potential age-sensitive contributing factors. The CDB was designed to identify and incorporate relevant pilot, medical, and accident data currently stored in several dissimilar data files into a structured, organized form capable of supporting rigorous data analysis.

## 1.2 Objectives

The purpose of this study was to conduct statistical analysis on historical data to investigate the relationship between pilot age and accident rates. The ultimate long-term aim of the Age 60 Project was to enhance aviation safety by increasing understanding about the relationships among pilot age, experience, and accident rates.

The specific aims of the project were:

- To consolidate the currently separate databases related to pilot certification and aviation accidents and incidents.
- To use this consolidated database to statistically examine the relationships that exist among chronological age, accidents, and other factors.

Although the study was primarily directed at pilots who fly for FAR Part 121 air carriers who are subject to the Age 60 Rule, additional analyses were conducted for other categories of pilots to take advantage of additional data available for active pilots beyond the age of 60, and to further examine the influence of confounding factors.

## 1.3 Constraints

The conclusions that could be drawn about the relationships among chronological age and accident rates were constrained by the kinds of data in the existing databases. It is important to keep in mind that there were a number of factors confounded with age, factors that would have affected the results in the study. The information contained in the databases did not allow us to untangle the confounding effects of all of those factors. This section will review some of the constraints that were considered in evaluating the methods and results of this study.

### 1.3.1 Methodological Problems in Studies of Aging

Advancing age is associated with declines in physiological functioning and an increase in the prevalence of disorders. However, it was important to recognize at the outset that individuals vary considerably in their rates of physiological aging and in their predisposition to disease. While average levels of functioning would decrease with increasing age, individual variability appeared to increase. Thus, group averages could be particularly poor predictors of individual performance among older persons.

Despite these problems in using chronological age as a meaningful marker of an individual's functioning, it was still important to investigate the relationship between increasing age and functioning, at least in terms of group patterns. However, the design of studies on aging presented difficult problems of interpretation. Cross-sectional studies compared (at a single point in time) groups of individuals that varied in age, rather than repeatedly testing the same group of individuals as they aged (a longitudinal design). It should be noted that cross-sectional and longitudinal studies did not always suggest the same age effects, even when using data from the same population over the same time period. There were interpretation difficulties with both of those simple research designs.

Cross-sectional data were difficult to interpret because our society changes so rapidly that individuals born at different times (different birth cohorts) can experience very different life circumstances. Thus, in a cross-sectional study, the different age groups can vary on a number of dimensions besides age (such as health, education, and life experiences). Differences in the behavior of these groups could reflect cohort effects which were difficult if not impossible to separate from aging effects.

In this study, older pilots could differ in significant ways from younger pilots in ways that were unrelated to the aging process. For example, older air carrier pilots could have differing educational backgrounds and employment experiences (such as military flying experience) than younger pilots. Older pilots also had more seniority than younger pilots and could select routes with substantially different levels of exposure to risk. For example, the number of takeoffs and landings per flight hour could decrease with age, as older pilots could use their seniority to choose longer routes with terminal operations confined to major metropolitan airports. This would result in fewer takeoffs and landings per hour of flight, arguably a lower risk environment. Unfortunately, the information contained in the existing databases did not allow examination of this potential confounding factor because pilots reported only hours flown for various periods of time, not the number of landings. One way to minimize this confound was to examine data for Part 91 general aviation pilots who did not operate in the framework of seniority rules.

Since longitudinal studies followed the same individuals over time, they avoided the confounding of cohort and aging effects that was found in cross-sectional studies. That type of study was extremely valuable because it permitted the direct examination of changes in individuals as they aged. However, the results of longitudinal studies were difficult to interpret for at least two reasons.

Since longitudinal studies required many years to complete, significant numbers of subjects could drop out of the study. This experimental mortality of subjects may not have been random, but rather biased in that those subjects with lower levels of performance may have been more likely to drop out. Thus, interpretation of the results of longitudinal studies was difficult because aging effects could have been confounded with experimental mortality effects. For example, in the study's context it was likely that the FAA's rigorous medical and operational performance standards screened out, over time, pilots more likely to be in accidents.

The results of longitudinal studies were also difficult to interpret because of the confounding of age effects and time-of-measurement effects. Since longitudinal studies were carried out over long periods of time, not only were individuals aging but the environmental context in which they were developing was also changing. For example, the context in which air carrier pilots performed had changed significantly over the past several decades in terms of the aircraft flown and the flying environment itself. If a group of pilots had different accident rates in 1960 when they were 30 years old compared to 1990 when they where 60 years old, it could be due to changes in the flying environment as well as aging-related changes in the pilots themselves. For example, as Figure 1-1 illustrates, an overall decline in counts of accidents was seen in the period 1976-1988 (as discussed in Section 3, the data for the year 1986 was not used in this study).

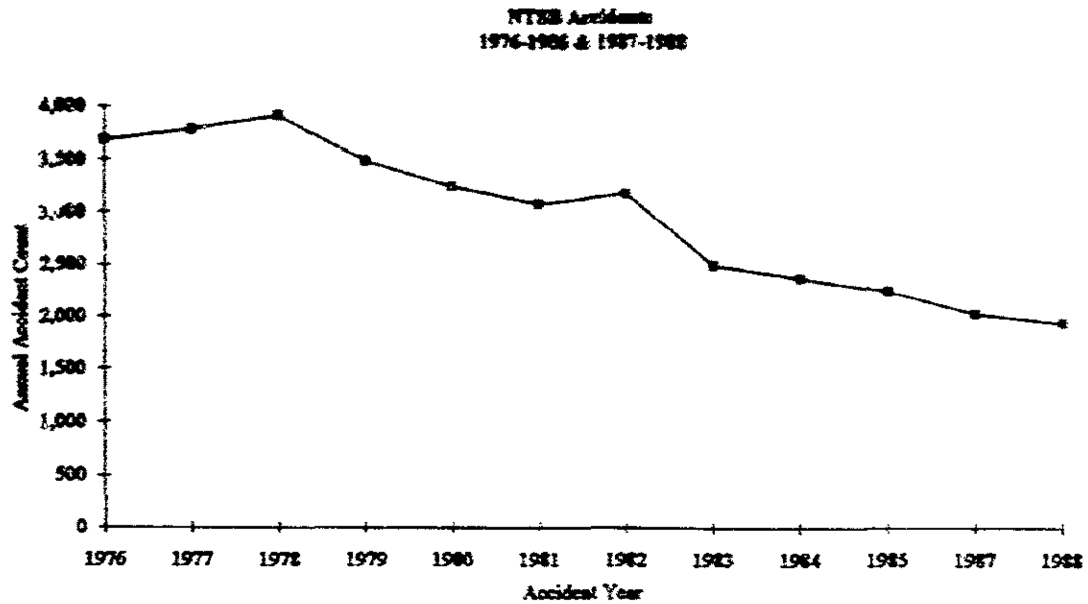


**Figure 1-1.** Number of accidents recorded in the NTSB database for the years 1976-1988.

Ideally, what was needed to fully re-evaluate the Age 60 Rule was data from several cohorts of Part 121 pilots who had been monitored over time, including data on pilots over age 60. Then both cross-sectional and longitudinal comparisons could be made of accident rates of pilots over age 60 and under age 60. However, the data that would have provided this direct comparison were simply not available in the database, primarily because airline pilots had been retired at age 60 since 1959. Examination of pilots who were not subject to the Age 60 Rule, such as Part 91 general aviation pilots, could have provided an alternate way to examine the relationship between chronological age and accident rates. However, as the next section will detail, the ability to examine specific groups of pilots such as Part 121 professional pilots versus Part 91 general aviation pilots was constrained by limitations inherent in the databases.

### 1.3.2 Difficulties Calculating Accident Rates

To examine whether accident rate increased with age, it was necessary to calculate the accident rate as the ratio of the number of accidents to the overall number of hours flown (an estimate of exposure) for various age groups and then to compare those accident rates. Also, since there were significant qualitative differences in type of flying that Part 121 air carrier pilots, Part 135 commuter/air taxi pilots, and Part 91 general aviation pilots engaged in, it would have been ideal to calculate separate accident ratios for each of those categories of flying.

For example, to answer the question whether Part 121 accident rates differed as a function of pilot age, it was necessary to identify Part 121 accidents and to get a good estimate of the exposure of pilots to those accidents. However, the information contained in the databases would not directly support those types of analyses.

While the accident databases included information about the numbers of Part 121, Part 135, and Part 91 accidents for pilots of different ages, there was no way to directly calculate exposure rates for those pilots. Precise exposure rates would have been based on the number of Part 121, Part 135, and Part 91 hours flown by pilots of different ages. Since the data for number of hours flown had to be based on all pilots, not just pilots who had been in accidents, those data were potentially available only in the FAA Comprehensive Airman Information System (CAIS) medical database, and were not available from the NTSB accident database.

Unfortunately, the CAIS medical database only included recent (over the past six months) and total flight time broken down by the medical class certificate of the pilot, not by the type of flying (i.e., Part 121, Part 135, or Part 91). A Class I medical certificate had to be renewed every six months and was required of all air transport pilots (ATP); a Class II certificate had to be renewed yearly and was required of all commercial pilots; a Class III medical certificate had to be renewed every 2 years and was required of all private and student pilots. However, while there was some relationship between class of medical certificate and type of flying, it was by no means a perfect fit.

For example, to be certified as a Part 121 pilot-in-command, a pilot had to initially and periodically demonstrate proficiency in flying the aircraft, possess an ATP pilot certificate and a rating for the specific aircraft to be flown, and possess a Class I medical certificate, obtainable by passing a semi-annual medical examination. Thus, all Part 121 hours were accumulated by pilots with a Class I medical certificate, but the reverse was not true. Not all hours reported by pilots with Class I medical certificates represented Part 121 flying. As Table 1-1 illustrates, only 3.38 percent of all accidents between 1983 and 1988 where the pilot in command had a Class I medical certificates involved Part 121 flights. In fact, the majority of accidents for Class I pilots (72 percent) were Part 91 flights.

Table 1-1. Number of accidents recorded in the NTSB database for the years 1983-1988 as a function of type of flying (Part 121, 135, and 91) and medical certification class. Percentages indicate the percentage of the total number of accidents within a medical certification class.

| | Class I | | Class II | | Class III | |
|---|---|---|---|---|---|---|
| Type of Flying | Accident Count | Percent | Accident Count | Percent | Accident Count | Percent |
| 121 | 57 | 3.36 | 1 | 0.02 | 0 | 0.00 |
| 135 | 351 | 20.72 | 273 | 6.23 | 0 | 0.00 |
| 91 | 1,211 | 71.49 | 3,277 | 74.77 | 4,981 | 99.64 |
| Other*1 | 75 | 4.43 | 832 | 18.98 | 18 | 0.36 |
| Total | 1,694 | | 4,383 | | 4,999 | |

There were many pilots holding a Class I medical certificate who did not fly air transport. For example, an air taxi service may have required its pilots to have a Class I medical certificate, even though FAA regulations allowed a pilot with a Class II certificate to fly an air taxi. Also note that a pilot may have had to use an out-of-date certificate in place of one from a lower class, provided the certificate was not out-of-date for the lower class. Thus a Class I medical certificate (good for 6 months) was, in effect, a Class II certificate for a year or a Class III certificate for 2 years. As Table 1-2 illustrates, the distribution of pilot certificates for those who had accidents varied greatly by medical certification. The number of Class I pilots with ATP and Commercial certificates was about the same while the majority of Class III pilots had private certificates.

Under certain conditions it may have been possible to identify Class I pilots who were flying under Part 121. For example, the CAIS medical database included information about the pilot's employer, the pilot's job, and the kind of flying (solely business, solely pleasure, or both). Restricting analyses to those Class I pilots who worked as pilots for scheduled airlines, who did not fly for pleasure alone, and who had flown a substantial number of hours within the last year, could have provided better estimates of accident rate for pilots most likely to be flying under Part 121.

**Table 1-2.** Number of pilots recorded in the NTSB database for the years 1976-1988 as a function of type of certificate held by the pilot (ATP, Commercial, etc.) and medical certification class. Percentages indicate the percentage of the total number of pilots within a medical certification class.

| | Class I | | Class II | | Class III | |
|---|---|---|---|---|---|---|
| Pilot Certificates | Pilot Count | Percent | Pilot Count | Percent | Pilot Count | Percent |
| ATP | 2,328 | 38.76 | 810 | 4.70 | 43 | 0.27 |
| Commercial | 2,553 | 42.51 | 11,796 | 68.46 | 824 | 5.25 |
| Private | 270 | 4.50 | 3,214 | 18.65 | 11,734 | 74.82 |
| Student | 75 | 1.25 | 203 | 1.18 | 2,987 | 19.05 |
| Other*2 | 780 | 12.99 | 1,207 | 7.01 | 95 | 0.61 |
| Total | 6,006 | | 17,230 | | 15,683 | |

Since the Age 60 Rule applied to Part 121 pilots, it may have been ideal to focus on age differences in the accident rates of this group of pilots. However, in addition to the difficulties estimating exposure rates for Part 121 pilots described above, there were two other factors that constrained the types of analyses that could be done on that group of pilots. First, Part 121 accidents were so infrequent that the data could have been too sparse to allow for valid statistical inferences. Second, because of the Age 60 Rule itself, there were no comparable data on accident rates for Part 121 pilots under and over age 60. As a comparison of Tables 1-3 and 1-4 illustrates, the distribution of accidents by type of flying underwent a dramatic change for Class I pilots at age 60. Those problems could be partially addressed by analyzing other groups of pilots.

**Table 1-3.** Number of accidents recorded in the NTSB database for the years 1976-1988 by pilots aged 20 to 60 as a function of type of flying (Part 121, 135, and 91) and medical certification class. Percentages indicate the percentage of the total number of accidents within a medical certification class.

| | Class I | | Class II | | Class III | |
|---|---|---|---|---|---|---|
| Type of Flying | Accident Count | Percent | Accident Count | Percent | Accident Count | Percent |
| 121 | 57 | 3.45 | 1 | 0.02 | 0 | 0.00 |
| 135 | 348 | 21.09 | 264 | 6.49 | 0 | 0.00 |
| 91 | 1,170 | 70.91 | 2,996 | 73.70 | 4,531 | 99.60 |
| Other*1 | 75 | 4.55 | 804 | 19.78 | 18 | 0.40 |
| Total | 1,650 | | 4,065 | | 4,549 | |

**Table 1-4.** Number of accidents recorded in the NTSB database for the years 1976-1988 by pilots aged 61 to 84 as a function of type of flying (Part 121, 135, and 91) and medical certification class. Percentages indicate the percentage of the total number of accidents within a medical certification class.

| | Class I | | Class II | | Class III | |
|---|---|---|---|---|---|---|
| Type of Flying | Accident Count | Percent | Accident Count | Percent | Accident Count | Percent |
| 121 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 135 | 3 | 6.82 | 9 | 2.83 | 0 | 0.00 |
| 91 | 41 | 93.18 | 281 | 88.36 | 450 | 100.00 |
| Other*1 | 0 | 0.00 | 28 | 8.81 | 0 | 0.00 |
| Total | 44 | | 318 | | 450 | |

For example, analyses could have focused on Class III pilots and Part 91 accidents involving Class III pilots. While those analyses were only indirectly relevant to the Age 60 Rule, they did provide a more general view of the effects of age on accident rate. However, there were limitations on the types of interpretations that could be drawn from that approach. Part 91 general aviation pilots did not need to meet as rigorous medical and proficiency standards as airline pilots, and their selection and licensure were not as rigorous. Nevertheless, when Class III pilots and Part 91 accidents were used to draw tentative inferences about Part 121 accident rates, the data needed to be selected so that the population was reasonably comparable to the group of Part 121 pilots to be analyzed. For example, the analyses could have been restricted to experienced pilots with high hours flown in the last year and high total flight time, both of which were characteristic of airline pilots.

That type of analysis of Part 91 accidents did provide information about the general effects of aging on aviation accidents. Further, it did cast light in an area where the Part 121 accidents left us totally in the dark: accidents by flyers older than 60. If the 60th birthday is an important milestone in flying ability, the data from the analysis of the Part 91 accidents should have reflected this, especially when age was examined year by year.

## 1.4 Approach

The overall approach taken in this project was to first develop the Consolidated Database and then to conduct experiments on the CDB. The CDB was designed to support scientific analysis, and is described in detail in Section 3 of this report. In the interest of maximizing the efficiency of output during the development effort, a parallel approach was adopted. Since the CAIS Medical Database and the NTSB accident database were the major databases of interest in this study, they were loaded and verified first so that analysis depending on those data could be started while the remaining databases were loaded. The other database of importance in the analysis was the CAIS Certification Database, because it provided a linkage between the accident and medical databases through the pilot's certificate number (see Section 3, Figure 3-1). Consequently the Certification Database was the third database to be installed in the CDB.

A number of supporting tabulations and analyses were conducted throughout the course of the work that were necessary and useful, but not revealing in regard to the scientific conclusions of the study. For example, pilot attrition studies and pilot counts were conducted to characterize the various groups that were used for analysis. These results and many others were not incorporated in this report.

## 1.5 Document Overview

The remainder of this report is organized as follows. Section 2 discusses prior research concerning accident rate and the age of the pilot. This includes a discussion of the Golaszewski report of 1983, which is the most widely cited previous work. Section 3 describes the Consolidated Database and provides an explanation of how the CDB was utilized to support the analytical work contained in this report. Section 4 describes in detail the analytical methodology employed in this study. The statistical approach used throughout the analyses is explained and justified. Section 5 presents the results of the analysis. The format used to present the results is to frame the discussion in a series of answers to questions that progress in a logical fashion to the conclusions concerning chronological age, accidents, and other factors. Finally, Section 6 summarizes and discusses the results of the analysis and offers conclusions relevant to the Age 60 Rule.

As previously noted, the results of analyses presented in this report are those that bear directly on the stated objectives of the research. The analytical results, tables, and figures contained in the report are but a small fraction of the overall analytical research that was conducted throughout the duration of this effort.

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*1 Other type of flying includes miscellaneous categories such as 103, 105, 123, 125, 127, 129, 133, 137, and 141.

*2 Other pilot certificates include flight engineer, foreign flight instructor, military, and special purpose.

## 2.0 PRIOR RESEARCH

A number of studies investigated the relationship between accident rate and the age of the pilot (Golaszewski, 1983; Guide and Gibbon, 1991; Mortimer, 1991; OTA, 1990). Golaszewski's study was widely cited and can be considered the basis for these subsequent studies. Indeed, both Mortimer and the OTA derived their data from Golaszewski's study. The methodology of Guide and Gibson was also similar to that of Golaszewski. Those studies are summarized below.

### 2.1 1983 Golaszewski Analysis

In 1983, Richard Golaszewski produced a report "The influence of total flight time, recent flight time and age on pilot accident rates" (Golaszewski, 1983). The report was based on data contained in the National Transportation Safety Board (NTSB) Accident Records Database and the FAA CAIS Medical Certification Database for the years 1976-1980. From the two databases, the age, recent flight time, and total flight time of licensed pilots were determined. Golaszewski estimated accident rates for different pilot categories as a function of the factorial combination of age, recent flight time, and total flight time. Recent flight time was construed as experience within the previous 12 months. The data were analyzed in two groups: all pilots and pilots holding Class III medical certificates. Golaszewski set up categories of recent flight time as 0-20 hours, 21-50 hours, 51-100 hours, 101-400 hours, and 401 hours and over. He used the NTSB Accident database to tabulate accidents by age, recent flight time, and total flight time for Class III pilots and for all pilots. The CAIS Medical Certification database was used to estimate the exposure (i.e. number of hours flown) for each class of pilot. Golaszewski used annualization factors to compute exposure as follows: for Class I pilots who reported every six months, the number of recent hours in each record were each divided by two; for Class II pilots, who reported on a yearly basis, the number of hours flown was not modified; for Class III pilots, who reported biannually, the number of hours flown was multiplied by two. All of Golaszewski's analyses were restricted to two groups, Class III pilots and Class I, II, and III pilots combined.

After visually inspecting his graphs, Golaszewski concluded:

1. Accident rates were inversely proportional to recent flight time.
2. For low recent flight time, older pilots had more accidents than younger pilots, while the converse held for higher recent flight time.
3. For recent flight time less than 50 hours, Class I and II pilots had more accidents than Class III pilots.

4. Accident rates were inversely proportional to total flight time.

5. Class III pilots had more accidents, regardless of total flight time.

6. For Class I and II pilots with 101 to 5,000 total flight hours, older pilots had more accidents than younger ones.

7. The older the Class III pilot, the less likely an accident until age 60, when accidents became more likely.

8. Pilots with over 1,000 total flight hours and less than 50 recent flight hours had the highest accident rates, while pilots with over 1,000 total hours and greater than 50 recent hours had the lowest accident rates.

9. For Class III pilots with low total flight time and fewer than 50 recent flight hours, accident rates increased with age; the converse was true if the number of recent flight hours exceeded 50.

10. For pilots with more than 50 recent flight hours and less than 1,000 total flight hours, accident rates decreased with age; the converse held for pilots with less than 50 recent flight hours and less than 1,000 total flight hours.

### 2.1.1 Drawbacks to Golaszewski's Methodology

Combining pilot classes, as done in the Golaszewski analysis, was inappropriate because it produced misleading accident rates. For example, pilots holding Class I medical certificates had relatively fewer accidents and higher flight hours. The accident rate profile of a heterogeneous group was influenced by the proportion of Class I pilots in that group. Further, because Class I pilots were involved in so few accidents, Golaszewski did not compute the accident rates within various categories of flying by Class I pilots. The fact that accidents involving Class I pilots were so rare strongly suggested that the distribution of such accidents across the various categories was different than for the groups of pilots Golaszewski did study, Class III pilots alone and all pilots. Further, although Class I pilots were involved in few accidents they accumulated a substantial number of flight hours. Thus they contributed substantially to the denominators (hours flown) of the accident rates and contributed relatively little to the numerators (number of accidents). This meant that differences in accident rates could have been artifacts; they could have reflected differences in flight hours accumulated by Class I pilots rather than differences in the likelihood of accidents.

Golaszewski included accidents by pilots whose medical certificates had lapsed. Their flight hours were not recorded in the CAIS medical database and their exposure to accidents could not be estimated. Thus, those pilots only contributed to the numerators of the accident rates. Any systematic bias in the distribution of those pilots by age would have distorted the corresponding accident rates.

Golaszewski performed no statistical analyses on his data, depending only on visual inspections of the data. As we argue in detail in Section 4.4, the data were quite amenable to statistical analysis. Statistical analyses would have told us which differences were real and were to be expected in the future as opposed to those differences that were chance occurrences. For example, points 9 and 10 in Golaszewski's summary above suggested a triple interaction among age, recent flight time, and total flight time. Without a statistical analysis, firm evidence for this conclusion was lacking.

The Age 60 Rule represents a sharp cutoff, presumably reflecting some relatively dramatic change in the pilots as they approach 60 years. The 10-year age categories used by Golaszewski were too gross to get a clear picture of such a change. A more fine grained analysis, say by year, would have been more appropriate.

## 2.2 1990 Office of Technology Assessment Analysis

In 1990, the Office of Technology Assessment (OTA) released a report (Office of Technology Assessment, 1990) that presented graphs of data supplied by Dr. Charles Billings of the NASA Ames Research Center. The figures stated that the data were from "Golaszewski 1983, and NTSB 1990". The OTA report drew the following major conclusions:

1. For Class I and II pilots with more that 1,000 hours total flight experience and more than 50 hours recent flight experience "an age effect was present and was beneficial until 50, after which rates increased".
2. For Class I and II pilots "an increase in accident rates with increasing age was seen after age 39 in pilots with 501-1,000 hours, after age 49 in pilots with 1001-5,000 hours, and after age 59 in pilots with over 5,000 hours".
3. For Class I and II pilots "who flew more than 100 hours/year, increasing age (and probably total experience) and increased recent flying time both had beneficial effects. After age 60, accident rates increased even if pilots continued to fly over 400 hours per year".

It appeared that the data for the OTA report were obtained by subtracting the numbers for Class III pilots from the numbers for the corresponding combined group of Class I, II, and III pilots, thus indirectly obtaining data for the corresponding group of combined Class I and II pilots. Conclusions from these data were tentative, because no statistical analyses were performed on the data. Unfortunately, whatever the source of the data, they did not bear directly on the Age 60 Rule, because they combined Class I and Class II pilots to create quite heterogeneous groups.

## 2.3 1991 Guide and Gibson Analysis

A third study was conducted by Guide and Gibson (1991) and reported at the 1991 meeting of the Human Factors Society. Their design was similar to Golaszewski's and utilized data for the years 1982 - 1988 from four sources: the NTSB Accident database, the Aircraft Owners and Pilots Association Air Safety Database, the FAA Statistical Handbook on Aviation, and the COMSIS Research Corporation. They used 5-year age categories, starting with 20-24 and finishing with 55-59. They computed accident rates in two ways: (1) per number of active pilots and (2) per number of annual hours flown. All analyses depended upon visually examining four figures displaying the above data; no statistical analyses were reported.

Three of the figures displayed the accidents per number of active pilots for air transport pilots, for commercial pilots, and for private pilots, respectively. Exposure was not accounted for in these figures. The fourth figure displayed accidents per hours flown for Part 135 pilots as a function of age and of hours flown in the preceding year (101-400 versus > 400), although the data for the 20-24 age group were omitted for some unstated reason. There appeared to be no discernible trends as a function of age in the data in the fourth figure. Indeed, differences among the various age groups appeared minimal, however, this was difficult to verify without statistical tests. For each of the seven age groups displayed, the pilots with more than 400 recent flight hours had an accident rate roughly one third that of the pilots with 101-400 recent flight hours. The probability of that happening by chance was less then 0.01 (applying the sign test, with $N=7$).

## 2.4 1991 Mortimer Analysis

Mortimer (1991) examined a random sample of 1,034 general aviation accidents drawn from the NTSB data base for the years 1985 and 1986. Although not clear from his description, he appeared to have estimated exposure by multiplying the number of pilots in various categories in 1985 and 1986 by the mean number of hours, per pilot, flown by the corresponding pilots in Golaszewski's report. Mortimer concluded from the resulting data, apparently without statistical analysis, that private pilots over 60 had accident rates at least twice that of their juniors. Mortimer's methodology had a number of weaknesses, particularly his estimation of exposure. If the percentage of pilots over 60 in 1985-1986 was twice that of 1976-1980, Mortimer's effect disappeared. Because Mortimer was vague about the exact nature of his calculations, they could not be readily reproduced or analyzed using the CDB data and therefore were not considered in this study.

## 3.0 CONSOLIDATED DATA BASE

This section summarizes the development of a Consolidated Database (CDB) to support diverse research needs in the aviation safety and human factors research area and provide more direct access to the wealth of information collected by the FAA and NTSB. The CDB merges several NTSB and FAA historical databases that are currently organized in heterogeneous formats into a single relationally structured database. Each of the historic databases contains information on a particular aspect of available information including the results of periodic medical examinations required for all pilots, pilot certifications and ratings information, accident investigations, pilot incidents, and pilot deviations. The consolidation of these databases allows researchers to pose questions that cannot be readily determined from a single database. Each of these historic databases was developed and maintained by separate organizational entities and organized for the needs of the specific organization. Researcher access to these historic databases to explore new hypotheses is difficult, if not impossible. Additionally, the individual databases are based upon diverse file and database management systems utilizing a variety of hardware and software environments. Semantically similar information is stored using a variety of formats and data models and each database uses different naming conventions.

A high level description of the FAA and NTSB source databases used in these analyses is provided as well as information on the processes used to verify the contents and to retrieve the information required for the analyses presented in this report. For additional details about the CDB, the reader is referred to the CDB Technical Reports: Age 60 Project Consolidated Database Implementation (Harris, Hillman, and Voros, 1992a) and Age 60 Project Consolidated Database User's Guide (Harris, Hillman, and Voros, 1992b) (see attached bibliographies for citations).

### 3.1 FAA and NTSB Historic Databases

The CDB incorporates information from several existing sources, including the FAA Comprehensive Airman Information System (CAIS) containing both medical history and certification data, the Accident/Incident Database (AIDS), the Pilot Deviation System (PDS), and the NTSB Accident database. These source databases contain information regarding pilot characteristics, operational experience, medical data, aviation deviations, incidents, and accidents as described below.

#### 3.1.1 FAA Comprehensive Airman Information System (CAIS)

The CAMI Comprehensive Airman Information System (CAIS), maintained in Oklahoma City, contains medical data for pilots as well as airman certificate information. The medical certification system contains information on airman applications for medical certification based upon physical standards prescribed in FAR, Parts 61 65, 67, and 187. CAIS airman information is organized into the following two groups of information:

1. Pilot certification which contains a single record for each pilot with the most recent information on the pilot's certificates, ratings, accidents, violations, cancellation/revocations, and limitations.
2. Medical certification which contains a record for each certification physical including date of birth, certification class, flight hours (civilian total and last six months), medical information (cardiovascular, vision, hearing, restrictions, and pathology codes).

From the pilot certificate database no historic information is available nor is there an indication of when the information for the pilot changes. For example, no information is provided about when a pilot obtained a particular certificate or rating.

### 3.1.2 NTSB Accident Records Database

The NTSB Accident Records Database, maintained in Washington, DC, contains information derived from accidents investigated by the NTSB. Three different forms have been used to collect the data. From 1962 to 1981, an Aircraft Accident Analysis Sheet (NTSB Form 6120.12) based on punched card images was used. In 1982, the form was revised (6120.4D NTSB Accident/Incident Report) to facilitate the collection of data in 693 fields plus a free-form narrative. The data collected from 1983 to the present are based upon the information contained on revised form 6120.4, NTSB Factual Report Aviation, which has 236 fields. The NTSB accident data for 1983 to the present contains an additional 22 files each of which provides information on a specific area such as a text narrative of the accident, causal factors, copilot information, etc. Information contained in the NTSB Accident Database includes the following: pilot information (age, flight hours for specific aircraft and all aircraft for last 24 hours, 30 days, 90 days, and overall total), weather, cabin crew and passenger information, aircraft information, operational phase, investigation results, and causes and factors. Currently, the NTSB information incorporated into the CDB includes the core file containing material provided on form 6120.4, the accident narrative file, cause factors detailed in the sequence of events file, and co-pilot file.

## 3.2 CDB Database Statistics

The contents of the CDB were verified, where possible, by comparing the number of records loaded from the media supplied by the database administrator. In addition, statistical sources were consulted where available. Table 3-1 presents statistics on the CAIS medical records included in the CDB compared to the information shown in FAA 1990 Yearbook (Table II.B, Receipts of Medical Certificate Applications by Class). The data in Table II.B is based upon receipt of medical certificates, while the data from the CDB is based upon year of medical examination and only includes those applications that were acceptably processed into the CAIS system.

The large discrepancy for 1986 CAIS medical records data shown in Table 3-1 was investigated further. Table 3-2 presents a month by month analysis of the CDB data versus the information presented in the FAA 1986 Yearbook (Table II.B, Receipts of Medical Certificate Applications by Class). It appears that the missing data for 1986 was irrevocably lost. The data for May, June, July, and August of 1986 show large variations between that shown in the FAA Yearbook. Unfortunately, no discernible pattern for the missing data could be established and therefore 1986 data were omitted from the analyses included in this report.

The information extracted from each of the source databases was stored in a series of tables in the CDB. Table 3-3 contains the number of records included in the CDB for each of the source databases used in these analyses as well as an indication of the associated time periods.

**Table 3-1.** A comparison of the number of medical certificates applications received reported in the FAA statistical handbook with the number of records loaded in the CDB for the years 1976-1988. The large discrepancy for 1986 is apparently due to lost records. See the text for more details.

| Year | FAA Statistical Handbook | CDB Database | Difference |
|---|---|---|---|
| 1976 | 542,159 | 524,449 | 17,710 |
| 1977 | 550,243 | 538,350 | 11,893 |
| 1978 | 565,534 | 558,973 | 6,561 |
| 1979 | 550,188 | 551,905 | -1,717 |
| 1980 | 529,051 | 504,015 | 25,036 |
| 1981 | 529,418 | 502,098 | 27,320 |
| 1982 | 463,241 | 479,916 | -16,675 |
| 1983 | 477,905 | 490,271 | -12,366 |
| 1984 | 463,617 | 468,919 | -5,302 |
| 1985 | 479,849 | 474,094 | 5,755 |
| 1986 | 474,392 | 347,604 | 126,788 |
| 1987 | 470,208 | 471,223 | -1,015 |
| 1988 | 466,326 | 463,749 | 2,577 |
| Total (All Years) | 6,562,131 | 6,375,566 | 186,565 |
| Total (Excluding 1986) | 6,087,739 | 6,027,962 | 59,777 |

**Table 3-2.** Count of medical certificates in the CDB for 1986 as a function of month and class. Note the low totals for May, June, July, and August.

| Month | Class I | Percent | Class II | Percent | Class III | Percent | Total | |
|---|---|---|---|---|---|---|---|---|
| January, 86 | 12,386 | 33% | 11,273 | 30% | 13,626 | 37% | 37,285 | |
| February, 86 | 10,642 | 33% | 9,957 | 31% | 11,822 | 36% | 32,421 | |
| March, 86 | 11,562 | 31% | 11,294 | 30% | 14,446 | 39% | 37,302 | |
| April, 86 | 11,660 | 30% | 11,298 | 29% | 15,773 | 41% | 38,731 | |
| May, 86 | 9,198 | 31% | 8,244 | 27% | 12,602 | 42% | 30,044 | |
| June, 86 | 1,358 | 43% | 805 | 25% | 1,024 | 32% | 3,187 | |
| July, 86 | 1,437 | 31% | 1,516 | 32% | 1,750 | 37% | 4,703 | |
| August, 86 | 3,518 | 27% | 4,403 | 34% | 5,018 | 39% | 12,939 | |
| September, 86 | 11,815 | 29% | 11,734 | 29% | 16,640 | 41% | 40,189 | |
| October, 86 | 12,560 | 31% | 11,730 | 29% | 16,383 | 40% | 40,673 | |
| November, 86 | 10,506 | 33% | 9,144 | 29% | 12,046 | 38% | 31,696 | |
| December, 86 | 11,308 | 34% | 9,736 | 29% | 12,148 | 37% | 33,192 | |
| CDB 1986 Total | 107,950 | 32% | 101,134 | 30% | 133,278 | 39% | 342,362 | |
| FAA 1986 Yearbook | 133,304 | 28% | 146,113 | 31% | 194,975 | 41% | 474,392 | |
| Difference | 25,354 | 19% | 44,979 | 31% | 61,697 | 32% | 132,930 | 28% |

**Table 3-3.** Count of the number of records in the CDB as a function of the source databases.

| CDB Source Database | Number of CDB records | Time Period Included in CDB |
|---|---|---|
| FAA Medical | 6,375,566 | 1976-1989 |
| NTSB Accident | 47,616 | 1976-1988 |
| FAA Certification | 2,954,999 | 1962-1988 |
| FAA Pilot Deviation System | 13,895 | 1986-1990 |
| FAA Accident/Incident | 41,341 | 1986-1991 |
| Total | 9,433,417 | |

## 3.3 CDB Organization

The development of the CDB involved designing a global structure that unified the diverse database information, identifying semantically equivalent data elements, and developing consistent formatting and coding schemes. The CDB was developed using the Oracle Relational Database Management System (RDBMS) on an HP 9000/750 UNIX Workstation. The information contained in each source database was examined and similar information, such as aircraft owner, pilot data, weather, accident causes, etc., was grouped into a set of Oracle tables.

Unique identifiers were required to link the CDB tables based upon the information available from the source data. For example, a mechanism for associating a pilot involved in an accident with that pilot's medical examination information was needed. The certification, accident (1982 to present), pilot deviation, and accident/incident database information contain the pilot certification number. However, the pilot records in the CAIS Medical Certification database are identified only by the pilot's social security number. Since the CAIS Certificate Database contains both the pilot's certificate number and social security number, this information was used to add an additional data element containing the pilot's certificate number to each medical record for the pilot. This mapping could not be readily accomplished because certificate numbers in the CAIS Certificate Database are not unique and it appears that the certificate numbers are reused. In order to uniquely identify a pilot, the following combination of database elements are required:

- NTSB Accident, Pilot Deviation -- certificate number and date of birth
- FAA Certificate -- certificate number and social security number

It is important to note that the personal identifiers in the NTSB Accident database prior to 1982 were removed and, therefore, accident information in this period could not be linked to other databases. Figure 3-1 illustrates how the source databases can be linked through the pilot certificate number in combination with appropriate additional fields as described above. For purposes of illustration, this figure only shows the certificate number.

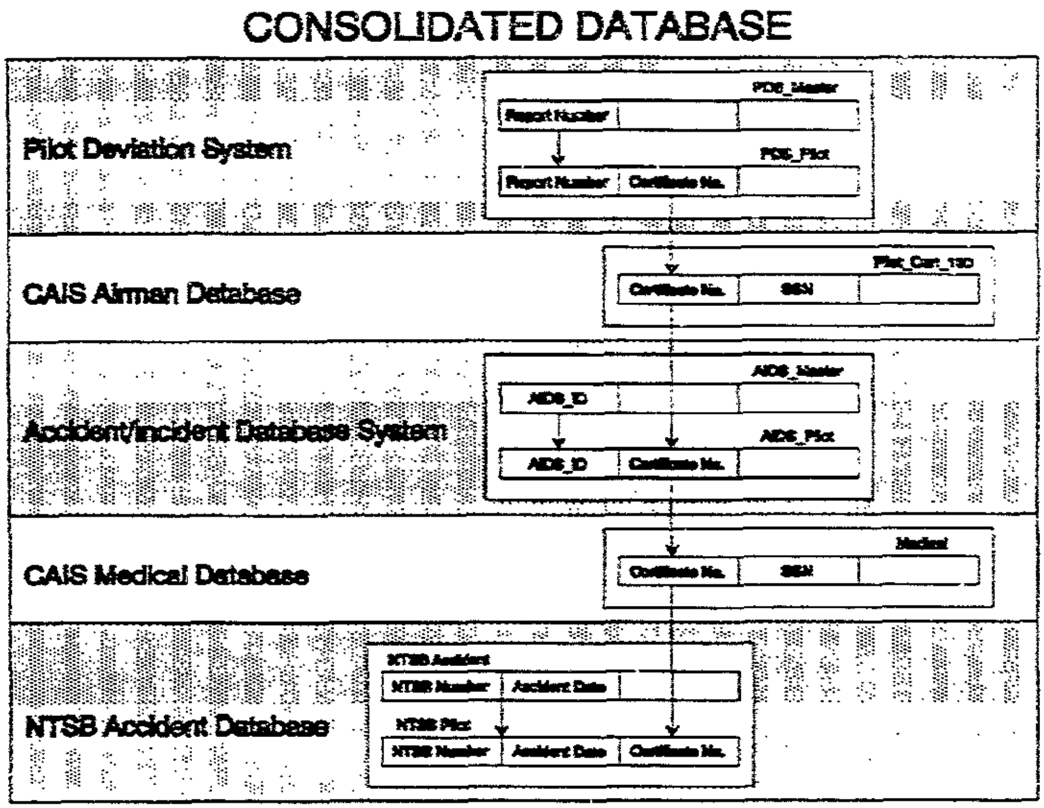


**Figure 3-1.** A view of the constituent databases of the CDB and how they may be linked using the pilot's certificate number.

The source databases used a variety of schemes for encoding information. These coding schemes were used to associate an abbreviation or a mnemonic with a particular entry in a set of possible values for a column of information. To facilitate the use of the CDB, common encoding schemes were developed for key pieces of data, such as pilot medical certification class. Table 3-4 illustrates the coding scheme developed for the CDB based upon those used in the NTSB Accident and FAA Medical for medical class (medical class is not contained in the AIDS and PDS databases).

**Table 3-4.** Encoding schemes for pilot medical class for the CDB, FAA Medical and NTSB databases.

| Pilot Medical Class | CDB | FAA Medical | NTSB Prior to 1982 | NTSB 1982 | NTSB 1983 to Present |
|---|---|---|---|---|---|
| I | 1 | 11-19 | A,D,G | I | 2 |
| II | 2 | 21-29 | B,E,H | II | 3 |
| III | 3 | 31-39 | C,F,I | III | 4 |
| None | 0 | 0 | J | Blank | 1 |
| Unknown | Null | 0 | Z | Blank | 0 |

## 3.4 CDB Utilization

### 3.4.1 Selection Criteria

The criteria for selecting accident and medical examination database records for inclusion in the CDB analyses described here were:

- The age of the pilot was between 20 and 74;
- The medical class was 1, 2, or 3; and
- Recent and total flight time were both valid and greater than zero.

Table 3-5 presents statistics on the CDB Medical records that were included in this study while Table 3-6 presents similar statistics for NTSB accident records. Although NTSB accident records were available for 1986, they were not used in any analyses that also involved 1986 medical records.

### 3.4.2 Accident Rate Calculation Procedure

The NTSB information in the CDB includes the pilot's age, medical class, and total flight hours and recent flight time (previous 90 days for all aircraft). The medical examination data in the CDB contains pilot's date of birth, medical class, total flight time, and recent flight time (previous six months). The term "recent flight hours" in this report is defined as the number of hours flown by a pilot for a single year.

Hours were annualized according to the Golaszewski study (see Section 2.1 for discussion of the Golaszewski methodology). The accident rate as calculated for a given group of pilots is computed as shown below based on the method developed by Golaszewski (1983):

$$\text{Accident Rate} = \frac{\text{Count of NTSB Accidents}}{\text{Total of FAA Medical Annual Flight Hours}}$$

**Table 3-5.** Count of the number of medical records in the CDB and the number of medical records used in the CDB experiments as a function of year (1976-1988). Note that the records from 1986 were not used in the CDB experiments, because a substantial number of records are missing for that year.

| Year | CDB Medical Records | Records Used in CDB Analyses |
|---|---|---|
| 1976 | 524,449 | 338,794 |
| 1977 | 538,350 | 348,080 |
| 1978 | 558,973 | 342,916 |
| 1979 | 551,905 | 347,590 |
| 1980 | 504,015 | 337,604 |
| 1981 | 502,098 | 333,348 |
| 1982 | 479,916 | 312,816 |
| 1983 | 490,271 | 317,583 |
| 1984 | 468,919 | 314,357 |
| 1985 | 474,094 | 324,311 |
| 1986 | 347,604 | **Not Used**[*3] |
| 1987 | 471,223 | 334,055 |
| 1988 | 463,749 | 334,124 |
| TOTAL -- All Years | 6,375,566 | 3,985,578 |

**Table 3-6.** Count of the number of accident records in the CDB and the number of accident records used in the CDB analyses as a function of year (1976-1988).

| Year | NTSB Accidents | Records Used in CDB Analyses |
|---|---|---|
| 1976 | 4,367 | 3,839 |
| 1977 | 4,468 | 3,947 |
| 1978 | 4,699 | 4,116 |
| 1979 | 4,208 | 3,632 |
| 1980 | 3,961 | 3,361 |
| 1981 | 3,877 | 3,187 |
| 1982 | 3,592 | 3,180 |
| 1983 | 3,555 | 2,494 |
| 1984 | 3,452 | 2,370 |
| 1985 | 3,092 | 2,247 |
| 1986 | 2,872 | **Not Used*3** |
| 1987 | 2,795 | 2,027 |
| 1988 | 2,678 | 1,941 |
| TOTAL -- All Years | 47,616 | 38,414 |

The procedure for generating the data required to calculate the accident rates for a categorical group of pilots, e.g., year of accident/medical examination, pilot age, pilot medical class, and recent flight hours categories (less than 250 per year, more than 500 per year, etc.) was as follows. The annual flight hours for the NTSB accidents was determined by multiplying the hours reported the past 90 days for flying all aircraft by 4. The recent flight hours contained in the medical examination data was for the past 6 months and this number was multiplied by 2 to obtain annual flight hours. Since pilots varied in the frequency in which medical examinations were required by medical class, the annualization factors shown in Table 3-7 were applied to the annual hours obtained from the medical and accident data.

**Table 3-7.** Annualization factors used to convert the total number of annual hours reported by a class of pilots to an estimate of the number of hours flown by that class during the year.

| Medical Class | Medical Examination Frequency | Annualization Factor Applied to Annual Flight Hours |
|---|---|---|
| I | Every six months | 0.5 |
| II | Once a year | 1.0 |
| III | Every two years | 2.0 |

### 3.4.3 Data Limitations

When utilizing the CDB for various studies, the limitations of the various component source databases were considered in determining the viability of the proposed study. Some of those limitations are described below.

Each of the databases used a different scheme for specifying invalid or unknown information. For example, NTSB Accident database filled the field with 9's or Z's while the FAA Medical database contained zeroes. Therefore, flight time information containing a zero was subject to a variety of interpretation -- it could mean:

1. The pilot did not have any flight time and actually entered a zero or
2. The information was unknown or missing and, in some databases, blank information was entered as a zero.

Frequently, data elements for a source database appeared to have potential for study but upon careful examination of the data, the element was not sufficiently populated to permit statistical analysis. For example, the NTSB Accident database contained data elements for day and night landings for the last 90 days for all aircraft. However, as Table 3-8 illustrates, the insufficient number of accident records with information supplied for this field precluded its use.

**Table 3-8.** Day and night landings for Class I, II, and III pilots from NTSB Accident Data 1983-1988 .

| NTSB Accidents (1983-1988) | Class I | | Class II | | Class III | |
|---|---|---|---|---|---|---|
| | Count | Percent Populated | Count | Percent Populated | Count | Percent Populated |
| Accidents Included in CDB | 2,005 | | 5,214 | | 5,933 | |
| Day Landings (Last 90 Days) | 406 | 20.2 | 895 | 17.2 | 886 | 14.9 |
| Night Landings (Last 90 Days) | 512 | 25.5 | 1,577 | 30.2 | 1,944 | 32.8 |

The CAIS Certificate data provided information on pilot certificates, e.g., ATP, commercial, private, etc. However, no information was provided about when the certificate was obtained and therefore usage of this information for historical data analysis was problematic. Although the CAIS Certificate and Medical Databases could be linked, generating accident rates for Class III pilots with private certificates for the period 1983-1988 could not be meaningfully accomplished since the CAIS certificate data was as of 1992 and the pilot certificates for the period 1983-1988 could not be determined.

An additional limitation was that the information obtained from the NTSB Accident database varied depending upon the particular time period. For example, the specification of the regulation the flight was conducted under, e.g., Part 121, Part 135, Part 91, was not available for data prior to 1982. Pilot identifier information, such as certificate number, was removed for data prior to 1982 and therefore data for this period could not be linked to the other databases for analysis.

In analyzing accidents based upon various groupings of causes, the NTSB Accident database information for the period 1982 to 1988 contained numerous detailed cause codes in the sequence of events file. No higher level cause categories such as medical, mechanical, pilot error, etc., were provided and therefore, each researcher had to examine the numeric codes and establish their own particular mapping of the codes to higher level causes categories.

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[*3] 2,073 accident records for 1986 met the selection criteria stated in Section 3.4.1.

## 4.0 METHODOLOGY

### 4.1 Plan of Analysis

A number of principles guided the analyses. First, it was inappropriate to aggregate data across medical classes, because this created heterogeneous groups with misleading accident rates. For example, Class I pilots had relatively few accidents and relatively high flight hours. If the medical class of the pilots was ignored in forming groups, the accident rates of the groups would have reflected differences in the proportion of Class I pilots in the various groups.

Second, the data for Class I pilots shed some light on the accident rates of Part 121 pilots, subject to a number of constraints. Only pilots younger than 60 should have been included, because no Part 121 pilots flew after 60. Further, the data for Class I pilots with high recent flight time were more characteristic of Part 121 pilots. Third, the data for Class III pilots provided convergent evidence on the effects of age on accident rate. While Class III pilots were less like Part 121 pilots, the data for that class were less affected by changes in the membership of the groups with age, especially the dramatic change seen for Class I pilots after age 60. Further, the accident rates for Class III pilots provided evidence for the general effects of aging. Finally, the Class II pilots formed a heterogeneous group and were the least useful group for shedding light on the age 60 rule.

All the analyses were based upon sets of data retrieved from the CDB. The details of the query used to obtain a given set of data from the CDB are shown in Appendix B. The analyses were of four general kinds as described in subsequent paragraphs:

1. Accident rates as a function of age,
2. Longitudinal view of accident rates,
3. Accident frequency as a function of age, and
4. Subsidiary analyses.

#### 4.1.1 Accident Rate as a Function of Age

The CDB provided medical records of all pilots for the years 1976-1985 and 1987-1988. These records contained the number of hours of recent flight time and of total flight time for all pilots of a given age in each medical class (I, II, and III), and these data, in turn, were used to estimate the total number of hours flown by a group of pilots in the preceding year. The CDB also provided records of all accidents during the years 1976-1985 and 1987-1988, records which contained the pilot's medical class, age, and number of hours of recent and of total flight time. From these data, the number of accidents by pilots in a given group could be counted. Thus, for some group of interest (e.g., Class I pilots who had at least 700 recent flight hours, who had at least 2,000 total flight hours, and who were of age 50-54) the accident rate was estimated by dividing the number of accidents for the group by the estimated number of hours flown by the group.

To validate the integrity of the CDB, the data set described by Golaszewski (1983) (i.e., for the years 1976-1980) was retrieved to determine whether our data agreed in detail with those reported by Golaszewski. Examination of those data indicated good agreement. See Appendix A for details.

Focusing on Class I pilots, the interaction of recent flight time and age on accident rate was explored. Then attention was restricted to those Class I pilots most like pilots of scheduled air carriers by considering only those pilots who had the necessary minimum total flight hours and who had the number of recent flight hours characteristic of pilots of scheduled air carriers. Next, only Part 121 pilots with ATP rating and high recent flight hours were considered. Finally, attention was shifted to Class III pilots with high recent flight hours to provide a different view of the effect of age on accident rate. In all cases above, the data were aggregated in a cross-sectional manner. For example, the data for 50-year-old pilots were aggregated for all pilots of that age without respect to the year in which the data were collected. Thus, the 50 year old pilot of 1976 was the 51 year old pilot of 1977. In 1976 that pilot's data were grouped with the 50-year-olds' data; in 1977 that pilot's data were grouped with the 51-year-olds' data.

### 4.1.2 Longitudinal View of Accident Rate

Because the data in the CDB spanned the years 1976-1985, one could take a longitudinal view of accident rate by following the same group for 10 years. In that analysis, accident rate as a function of birth year was examined. For example, the accident rate of pilots born from 1946-1950 was examined for each of the 10 years from 1976 to 1985.

### 4.1.3 Accident Frequency as a Function of Age

In addition to the age of the pilot, the CDB recorded a great deal of information about each accident. Thus the accidents recorded in the CDB could be classified according to the age of the pilot and some second factor, e.g., the time of day when the accident occurred. The resulting data could be analyzed to determine whether the distribution of accidents in the various categories of the second factor differed as a function of age, e.g., whether older pilots were more likely to be involved in an accident at dusk than younger pilots.

### 4.1.4 Subsidiary Analyses

The analyses above raised a number of questions about the underlying population of pilots. For example, given that the formation of the groups was not under the experimenters' control, how did the membership of the groups change as a function of age? This question suggested that the attrition and accretion of groups as a function of age should have been studied.

## 4.2 Assumptions of the Statistics

To maintain their certification, holders of Class I certificates obtained medical examinations every six months, holders of Class II certificates every year, and holders of Class III certificates every two years. In all cases, pilots stated the number of hours flown in the last six months and the number of total hours flown. We defined "recent flight hours flown" as the number of hours flown in the previous year. Thus, doubling the number of hours flown in the previous six months was a reasonable estimate of recent hours flown. To use those data to estimate the recent hours flown by various categories of pilots, the data had to be further "annualized." Thus, because the Class I pilots reported their recent hours twice a year, those recent flight hours were divided by two when aggregated. Similarly, the recent hours flown which were reported by Class III pilots were multiplied by two when aggregated.

The statistical approach, which is described in more detail below, assumed accident rate was normally distributed in the case of the F-test of the analysis of variance and assumed accidents were independent events in the case of the chi-square test. The latter assumption obviously held, while the former assumption merited more discussion. A member of any particular group of pilots had a given probability of being in an accident. Each observation from that group constituted an independent Bernoulli trial, i.e., a trial for which there was or was not an accident. Because the observations were independent, the number of accidents for the given group was binomially distributed. (Drake, 1967). The normal distribution is a good approximation of the binomial when the mean is larger than 3 standard deviations and at least 3 standard deviations less than the number of observations (Drake, 1967). Our analyses were restricted to those data that satisfied that criterion, and the accident rates were therefore approximately normally distributed.

## 4.3 The Statistical Approach

The analysis of variance (ANOVA) was used to analyze the accident rate data, and the chi-square statistic was used to analyze the frequency data. For statistical analyses using the ANOVA, the test was applied to completely crossed factorial designs, i.e., designs in which all combinations of levels of each factor occurred. Such an ANOVA yields an F statistic for each main effect and interaction. When interactions are significant in completely crossed designs, the interpretation of any significant main effects must take into account the significant interaction(s). Indeed, in some cases, the significant main effect takes a back seat to the significant interaction. That is, ignoring the significant main effect in favor of the significant interaction may clarify the interpretation. That approach was taken in interpreting the results shown below.

In our analysis of accident rates, an ANOVA was used that treated the data as proportions (Games, 1978). For such an analysis, the value of the degrees of freedom (df) for the denominator was infinite, because the estimate of the variance was exact (Games, 1978, table 3). For all F values reported, only the degrees of freedom for the numerator were given, and it should be understood that the value of the degrees of freedom for the denominator was infinite.

The chi-square test was applied to counts of accidents which were categorized according to the age-group of the pilot and according to some second factor, e.g., season of the year. Those categorizations led to two-dimensional tables of counts (so called two-way contingency tables). The chi-square test can be applied to any two-way table each of whose cells have expected frequency (as computed in preparation for the chi-square test) equal to 5 or greater (Hays, 1973, p. 723).

## 4.4 Justification of the Use of Statistics

Golaszewski (1983) argued that statistical analyses should not have been applied to his data because the data constituted the whole population, and the data were not normally distributed. Following his lead, Billings (OTA, 1990), Guide and Gibson (1991), and Mortimer (1991) also failed to apply statistical analyses to their data.

Above, it was explained why it was reasonable to assume that the data were normally distributed. The question of whether the data constituted the whole population depended on the inferences desired. This study required inferences about the population of all possible flights. In particular, the probability of an accident as a function of age in the population of all possible flights needed to be inferred. Our data could indeed be used to make such inferences. To understand this, consider the logic of statistical testing in more detail for the example of comparing the probabilities of an accident in two groups. The probability of an accident in each group was estimated by conducting an analysis in which we drew a sample of observations from each group and computed the proportion of observations in each sample that were accidents. Then a statistical test was performed to determine whether the two proportions differed sufficiently to conclude that it was unreasonable to assume that the probability of an accident was the same for both groups. If it was unreasonable to assume equal probabilities, then a similar difference in the same direction was expected when repeating the anaylsis. If the assumption of equal probabilities was reasonable, there was no statistical evidence for predicting the outcome when repeating the analysis. Our data were from an analysis which was more elaborate (and very large) but perfectly analogous to the above example. It was important to infer whether the same results would occur when the analysis was repeated (the following year). Without inference, the data spoke for a population and the question became "Was the policy of mandatory retirement at age 60 justified for that population (and only that population)?" That question might have had some academic interest, but provided no direction for future policy decision, unless one also asked, "Could we infer anything from past performance of the policy to the performance of the policy now and in the future?"

## 5.0 RESULTS

The results of the data analyses were organized according to a series of questions to be answered. The text following a question presented first the data that addressed the question, followed by the results of statistical analyses on the data which were usually presented in an accompanying figure. Appendix B contains the backup data for each figure along with the parameters used to extract the necessary information from the CDB. Usually, the text would be silent about effects that were statistically insignificant. The analyses of variance (ANOVAs) were for completely crossed factorial designs and subsidiary comparisons (or contrasts, see Hays, 1973), where the degrees of freedom for the denominator were always infinite. Thus, for ANOVAs, only the degrees of freedom for the numerator were reported. Finally, how the results of the statistical analyses had a bearing on the original question was discussed.

When discussing the results, it is important to keep in mind that there were a number of factors confounded with age, factors that could affect the outcomes in this study. First, the composition of various groups changed with age. For example, it was likely that the FAA's rigorous medical and operational proficiency standards screened out, over time, pilots more likely to be in accidents. That issue was addressed to some extent with appropriate samples of data from the CDB. Furthermore, the proportion of pilots flying under Part 121 decreased suddenly and dramatically at age 60. Second, the number of landings per flight hour could decrease with age, because older pilots could use their seniority to choose longer routes. Third, the safety characteristics of the route and the airports could be correlated with age for similar reasons. Those latter two factors in regard to Part 121 pilots could not be addressed by the data in the CDB but weakened some interpretations of the results. Note that if an increase in accident rate with age was observed in the data, such an increase would have occurred despite the above confounds, whereas if a decrease in accident rate was observed in the data, such a decrease could be attributed to the above confounds. Analysis of data for Class III (Part 91) pilots minimized the effect of these confounds because those pilots did not operate in the framework of the more rigorous standards or of seniority rules.

### 5.1 Age and Accident Rate

#### 5.1.1 Did Accident Rates of Class I Pilots Change with Age?

Here, all Class I pilots were grouped together without regard to total and recent flight experience. We wanted to get an overall view of the relationship between age and accident rate, knowing that we could not readily generalize to Part 121 pilots, who were a select subgroup of Class I pilots. Data were restricted to pilots between 30 and 59, grouped in 5-year age groups, because that was the age range of Part 121 pilots. Figure 5-1 displays those data. Pilot age affected accident rate for those data

(F(5)=84.69, p<.01). In particular, accident rate decreased with increased age for the younger pilots, leveling off for the older pilots (linear trend, F(1)=306.03, p<.01; and quadratic trend, F(1)=106.02, p<.01).


**Figure 5-1.** Accident rates for all Class I pilots for the years 1976-1985 and 1987-1988 as a function of age. Pilots were grouped in 5-year intervals. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

### 5.1.2 What Was the Relationship Between Age and Recent Flight Time for Class I Pilots?

Golaszewski's (1983) data suggested that flight time affected accident rate and interacted with pilot age. That relationship was examined more closely for Class I pilots with more than 2,000 hours of total flight time. A minimum 2,000 hours of total flight time was chosen because it was the Air Transport Pilot (ATP) requirement for Part 121 pilots. A preliminary analysis determined how total flight time affected the accident rates of pilots with more than 2,000 total flight hours. With three levels of total flight time (2,000-5,000 hours, 5,000-10,000 hours, and >10,000 hours), an ANOVA showed no effect for total flight hours and no interaction with pilot age. Therefore, subsequent analyses ignored total flight hours as a factor, other than focusing on pilots with more than 2,000 total flight hours. Figure 5-2 displays accident rates for Class I pilots with more than 2,000 total flight hours as a function of age and of recent flight time, where recent flight time was defined as the number of hours flown in the previous year. For those data, accident rate decreased with increased age until 40 and then leveled off (F(5)=34.01, p<.01), accident rate decreased with increased recent flight time (F(7)=415.75, p<.01), and the differences in accident rate among the recent flight time groups decreased with increased age (F(35)=1.65, p<.01).

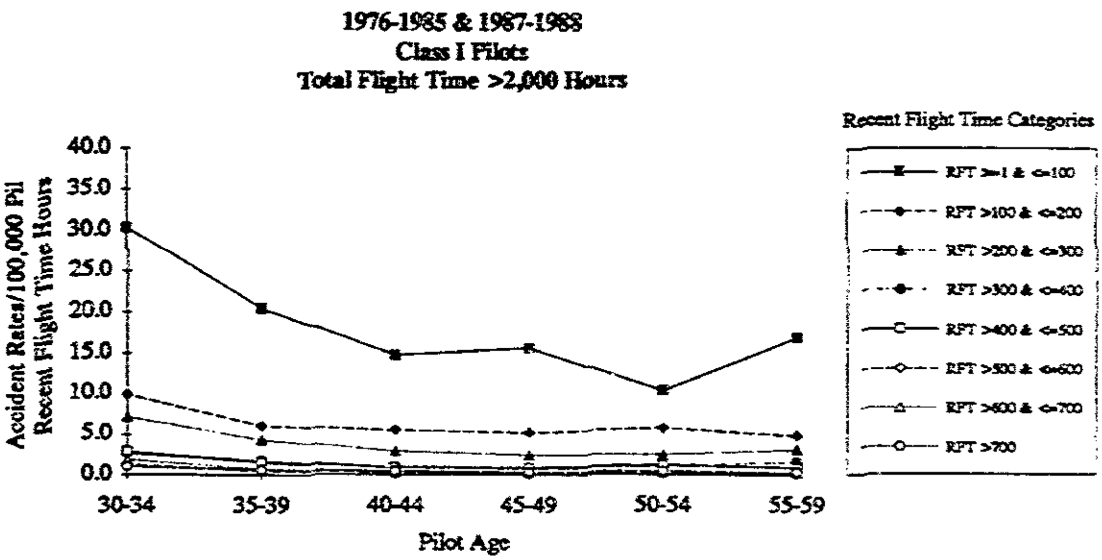


**Figure 5-2.** Accident rates for all Class I pilots with more than 2,000 hours total flight time for the years 1976-1985 and 1987-1988 as a function of age and of recent flight hours (hours flown in the preceding 12 months). Pilots are grouped in 5-year intervals. The numerator for rate is obtained by counting all accidents in the NTSB for the given group of pilots. The denominator is obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

### 5.1.3 How Did Accident Rate Change with Age for Pilots with Relatively High Recent Flight Time?

The data of Figure 5-2 show that recent flight time was a crucial variable when studying accident rate, especially because it interacted with the effects of age. Because Part 121 pilots typically had high recent flight time, Class I pilots with at least 250 hours of recent flight time were next examined, a group quite likely to include most Part 121 pilots. The data for those pilots are shown in Figure 5-3. Accident rates changed with age (F(5)=68.82, p<.01), initially decreasing and then leveling off (contrast for linear trend, F(1)=247.06, p<.01; contrast for quadratic trend, F(1)=80.37, p<.01).

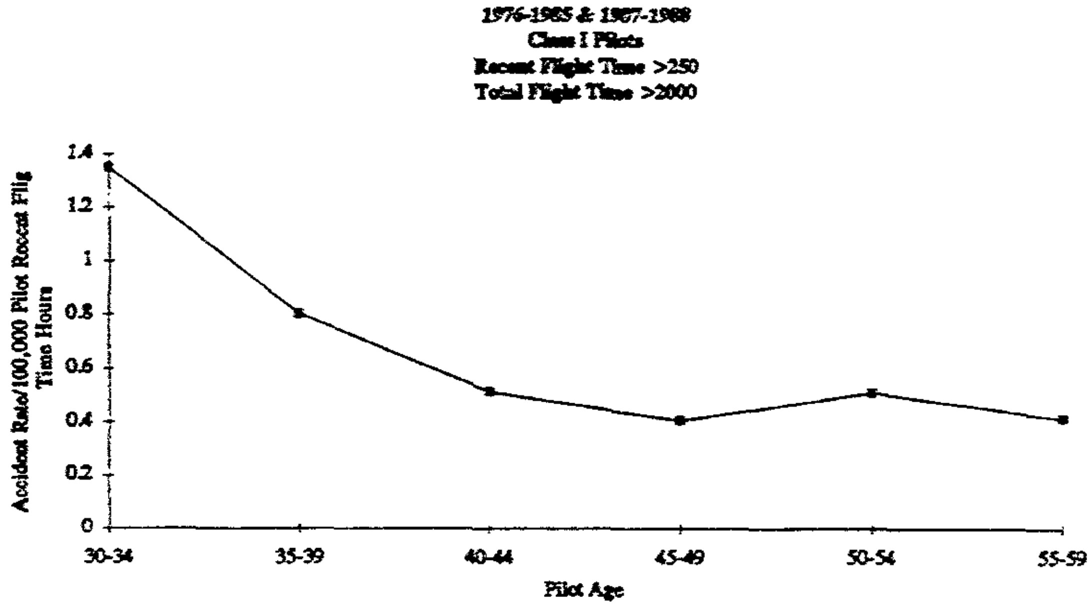


**Figure 5-3.** Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 250 recent flight hours (hours flown in the preceding 12 months) for 1976-1985 and 1987-1988 as a function of age. Pilots were grouped in 5-year intervals. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

A full-time pilot for a scheduled air carrier typically logged about 70 flight hours a month (Brown, 1992). Thus, it was likely that the group of Class I pilots who had 700 or more recent flight hours and more than 2,000 total flight hours more closely fit a profile of scheduled air carrier pilots than did the groups of Figure 5-3. To be sure that 700 recent flight hours was a reasonable number for Class I pilots, the distribution of Class I pilots as a function of age and recent flight hours was determined. Those data are shown in Figure 5-4. Clearly a substantial proportion of Class I pilots had more than 700 hours of recent flight time, independent of age. In general, 30.0 percent of Class I pilots with more than 2,000 total flight hours had more than 700 recent flight hours.

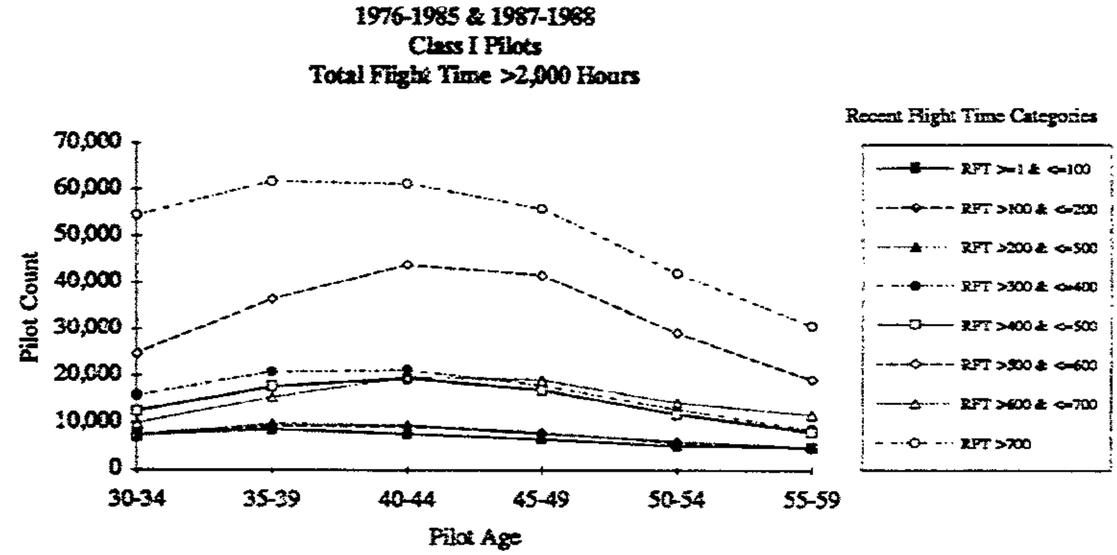


**Figure 5-4.** Counts of pilots in the CDB for 1976-1985 and 1987-1988 with more than 2,000 total flight hours as a function of age and of recent flight hours (hours flown in the preceding 12 months).

Figure 5-5 shows accident rate as a function of age for Class I pilots with more than 700 recent flight hours and more than 2,000 total flight hours. Accident rate decreased with increased age and then leveled off (overall $F(5)=23.62$, $p<.01$; linear trend, $F(1)=98.60$, $p<.01$; quadratic trend, $F(1)=12.74$, $p<.01$).

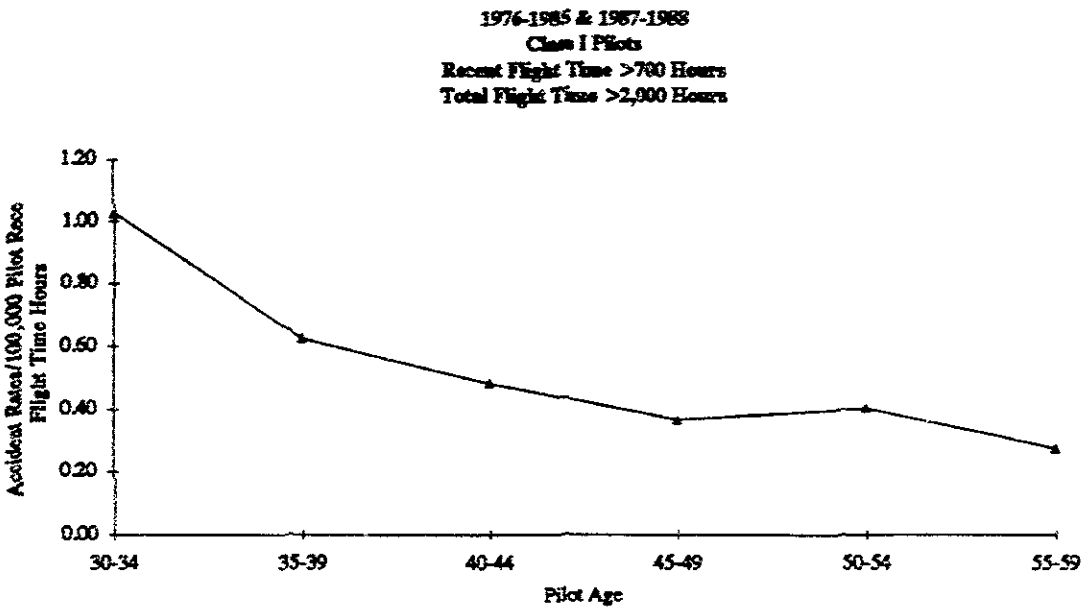


**Figure 5-5.** Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours (hours flown in the preceding 12 months) for 1976-1985 and 1987-1988 as a function of age. Pilots were grouped in 5-year intervals. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

Given the power of the CDB, the above analysis could be further refined. In particular, the medical and certificate databases provided information about the pilot's employer and the pilot's level of certification. We chose to again examine accident rate as a function of age, restricting our attention to pilots with ATP ratings who were employed by major airlines and who had more than 700 recent flight hours. The data for those pilots are shown in Figure 5-6. Analysis of those data was problematic, for two reasons. First, the certificate data about when a particular certification was obtained were only the current certifications for a pilot, and, second, because those pilots had so few accidents. The lower the probability of an accident the more fragile (unreliable) is the statistical analysis. Thus, we were confronted with a statistical uncertainty principle: the more refined the analysis, the less reliable is the analysis. For the data of Figure 5-6, there was no effect due to age ($F(5)=0.84$).

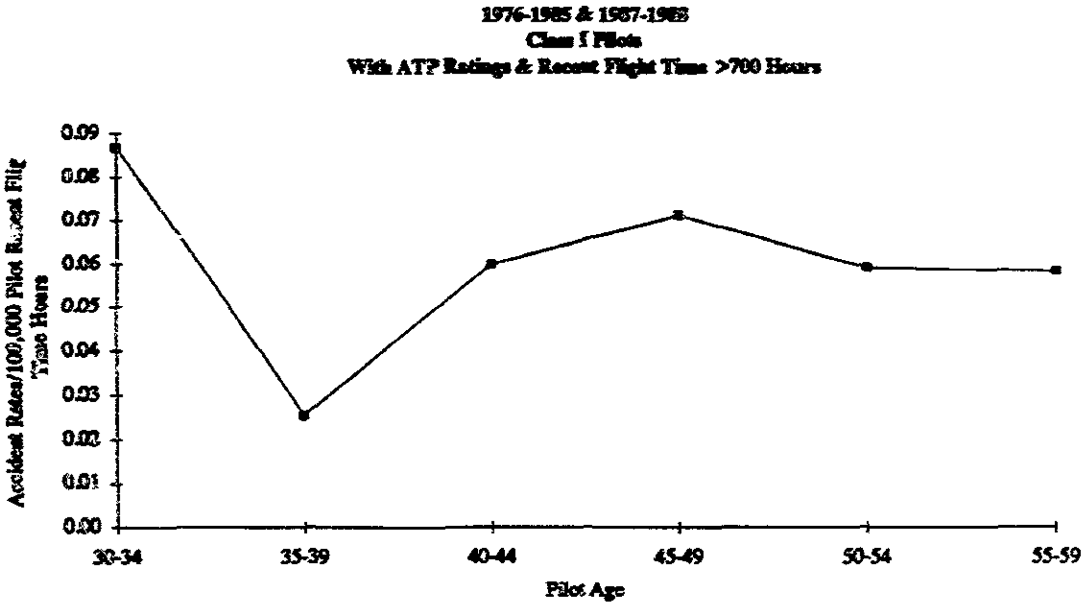


**Figure 5-6.** Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours (hours flown in the preceding 12 months), who had an ATP rating, and who were employed by a major airline, for 1976-1985 and 1987-1988 as a function of age. Pilots were grouped in 5-year intervals. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

### 5.1.4 What Was the Relationship Between Age and Recent Flight Time for Class II Pilots?

As pointed out in Section 4.1, the data for Class II pilots were not very useful for our purposes, because groups of Class II pilots are heterogeneous. Nevertheless, for the sake of completeness, accident rates for Class II pilots were briefly examined. Figure 5-7 shows the accident rates of Class II pilots as a function of age. Note that here the data for pilot ages 30 through 69 was examined. For those data, accident rate decreased with age, leveling off for older pilots (overall $F(7)=12.30$, $p<.01$; linear trend, $F(1)=59.70$, $p<.01$; quadratic trend, $F(1)=10.16$, $p<.01$).

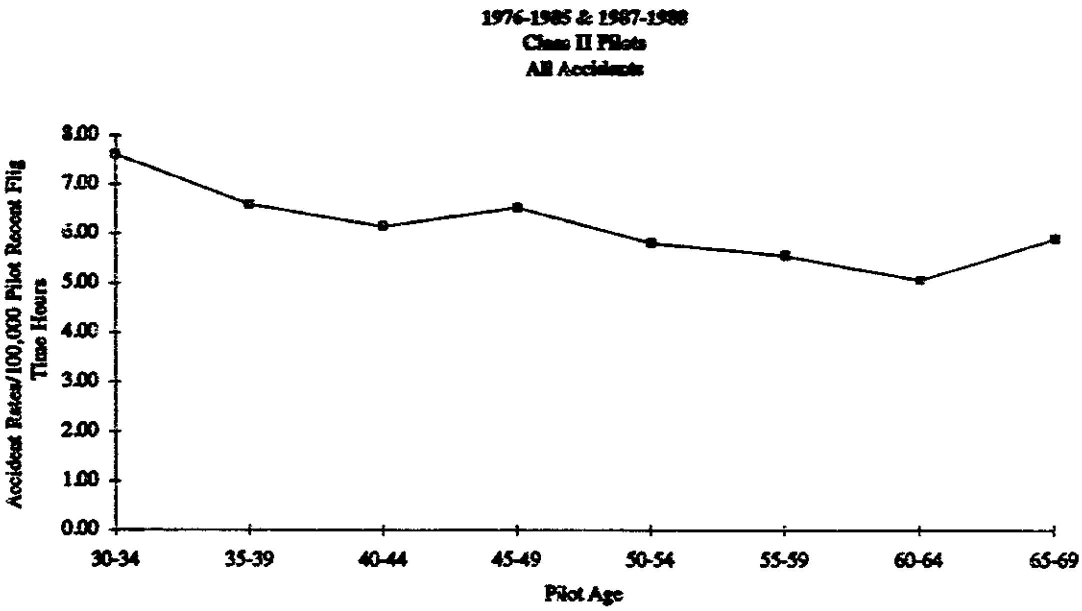


**Figure 5-7.** Accident rates for all Class II pilots for the years 1976-1985 and 1987-1988 as a function of age. Pilots were grouped in 5-year intervals. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

### 5.1.5 What Was the Relationship Between Age and Recent Flight Time for Class III Pilots?

The accident rates of Class III pilots were examined, starting with a broad picture of Class III pilots, followed by more narrowly focused pictures. Figure 5-8 presents accident rates for all Class III pilots. Just as for all Class I pilots and for all Class II pilots, accident rate decreased with age for all Class III pilots, leveling off for older pilots (overall $F(7)=27.49$, $p<.01$; linear trend, $F(1)=165.34$, $p<.01$; quadratic trend, $F(1)=12.16$, $p<.01$).

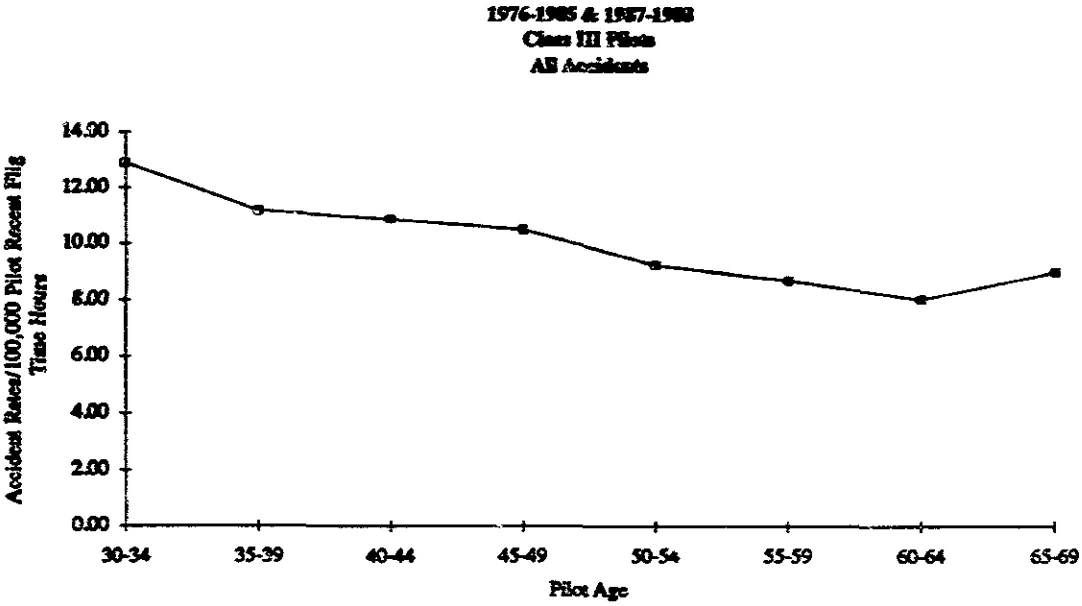


**Figure 5-8.** Accident rates for all Class III pilots for the years 1976-1985 and 1987-1988 as a function of age. Pilots were grouped in 5-year intervals. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

Next, the focus was on Class III pilots who were relatively experienced in terms of total flight time and relatively practiced in terms of recent flight time. The distribution of Class III pilots as a function of recent flight time showed that 27.8% of Class III pilots had more than 50 hours of recent flight time. That is the percentage of Class III pilots with more than 50 hours of recent flight time (30.0%) was roughly the same as the percentage of Class I pilots with more than 700 hours of recent flight time (30.0%). Consequently, we chose to examine the accident rates of Class III pilots with more than 50 recent flight hours and more than 500 total flight hours. Those data are shown in Figure 5-9. Accident rate decreased with age, leveling off for older pilots (overall $F(7)=6.75$, $p<.01$; linear trend, $F(1)=33.86$, $p<.01$; quadratic trend, $F(1)=7.23$, $p<.01$).

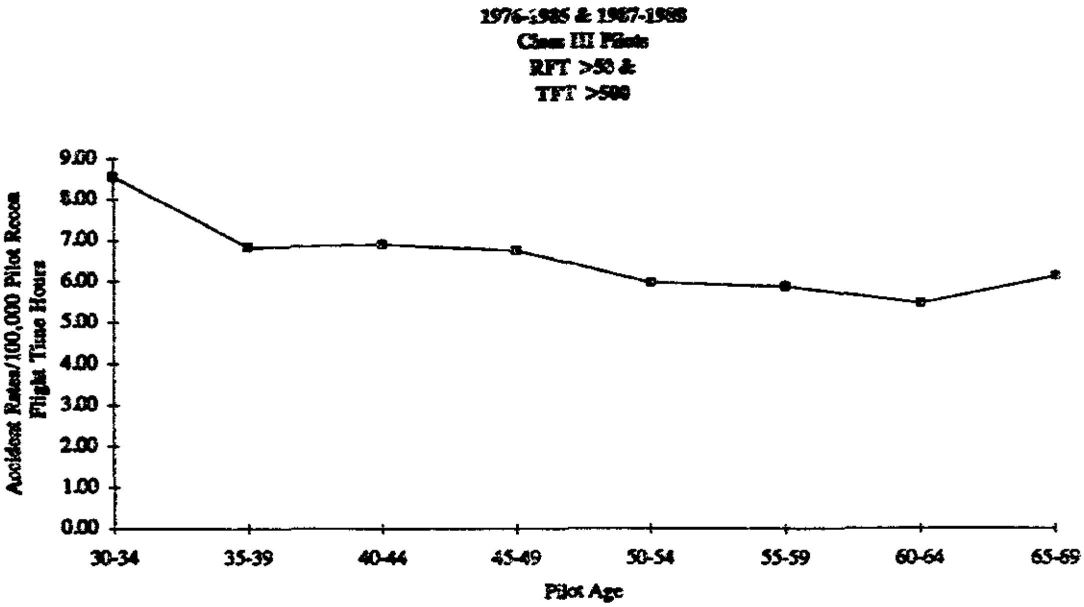


**Figure 5-9.** Accident rates for all Class III pilots with more than 500 total flight hours and more than 50 recent flight hours (hours flown in the preceding 12 months) for the years 1976-1985 and 1987-1988 as a function of age. Pilots were grouped in 5-year intervals. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

Whereas the membership of the groups of pilots underwent dramatic change at age 60 for Class I pilots, no such change occurred for Class III pilots. Thus, while Class III pilots differed in many ways from Class I pilots, their accident rate after age 60 revealed more about the general effect of age. Further, because accidents were more numerous for Class III pilots, analyses of accident rate were statistically more reliable. In particular, the accident rate for each year of age could be examined in a more robust manner, rather than aggregating pilots in five-year age categories. Our main interest lay in the years near age 60. Thus, we examined the accident rates of Class III pilots who had more than 500 total flight hours, who had more than 50 recent flight hours, and who were between the ages of 50 and 69. Those data were shown in Figure 5-10. For those pilots, age had no effect on accident rate (overall $F(19)=0.99$; linear trend, $F(1)=0.12$).

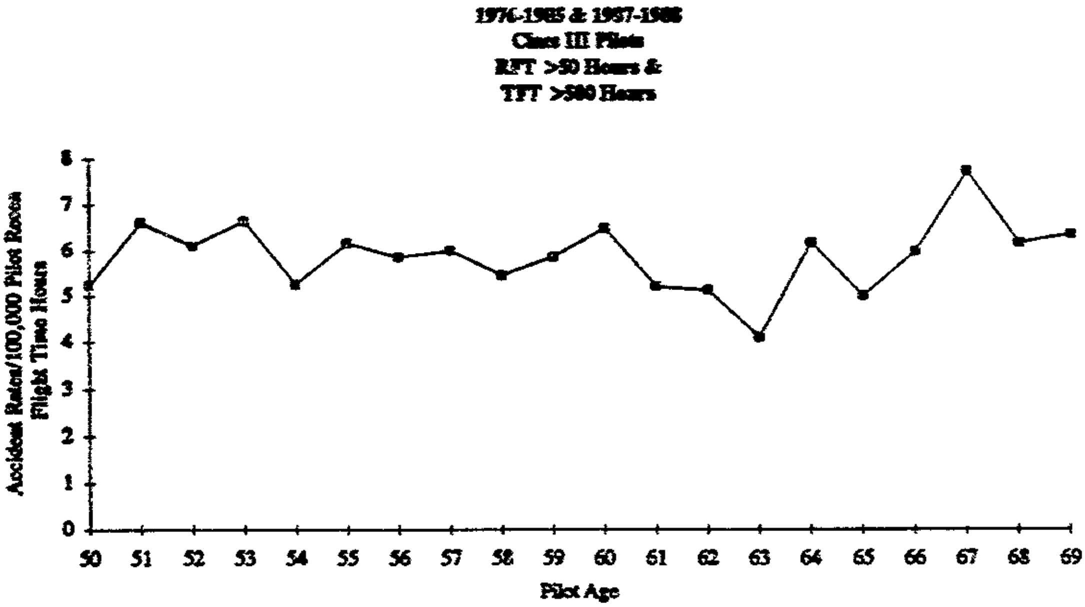


**Figure 5-10.** Accident rates for Class III pilots between the ages of 50 and 69 with more than 500 total flight hours and more than 50 recent flight hours (hours flown in the preceding 12 months) for the years 1976-1985 and 1987-1988 as a function of age. Pilots were grouped in single-year intervals. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

## 5.2 Longitudinal View of Accident Rates

### 5.2.1 Could the Accident Rates of Pilots in the Same Birth-Cohort Be Examined Over Time?

Yes. All pilots born in a particular period could be characterized for a particular year in the database, and those pilots with the same characteristics who appeared in the database in subsequent years could be identified. Then the accident rates of the group whose membership changed to some degree each subsequent year could be computed for each year. By necessity, previous studies approached the data from a cross-sectional point of view, examining pilots of different ages at one particular time. However, the greater scope of the data in the CDB afforded a more longitudinal view. To take advantage of that powerful feature, cohorts of pilots for the years 1976-1985 were studied. Because there were some changes in group composition over time, this was not a true longitudinal study but was referred to in this report as quasi-longitudinal. It would have been desirable to follow the cohorts longer, i.e., from 1976 to 1988, but the absence of data for 1986 made such an analysis problematic. The analyses described below focused on Class I and Class III pilots with high flight hours. In each case, the accident rate of a group of pilots born during a particular 5-year period was examined in each of the ten years from 1976 to 1985. For example, pilots born in 1952-1956 were followed by computing the accident rate of 20-24 year-olds in 1976, the accident rate of 21-25 year-olds in 1977, the accident rate of 22-26 year-olds in 1978, etc. In this fashion, pilots in a particular birth-cohort could be tracked over a ten year period.

### 5.2.2 What Did a Quasi-Longitudinal Analysis of Class I Pilots Show?

Figure 5-11 displays accident rates for Class I pilots with more than 700 recent flights hours and more than 2,000 total flight hours as a function of year of birth and as a function of the year in which the accident occurred (1976-1985). The data of Figure 5-11 can be thought of as overlapping snapshots of the curve relating accident rate to age. For example, the pilots born from 1946-1950 appear as 31-35 year olds in 1981, while the pilots born from 1941-1945 appear as 31-35 year olds in 1976. Note that the various groups suffered both from attrition and from accretion as some pilots failed to renew their certification and other pilots gained initial certification or renew lapsed certification. For those data, accident rate decreased with age, i.e., time from birth ($F(4)=23.49$, $p<.01$), decreased with year in which data were collected, i.e., a second way to measure age, ($F(9)=5.35$, $p<.01$), and the decrease in accident rate with year of data collection was greater for younger pilots than older pilots (interaction of age and year of data collection, ($F(36)=2.03$, $p<.01$). Accident rate initially decreased as function of age (linear contrast, $F(1)=63.76$, $p<.01$), and then leveled off (quadratic contrast, $F(1)=28.46$, $p<.01$). Accident rate linearly decreased as a function of year of data collection (linear contrast, $F(1)=44.30$, $p<.01$). Figure 5-12 displays the data of Figure 5-11 as a function of age, distinguishing the pilots by date of birth. The data were obtained directly from Figure 5-11 by shifting the curve for the pilots born from 1941-1945 five years to the right, shifting the curve for the pilots born from 1936-1940 ten years to the right, etc. For the data of Figure 5-12, accident rate decreased as a function of age ($F(4)=4.06$, $p<.01$), as a function of the year in which the data were collected (age from a different point of view, $F(3)=11.08$, $p<.01$), and accident rate was lower when the data for an age group were collected five years later ($F(1)=6.43$, $p<.05$).

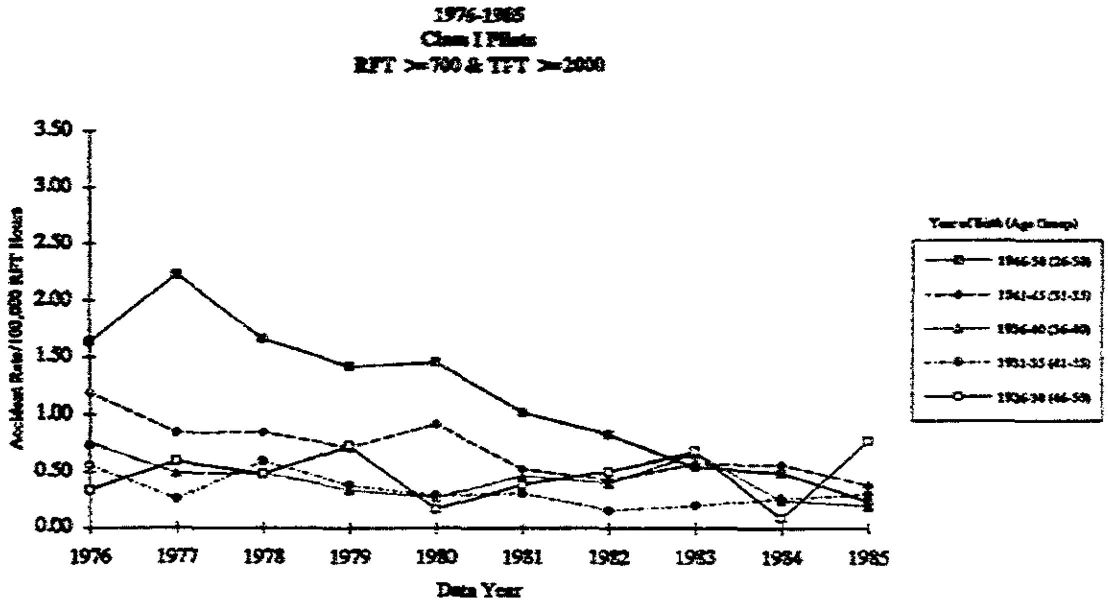


**Figure 5-11.** Accident rates for Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours (hours flown in the preceding 12 months) for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected. Pilots were grouped in 5-year intervals according to date of birth and in single year intervals according to the year in which the data were collected. The oldest age for including pilots was 59. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

The data of Figures 5-11 and 5-12 are quite striking. They appear to provide various views of an underlying curve showing accident rate decreasing with age. Only pilots under 60 were included for the data of Figures 5-11 and 5-12, because the age groups over 60 had a dramatically different membership. The milder changes in the groups under 60 as time passed could also explain the decrease of accident rate with age. If poorer pilots dropped out of the groups and better pilots entered the groups with the passage of time, then the accident rate would go down. An absence of changes in the membership of the groups over time would argue against this interpretation. This question will be examined in more detail below.

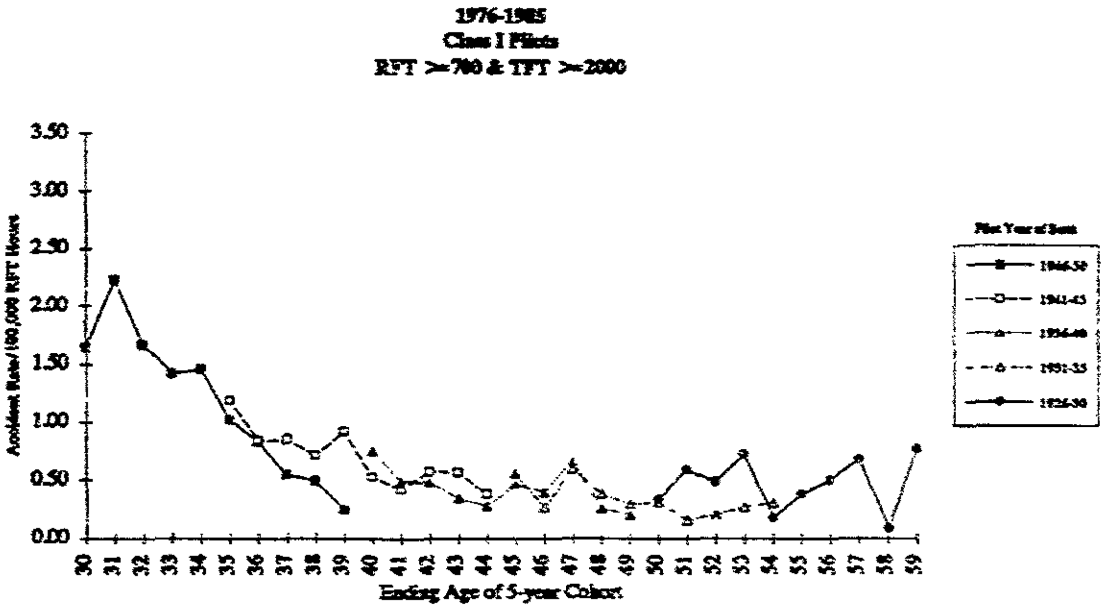


**Figure 5-12.** Accident rates for Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours (hours flown in the preceding 12 months) for the years 1976-1985 and 1987-1988 as a function of date of birth and of age year in which the data were collected. Pilots were grouped in 5-year intervals according to date of birth and in single year intervals according to the year in which the data were collected. This figure recapitulates the data of Figure 5-11 by listing the various groups according to the ending age of each 5-year cohort. The oldest age for including pilots was 59. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

### 5.2.3 What Did a Quasi-Longitudinal Analysis of Class III Pilots Show?

Longitudinal analyses analogous to the ones in Section 5.2.1 were carried out for Class III pilots who were between the ages of 26 and 60 in 1976, who had more than 500 total flight hours, and who had more than 50 recent flight hours. Note that for Class III pilots the data extended to pilots as old as 69, whereas in the longitudinal analysis for Class I pilots the pilots were no older than 59. Figure 5-13 presents the accident rates of Class III pilots as a function of year of birth and of year in which the data were collected. For those data, accident rate decreased as year increased ($F(9)=6.93$, $p<.01$), accident rate decreased as time from birth increased ($F(6)=7.11$, $p<.01$), and the decrease over years was greater for the younger pilots (interaction, F(54)=1.52, p<.01). Finally, the decrease in accident rate over years was strictly linear (linear contrast, F(1)=53.82, p<.01).

The data for the Class III pilots mirrored the data for the Class I pilots, except that there was no leveling off of accident rate with year for the Class III pilots.

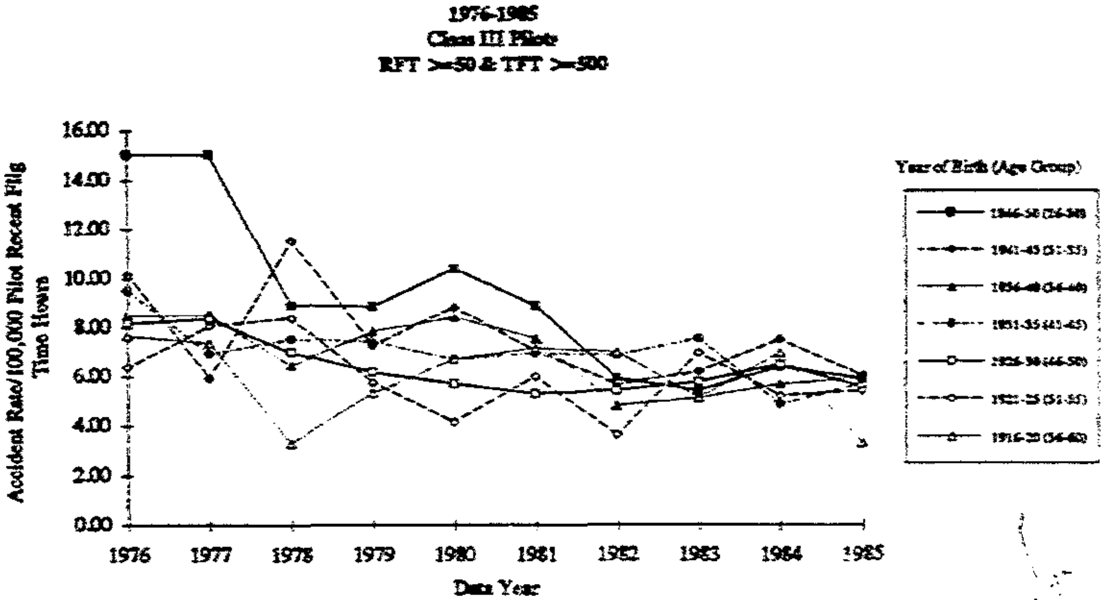


**Figure 5-13.** Accident rates for Class III pilots with more than 500 total flight hours and more than 50 recent flight hours (hours flown in the preceding 12 months) for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected. Pilots were grouped in 5-year intervals according to date of birth and in single year intervals according to the year in which the data were collected. The oldest age for including pilots was 69. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

Figure 5-14 recapitulates the data of Figure 5-13 in the same way that Figure 5-12 recapitulates the data of Figure 5-11. For the data of Figure 5-14 accident rate decreased as a function of age (F(5)=4.19, p<.01), accident rate decreased as a function of the year in which the data were collected (a different view of age, F(4)=3.35, p<.01), accident rate was lower when the data for an age group were collected five years later (F(1)=19.54, p<.01), and the details of the changes in accident rate over time differed for the various groups (triple interaction, F(20)=1.58, p<.05).

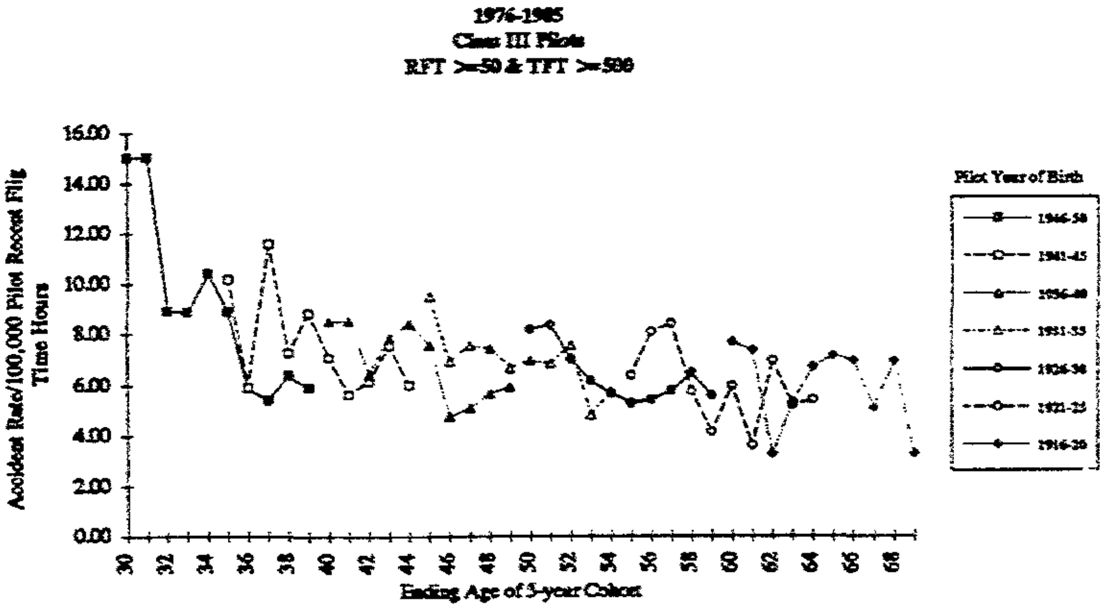


**Figure 5-14.** Accident rates for Class III pilots with more than 500 total flight hours and more than 50 recent flight hours (hours flown in the preceding 12 months) for the years 1976-1985 and 1987-1988 as a function of date of birth and of age year in which the data were collected. Pilots were grouped in 5-year intervals according to date of birth and in single year intervals according to the year in which the data were collected. This figure recapitulates the data of Figure 5-11 by listing the various groups according to the ending age of each 5-year cohort. The oldest age for including pilots was 69. The numerator for rate was obtained by counting all accidents in the NTSB for the given group of pilots. The denominator was obtained by accumulating from the medical database the total annualized hours flown during the year by pilots in the given group. See Table 3-6 for the annualization factors.

## 5.3 Analyses of Accident Frequencies

A number of analyses were considered, based upon the accident records originating in the NTSB database. First, analyses were considered which were based upon the Chi-Square statistic, and then some analyses were considered based upon the analysis of variance (ANOVA), i.e., the F statistic.

In all of the Chi-Square analyses, the accidents were categorized according to the age of the pilot and according to some second factor, e.g., season of the year, and then the number of accidents were counted for each combination of age category and second factor category. Thus, if the ages were categorized as 30-34, 35-39, ..., 55-59 (six categories of age) and the second factor was season of the year (four categories), then there would be 6 x 4 = 24 "cells" each containing the number of accidents appropriate for the cell, e.g., accidents by 30-34 year olds in winter.

The Chi-Square analysis was appropriate for such data, so long as the cell-entries were "reasonably large" (usually taken to mean numbers $>5$; Hays, 1973). *The Chi-Square statistic answered the question, "Was it reasonable to believe that the* proportion of accidents in each of the categories of the second factor did not depend upon age?" Thus, when we had a significant Chi-Square (here taken to mean $p>.05$), we concluded that "the proportions of accidents among the various categories of the second factor varied as a function of age."

In all cases, all accidents occurring from 1983 to 1988 for Class I pilots were considered.

### 5.3.1 Chi-Square Analyses

#### 5.3.1.1 Did the proportion of pilots with a medical waiver change as a function of age?

Yes, Chi-Square(5)=12.99, $p=.024$. A greater proportion of the older pilots in accidents had medical waivers than did the younger pilots. The proportions for the various groups are displayed in Table 5-1. The increase in proportion of medical waiver for older pilots in accidents could reflect a concomitant increase for all Class I pilots. To check this, the CDB was used to obtain the proportion of all Class I pilots with a medical waiver as a function of age, where attention was restricted to pilots examined between 1 February 1988 and 30 June 1988. Those data are displayed in Table 5-2. The proportion of pilots with medical waivers differed with age, Chi-Square(5)=102.40, $p<.001$. The patterns seen in Tables 5-1 and 5-2 differ somewhat, but for both tables, the older pilots had more medical waivers, and it did not appear that possession of a medical waiver was implicated with having an accident.

**Table 5-1.** Percent of Class I pilots who had a medical waiver and were involved in an accident as a function of age. Data are from the NTSB database for the years 1983-1988.

| | Age | | | | | |
|---|---|---|---|---|---|---|
| | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 |
| Percent | 4.8 | 3.6 | 3.1 | 4.9 | 7.0 | 10.3 |
| Number of Accidents | 419 | 415 | 318 | 224 | 200 | 116 |

**Table 5-2.** Percent of Class I pilots who had a medical waiver as a function of age. Data are from the Medical database for 1 February 1988 to 30 June 1988.

| | Age | | | | | |
|---|---|---|---|---|---|---|
| | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 |
| Percent | 9.1 | 8.1 | 6.8 | 6.3 | 6.9 | 9.9 |
| Number of Pilots | 10291 | 9479 | 10329 | 10085 | 7595 | 4008 |

5.3.1.2 Did the proportions of accidents in the various seasons of the year change with age, if we defined the seasons by the quarters of the year?

No, Chi-Square(15)=24.04, p>.05.

5.3.1.3 Did the proportion of accidents that involved (at least in part) pilot error vary with age?

No, Chi-Square(5)=4.75, p>0.05.

5.3.1.4 Did the proportion of accidents in which there was a weather visibility restriction depend on age?

No, Chi-Square(5)=8.27, p>0.05, although it is worth noting that the vast majority of the accidents involved such a restriction.

5.3.1.5 Did the proportions of accidents during various times of day (daylight, dusk, nighttime, dawn) vary as a function of age?

A careful analysis of this question would involve taking the geographical location and the time of year into account in determining when dusk and dawn occur. We crudely defined dusk as the hours 16:30 to 19:39 and dawn as the hours 4:30 to 7:30. For this crude approximation the answer was no, Chi-Square(15)=11.78, p>0.05.

5.3.1.6 Did the proportions of accidents during various phases of flight ( (a) takeoff, climb, (b) approach, descent, landing, (c) other) vary as a function of age?

No, Chi-Square(10)=14.82, p=0.15.

5.3.2 Analyses of Variance (ANOVA)

The NTSB recorded the amount of recent and total flight time flown by the pilot in the same type of aircraft as the one in which the accident occurred. For each year of age, the average amount of recent flight time and of total flight time the pilots spent in an aircraft of the same type was computed. Thus, for each group of five years (30-34, ..., 55-59), we had five data points. To those data a one-way ANOVA was applied.

5.3.2.1 Did the total time in the same type aircraft vary as a function of age?

Yes, $F(5,24)=5.66$, $p<.01$. The older the pilot, the greater time spent in the same type aircraft. This was not surprising. The data are displayed in Table 5-3.

**Table 5-3.** **Mean number of total flight hours, as a function of age, in the same type of aircraft as the one in which an accident occurred. These data were for Class I pilots involved in accidents during 1983-1988.**

| Age Group | Mean hours Total Flight Time |
|---|---|
| 30-34 | 601 |
| 35-39 | 727 |
| 40-44 | 755 |
| 45-49 | 1,143 |
| 50-54 | 1,232 |
| 55-59 | 2,094 |

5.3.2.2 Did the recent time in the same type aircraft vary as a function of age?

No, $F(5,24)=0.56$, $p>.50$). The data are shown in Table 5-4. One might hypothesize that lack of recent experience with an aircraft was more likely to lead to an accident for a pilot with less overall experience with the aircraft, but the data (Sections 5.3.2.1 and 5.3.2.2) lent no support to that hypothesis.

**Table 5-4.** Mean number of recent flight hours, as a function of age, in the same type of aircraft as the one in which an accident occurred. These data were for Class I pilots involved in accidents during 1983-1988.

| Age Group | Mean hours Recent Flight Time |
|---|---|
| 30-34 | 57 |
| 35-39 | 51 |
| 40-44 | 52 |
| 45-49 | 46 |
| 50-54 | 55 |
| 55-59 | 43 |

## 5.4 Limitations Placed on the Analyses by the Data

All analyses had been conducted on intact data. This meant that the "groups of interest" were self-selected in numerous ways and were not under experimental control. Thus, extreme care had to be taken to be sure that other factors were not confounded with factors examined in this study. Below, two possible confounding factors were considered in detail, factors we had previously alluded to: the change in membership of groups over time and the possibility that the number of takeoffs per flight hour changed with age.

### 5.4.1 What Were the Changes in Membership Associated with Age?

Change in the membership of groups is best illustrated in the context of the data shown in Figures 5-11, 5-12, 5-13, and 5-14. Those figures purport to follow the same pilots over 10 years, but, as suggested at the end of Section 5.2.1, this was only partially true, because the membership of the groups changed to some extent each year as some pilots allowed their medical certificates to lapse and other pilots obtained their initial certificates or renew lapsed certificates. If the changes in the membership of the groups were small, then those changes would have, at most, small effects on the accident rates. Figures 5-15, 5-16, and 5-17 view from two different perspectives the degree to which groups changed in membership. The data in these figures are not exhaustive but indicate the nature of the problem. An exhaustive study of the problem would only serve to determine the precise size of the problem but would provide no insight into how changes in membership of the groups affected accident rates. Figure 5-15 displays the change in membership, from one year to the next, of the group of Class I pilots aged 36-40 in 1976, with at least 250 recent flight hours and at least 2,000 total flight hours. The left (black) bar of a pair gives the number of pilots in the group for the first year, and the right (gray) bar gives the number of those pilots still in the group the following year. For example, of the approximately 11,800 pilots in the group in 1976, approximately 9,200 remained in 1977. Meanwhile, the group in 1977 consisted of approximately 12,200 pilots, information that can be gleaned from the set of bars for 1977-1978. Approximately 85 percent of the pilots appearing one year were still present the following year. In general, the group for the following year was larger than the group the previous year so that the "holdovers" represented less than 85% of the pilots the following year.

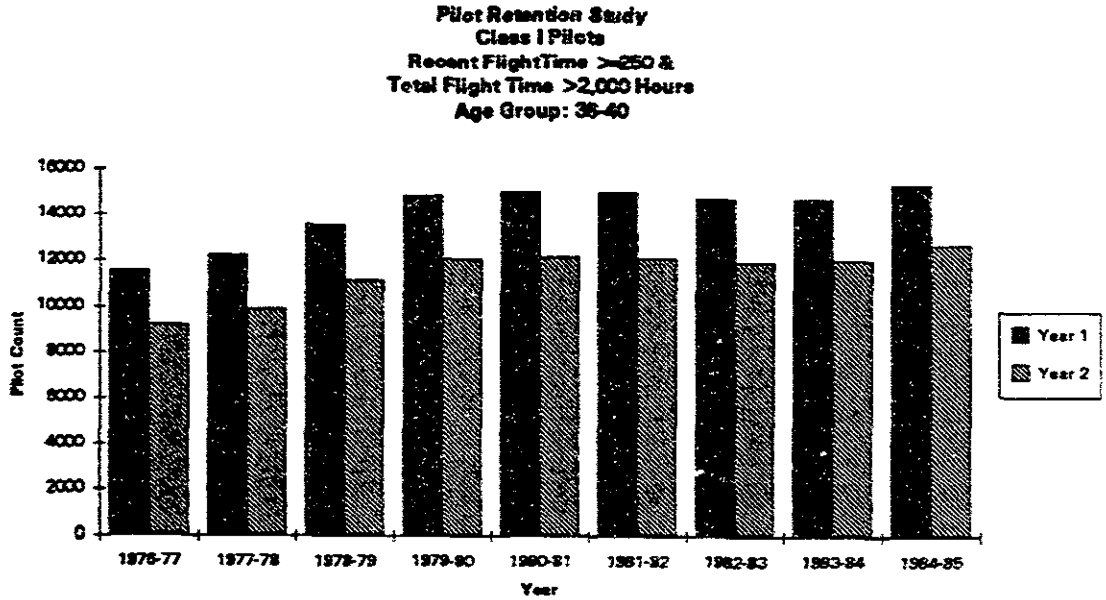


**Figure 5-15.** Count of Class I pilots aged 36-40 with more than 2,000 total flight hours and more than 250 recent flight hours (hour flown the preceding 12 months) for the years 1976-1985. The dark bar gives a count of all pilots who appeared in the given year. The light bar gives a count of those pilots who appeared in the following year and in the given year, i.e., the light bar measures retention.

One might infer from the data of Figure 5-15 that the groups had changed membership completely after about 5 years, but this assumes that pilots who leave a group never return. The data of Figures 5-16 and 5-17 suggest this is not the case. Each figure follows the change in size of a group over ten years and contrasts that with the number of pilots from 1977 who appeared in subsequent years. Figure 5-16 displays data for 26-30 year old, Class I pilots, and Figure 5-17 displays data for 46-50 year old, Class I pilots. In each case, the change in count for the pilots originally counted in 1976 was largest the first year. For the younger pilots, there was actually a slight increase in count in later years as pilots apparently renewed lapsed certificates more frequently than they let them lapse. For the older pilots, the influx of new pilots led to minimal changes in the membership of the group originally counted in 1976. On the other hand, the group was decreasing substantially in size in the later years, probably reflecting the effect of the Age 60 rule. For younger pilots, the groups were changing substantially in size because of the influx of new pilots, and for older pilots the groups were changing in size because of attrition. In either case, the groups underwent substantial change in membership, opening the door to a confounding of changes in membership with age.

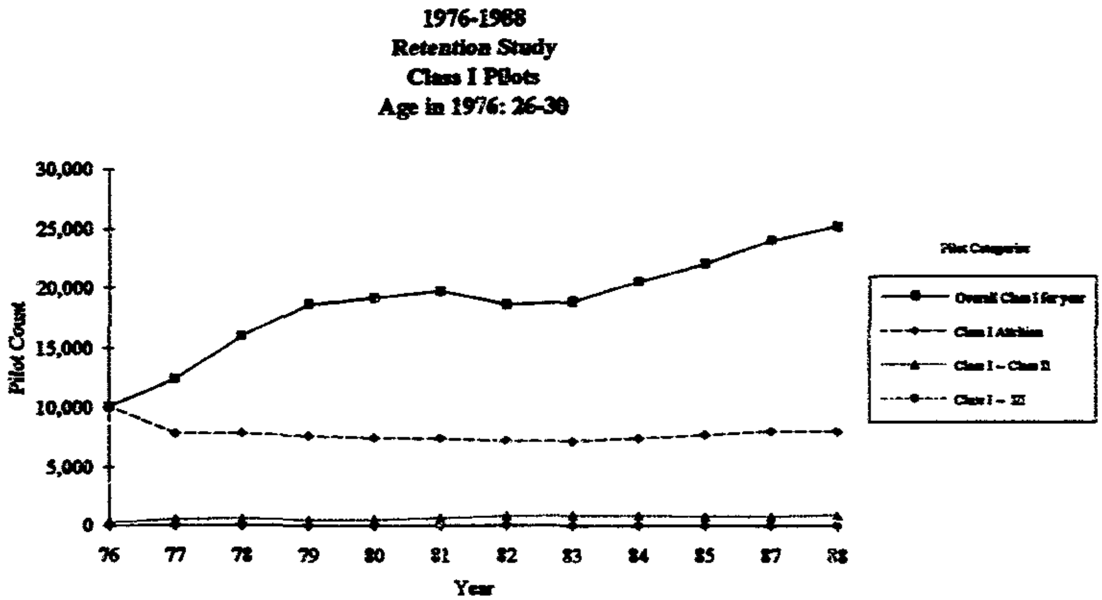


**Figure 5-16.** Counts of Class I pilots aged 26-30 for the years 1976-1985 and 1987-1988 as a function of year. The top line counts all pilots. The second line counts those pilots appearing in 1976 and in the given subsequent year, i.e., the data point for 79 counts those pilots who appeared both in 1976 and 1979, a measure of retention. The bottom two lines count those Class I pilots appearing in 1976 who appeared in a subsequent year as a Class II or Class III pilot.

As an aside, it is interesting to note that Figure 5-17 shows that very few Class I pilots who allowed their medical certificate to lapse continued to fly, i.e., they usually did not get Class II or Class III medical certificates. Thus, the accident rates of Class II and Class III pilots should have been relatively unaffected by an influx of former Class I pilots.

## 5.4.2 What Were the Difficulties in Estimating Exposure?

In all of the analyses, exposure was measured in terms of the number of flight hours. However, accidents were more likely to occur during takeoff and landing. For example, Trammell (1980), in a study of corporate flight, found that 47 percent of the accidents occurred in the landing of the aircraft phase which represented 3 percent of the total flight time. All things being equal, pilots flying longer flights should have had fewer accidents per flight hour, i.e., a lower accident rate. It is reasonable to assume that older pilots of scheduled air carriers could exercise seniority to opt for longer flights thus reducing their risk of an accident. If so, then age was confounded with length of flight, masking an increased likelihood of being in an accident. If, on the other hand, the number of flights per hour was constant with respect to age, then flight hours, as a measure of exposure were not confounded with age. The data from the NTSB database were used to assess this question, at least for pilots in accidents.

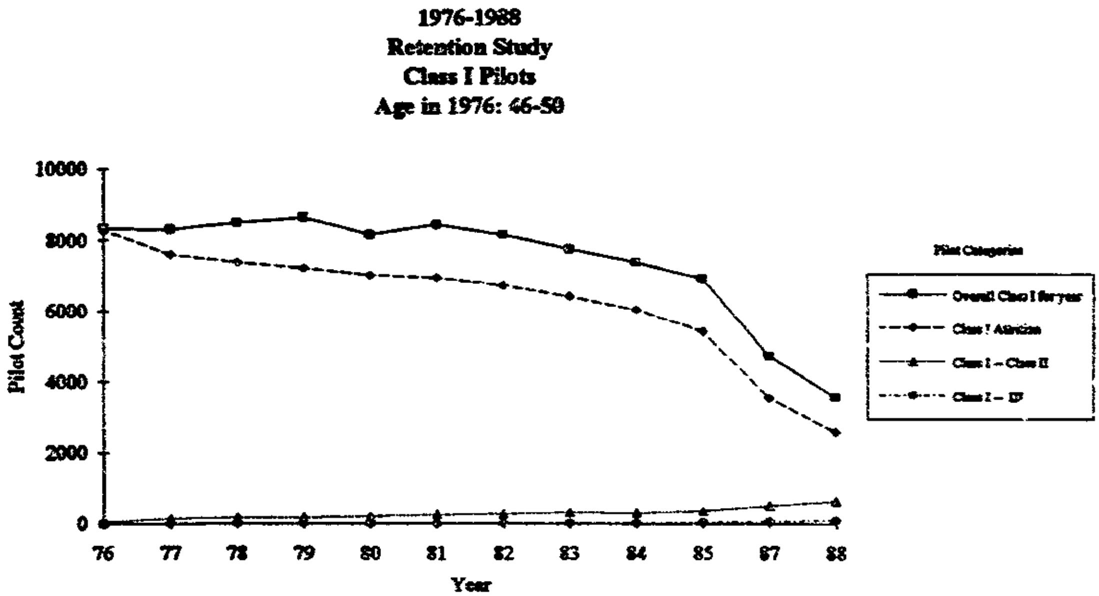


**Figure 5-17.** Counts of Class I pilots aged 46-50 for the years 1976-1985 and 1987-1988 as a function of year. The top line counts all pilots. The second line counts those pilots appearing in 1976 and in the given subsequent year, i.e., the data point for 79 counts those pilots who appeared both in 1976 and 1979, a measure of retention. The bottom two lines count those Class I pilots appearing in 1976 who appeared in a subsequent year as a Class II or Class III pilot.

The NTSB database includes fields to record the number of takeoffs by the pilot in the last 90 days, however, approximately 80 percent of the time this field was empty for Class I pilots and therefore could not be meaningfully analyzed. Additionally, whether age was confounded with number of flights or flight hours was not the sole criterion of whether flight hours were a good measure of exposure, although it was most relevant in this case. Night flight time, weather, etc. also influenced quality of exposure.

## 6.0 SUMMARY AND DISCUSSION

The foundation for analyzing data from the CDB was based on the justification presented in Section 4, which supported traditional statistical analyses. Aggregating data from 1976-1988 (excluding 1986) provided a more extensive data set and improved the reliability of the analyses.

### 6.1 Conclusions Based Upon Flight Time Analyses

When the accident rate for each medical certificate class of pilots was examined as a function of age (Figures 5-1, 5-7, and 5-8, for Classes I, II, and III, respectively), a decrease in accident rate was found for the younger pilots, followed by a leveling off for older pilots.

The data of Figure 5-2, which display the accident rates of Class I pilots with more than 2,000 total flight hours, show that the more recent flight time a pilot had, the less likely the pilot would be in an accident. Indeed, recent flight time was the dominant factor affecting accident rates. Further, for Class I pilots with more than 2,000 total flight hours, no effect of total flight time on accident rates was found.

The data of Figures 5-1, 5-2, 5-3, 5-5, and 5-6, represent progressive attempts to home in on groups of pilots that are most typical of Part 121 pilots. With the exception of the data of Figure 5-6, for which no effect of age was found, all the data indicated a modest decrease in accident rate with age, with a leveling off for older pilots.

When the rates of Class III pilots aged 50 to 70, with more than 500 total flight hours, and with more than 50 recent flight hours were examined as a function of age, year by year, no effect for age was found (Figure 5-10).

### 6.2 Conclusions Based Upon the Quasi-Longitudinal Analyses

Accident rates of Class I and of Class III pilots with high recent flight time were examined from a longitudinal perspective, i.e., various cohorts were followed for a 10 year period. Again, accident rates initially decreased with age and then leveled off (Figures 5-11, 5-12, 5-13, and 5-14).

### 6.3 Conclusions Relevant to the Age 60 Rule

The Age 60 rule applies to pilots employed by scheduled air carriers. Lacking the ability to directly determine the flight hours of that specific group of pilots, the accident rates of reasonably comparable groups were examined, i.e., Class I pilots with at least 2,000 total flight hours and at least 700 recent flight hours, and pilots with more than 700 recent flight hours who had ATP certificate and who were employed by a major airline. For the former group, accident rates decreased with age, leveling off for older pilots (Figure 5-5), and for the latter group no effect was found due to age, probably because of lack of statistical power, i.e., the sample size was too small.

In an attempt to examine accident rates for the age range 50-70 and to minimize the possible confound of older pilots of scheduled carriers having fewer takeoffs and landings per flight hour (which would mask an increase in accident rate), experienced Class III pilots with high recent flight time were examined. For Class III pilots with at least 500 total flight hours and at least 50 recent flight hours, age had no effect on accident rate (Figure 5-10).

Our analyses provided no support for the hypothesis that the pilots of scheduled air carriers had increased accident rates as they neared the age of 60. Most of the analyses indicated a slight downward trend with age, but those results must be treated cautiously because of the number of potentially confounding factors. The data did provide indirect evidence that any changes in takeoffs and landings per flight hour with age had little affect on accident rate, because such an effect would only occur for Part 121 pilots exercising seniority. Yet the data for all the various groups of pilots were remarkably consistent in showing a modest decrease in accident rate with age, a trend shared by the data of Figure 5-5. That is, the same modest effect of age appeared in all the data and was not solely due to changes in takeoffs per flight hour as the pilot aged. On the other hand, substantial changes in membership of the groups of pilots from year to year made interpretation of the modest decrease in accident rate with age problematic. It was as easy to conclude that the FAA's system improved the composition of the groups over time as it was to conclude that pilots' performance improved with age.

In all of our analyses, we saw no hint of an increase in accident rate for pilots of scheduled air carriers as they neared their 60th birthday. There were no data available on scheduled air carrier pilots beyond age 60. To what age could retirement for those pilots be safely put off? This question must be answered very conservatively because of the possibility of catastrophic results.

Statisticians distinguish between "planned" and "post-hoc" tests. Planned tests are formulated before collecting the data while post-hoc tests are formulated after looking at the data. Statistical controls are applied to the latter test to counteract their being biased in favor of finding statistical significance. In the analyses discussed below, the statistical tests were treated as planned tests to maximize the probability of finding even hints of an increase in accident rate with age for pilots near age 60. It is quite likely that any trend detected is spurious, but we were being conservative.

Because we were concerned with accident rates for pilots after age 60, we were forced to look at the data for Medical Class II and III pilots.

Examining the data for all Medical Class II pilots (see Figure 5-7), the accident rate for group 60-64 did not differ from that of group 55-59 ($F(1)=2.99$, $p>.05$), but was lower than that of group 65-69 ($F(1)=8.41$, $p<.01$ if planned; $F(7)=1.20$, not significant if post-hoc).

For all Class III pilots, (see Figure 5-8), the accident rate for group 60-64 did not differ from that of 50-59 ($F(1)=2.7$, $p>.05$) but was lower than that of group 65-69 ($F(1)=5.9$, $p<.05$ if planned; $F(7)=0.84$, not significant if post-hoc).

For Class III pilots with more than 500 total flight hours and more than 50 recent flight hours (see Figure 5-9), the accident rate for group 60-64 did not differ from that of group 55-59 ($F(1)=0.75$, $p>.05$) or from that of group 65-69 ($F(1)=2.01$, $p>.05$).

Finally, looking year-by-year at the accident rates of Class III pilots with more than 500 total flight hours and more than 50 recent flight hours (see Figure 5-10), there was an increase in accident rate for the years 63 through 69 (linear trend, $F(1)=5.93$, $p<.05$ if planned; not significant if post-hoc).

Taken together, these analyses give a hint, and a hint only, of an increase in accident rate for Class III pilots older than 63 years of age. This suggests that one could cautiously increase the retirement age to age 63.

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# APPENDIX A

## Comparison of Golaszewski Study and Age 60 Study

## APPENDIX A. COMPARISON OF GOLASZEWSKI STUDY AND AGE 60 STUDY

When the accidents in the CDB were segregated into the fine-grained categories used by Golaszewski (e.g., Pilots aged 17019, with Class III certificate, and with 501-1000 total flight hours), the CDB data agreed almost exactly with that of Golaszewski, as shown in Table A-1. For example, for the recent flight time analysis, the CDB included 18,101 of the 18,366 accidents counted by Golaszewski (Golaszewski, 1983, Appendix A-1) and 306,775 summed recent flight time versus 307,579 included by Golaszewski.

## Table A-1. 1976-1980 Data -- Golaszewski versus Age 60 Study

| Class I,II,&III Pilots<br>All Ages<br>Recent Flight Time | Golaszewski | | | | Age 60 1976-1980 | | | | Difference<br>Golaszewski - Age 60 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recent Time Interval | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate |
| 0-20 | 1,930 | 9,031 | 1,684 | 18.7 | 794 | 8,980 | 1,603 | 17.9 | 1,136 | 51 | 81 | 0.8 |
| 21-50 | 459 | 16,660 | 2,415 | 14.5 | 459 | 16,683 | 2,338 | 14.0 | 0 | -23 | 77 | 0.5 |
| 51-100 | 382 | 30,759 | 3,577 | 11.6 | 383 | 30,896 | 3,521 | 11.4 | -1 | -138 | 56 | 0.2 |
| 101-400 | 339 | 74,006 | 6,585 | 8.9 | 339 | 73,982 | 6,523 | 8.8 | 0 | 24 | 62 | 0.1 |
| >400 | 241 | 177,124 | 4,105 | 2.3 | 240 | 176,235 | 4,116 | 2.3 | 1 | 889 | -11 | 0.0 |
| All | 3,351 | 307,579 | 18,366 | 6.0 | 2,215 | 306,775 | 18,101 | 5.9 | 1,136 | 804 | 265 | 0.1 |

*NOTE: Golaszewski may have included incidents (342 from 1976-1980) from the NTSB database*

| Total Flight Time | Golaszewski | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Time Interval | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate |
| 0-100 | 1,621 | 20,704 | 2,960 | 14.3 | 782 | 20,602 | 2,637 | 12.8 | 839 | 102 | 323 | 1.5 |
| 101-500 | 868 | 45,291 | 5,561 | 12.3 | 667 | 45,654 | 4,980 | 10.9 | 201 | -363 | 581 | 1.4 |
| 501-1000 | 261 | 28,824 | 2,688 | 9.3 | 221 | 28,960 | 2,384 | 8.2 | 40 | -136 | 304 | 1.1 |
| 1001-5000 | 382 | 98,641 | 6,249 | 6.3 | 338 | 98,823 | 5,610 | 5.7 | 44 | -182 | 639 | 0.6 |
| >5000 | 218 | 114,118 | 2,780 | 2.4 | 206 | 112,736 | 2,490 | 2.2 | 12 | 1,383 | 290 | 0.2 |
| All | 3,350 | 307,578 | 20,238 | 6.6 | 2,215 | 306,775 | 18,101 | 5.9 | 1,135 | 802 | 2,137 | 0.7 |

*N OTE: Golaszewski only required total flight time to be valid in NTSB for Total Flight Time analyses*

| Recent and Total Flight Time | Golaszewski | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recent&Total Time Interval | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate | Pilots (000s) | RFT Hours (000s) | Accidents | Accident Rate |
| >50 & >1000 | 466 | 210,539 | 7,389 | 3.5 | 465 | 209,332 | 7,420 | 3.5 | 1 | 1,207 | -31 | 0.0 |
| <=50 & >1000 | 134 | 2,222 | 700 | 31.6 | 80 | 2,227 | 680 | 30.5 | 54 | -5 | 20 | 1.0 |
| >50 & <=1000 | 495 | 71,350 | 6,837 | 9.6 | 498 | 71,780 | 6,740 | 9.4 | -3 | -430 | 97 | 0.2 |
| <=50 & <=1000 | 2,255 | 23,469 | 3,375 | 14.4 | 1,173 | 23,436 | 3,261 | 13.9 | 1,082 | 33 | 114 | 0.5 |
| All | 3,350 | 307,580 | 18,301 | 5.9 | 2,215 | 306,775 | 18,101 | 5.9 | 1,135 | 805 | 200 | 0.0 |

## APPENDIX B

**Database Queries**

## APPENDIX B. DATABASE QUERIES AND BACKUP DATA

This appendix contains the parameters that were used to extract the data from the CDB for each of the figures in Section 5. The database parameters are grouped by source database. After the set of parameters, the spreadsheet containing the data used to generate the named figure is shown.

**Table B-1A.** Figure 5-1 (Accident rates for all Class I pilots for the years 1976-1985 and 1987-1988 as a function of age) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age: 30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time > 0 |
| | Total Flight Time > 0 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age: 30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time > 0 |
| | Total Flight Time > 0 |

**Table B-1B.** Figure 5-1 (Accident rates for all Class I pilots for the years 1976-1985 and 1987-1988 as a function of age) Spreadsheet

| 1976-1985 & 1987-1988 Class I Pilots All Accidents | | | |
|---|---|---|---|
| Pilot Age | Accident Rate | Annualized Recent Time | Accident Count |
| 30-34 | 1.78 | 56,737,745 | 1,009 |
| 35-39 | 1.19 | 61,136,517 | 729 |
| 40-44 | 0.75 | 62,044,266 | 464 |
| 45-49 | 0.63 | 55,719,557 | 352 |
| 50-54 | 0.72 | 40,084,335 | 287 |
| 55-59 | 0.67 | 28,424,898 | 190 |

**Table B-2A.** Figure 5-2 (Accident rates for all Class I pilots with more than 2,000 hours total flight time for the years 1976-1985 and 1987-1988 as a function of age and of recent flight hours ) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time:<br>1-100; 101-200; 201-300; 301-400; 401-500; 501-600; 601-700; > 700 |
| | Total Flight Time > 2,000 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time:<br>1-100; 101-200; 201-300; 301-400; 401-500; 501-600; 601-700; > 700 |
| | Total Flight Time > 2,000 |

**Table B-2B.** Figure 5-2 (Accident rates for all Class I pilots with more than 2,000 hours total flight time for the years 1976-1985 and 1987-1988 as a function of age and of recent flight hours) Spreadsheet

| Recent Flight Time Categories | RFT >= 1 & <= 100 | | | RFT > 100 & <= 200 | | |
|---|---|---|---|---|---|---|
| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate | Annualized Recent Time | Accident Count | Accident Rate |
| 30-34 | 230,426 | 70 | 30.4 | 674,613 | 67 | 9.9 |
| 35-39 | 274,127 | 56 | 20.4 | 857,034 | 52 | 6.1 |
| 40-44 | 250,828 | 37 | 14.8 | 849,293 | 47 | 5.5 |
| 45-49 | 217,995 | 34 | 15.6 | 711,689 | 37 | 5.2 |
| 50-54 | 164,737 | 17 | 10.3 | 522,016 | 30 | 5.7 |
| 55-59 | 148,464 | 25 | 16.8 | 396,124 | 19 | 4.8 |

| Recent Flight Time Categories | RFT >= 200 & <= 300 | | | RFT > 300 & <= 400 | | |
|---|---|---|---|---|---|---|
| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate | Annualized Recent Time | Accident Count | Accident Rate |
| 30-34 | 1,032,608 | 74 | 7.2 | 3,107,194 | 81 | 2.6 |
| 35-39 | 1,396,077 | 61 | 4.4 | 4,077,475 | 73 | 1.8 |
| 40-44 | 1,356,930 | 40 | 2.9 | 4,161,049 | 37 | 0.9 |
| 45-49 | 1,101,346 | 27 | 2.5 | 3,505,594 | 26 | 0.7 |
| 50-54 | 858,691 | 21 | 2.4 | 2,492,696 | 27 | 1.1 |
| 55-59 | 676,359 | 21 | 3.1 | 1,678,659 | 27 | 1.6 |

| Recent Flight Time Categories | RFT >= 400 & <= 500 | | | RFT > 500 & <= 600 | | |
|---|---|---|---|---|---|---|
| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate | Annualized Recent Time | Accident Count | Accident Rate |
| 30-34 | 3,057,868 | 87 | 2.8 | 7,388,744 | 93 | 1.3 |
| 35-39 | 4.335,532 | 69 | 1.6 | 10,863,095 | 57 | 0.5 |
| 40-44 | 4,723,456 | 44 | 0.9 | 13,058,950 | 47 | 0.4 |
| 45-49 | 4,098,322 | 36 | 0.9 | 12,325,819 | 24 | 0.2 |
| 50-54 | 2,866,359 | 34 | 1.2 | 8,631,532 | 28 | 0.3 |
| 55-59 | 1,963,496 | 17 | 0.9 | 5,641,909 | 11 | 0.2 |

| Recent Flight Time Categories | RFT >= 600 & <= 700 | | | RFT >= 700 | | |
|---|---|---|---|---|---|---|
| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate | Annualized Recent Time | Accident Count | Accident Rate |
| 30-34 | 3,385,503 | 64 | 1.9 | 25,422,449 | 261 | 1.0 |
| 35-39 | 5,310,635 | 39 | 0.7 | 27,658,475 | 173 | 0.6 |
| 40-44 | 6,698,412 | 24 | 0.4 | 26,891,304 | 130 | 0.5 |
| 45-49 | 6,435,119 | 24 | 0.4 | 24,218,236 | 89 | 0.4 |
| 50-54 | 4,845,841 | 20 | 0.4 | 18,107,355 | 73 | 0.4 |
| 55-59 | 3,950,581 | 11 | 0.3 | 13,098,110 | 36 | 0.3 |

**Table B-3A.** Figure 5-3 (Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 250 recent flight hours for 1976-1985 and 1987-1988 as a function of age) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time > 250 |
| | Total Flight Time > 2,000 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time > 250 |
| | Total Flight Time > 2,000 |

**Table B-3B.** Figure 5-3 (Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 250 recent flight hours for 1976-1985 and 1987-1988 as a function of age) Spreadsheet

| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate |
|---|---|---|---|
| 30-34 | 44,791,490 | 605 | 1.4 |
| 35-39 | 54,331,786 | 436 | 0.8 |
| 40-44 | 56,993,943 | 294 | 0.5 |
| 45-49 | 51,599,381 | 211 | 0.4 |
| 50-54 | 37,611,987 | 193 | 0.5 |
| 55-59 | 26,664,584 | 111 | 0.4 |

**Table B-4A.** Figure 5-4 (Counts of pilots in the CDB for 1976-1985 and 1987-1988 with more than 2,000 total flight hours as a function of age and of recent flight hours) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age: 30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time: 1-100; 101-200; 201-300; 301-400; 401-500; 501-600; 601-700; > 700 |
| | Total Flight Time > 2,000 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age: 30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time: 1-100; 101-200; 201-300; 301-400; 401-500; 501-600; 601-700; > 700 |
| | Total Flight Time > 2,000 |

**Table B-4B.** Figure 5-4 (Counts of pilots in the CDB for 1976-1985 and 1987-1988 with more than 2,000 total flight hours as a function of age and of recent flight hours) Spreadsheet

| Pilot Age | RFT >= 1 & <= 100 | RFT > 100 & <= 200 | RFT > 200 & <= 300 | RFT > 300 & <= 400 | RFT > 400 & <= 500 | RFT > 500 & <= 600 | RFT > 600 & <= 700 | RFT > 700 |
|---|---|---|---|---|---|---|---|---|
| 30-34 | 7,597 | 7,387 | 7,258 | 15,858 | 12,477 | 24,815 | 9,843 | 54,584 |
| 35-39 | 8,752 | 9,404 | 9,858 | 20,872 | 17,747 | 36,549 | 15,550 | 61,816 |
| 40-44 | 7,827 | 9,400 | 9,629 | 21,316 | 19,446 | 44,064 | 19,765 | 61,393 |
| 45-49 | 6,656 | 7,947 | 7,914 | 18,015 | 16,969 | 41,644 | 19,080 | 55,953 |
| 50-54 | 5,230 | 5,925 | 6,197 | 12,863 | 11,929 | 29,233 | 14,407 | 42,150 |
| 55-59 | 4,891 | 4,614 | 4,920 | 8,746 | 8,252 | 19,222 | 11,807 | 30,826 |

**Table B-5A.** Figure 5-5 (Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours for 1976-1985 and 1987-1988 as a function of age) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time > 700 |
| | Total Flight Time > 2,000 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time > 700 |
| | Total Flight Time > 2,000 |

**Table B-5B.** Figure 5-5 (Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours for 1976-1985 and 1987-1988 as a function of age) Spreadsheet

| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate |
|---|---|---|---|
| 30-34 | 25,422,449 | 261 | 1.0 |
| 35-39 | 27,658,475 | 173 | 0.6 |
| 40-44 | 26,891,304 | 130 | 0.5 |
| 45-49 | 24,218,236 | 89 | 0.4 |
| 50-54 | 18,107,355 | 73 | 0.4 |
| 55-59 | 13,098,110 | 36 | 0.3 |

**Table B-6A.** Figure 5-6 (Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours, who had an ATP rating, and who were employed by a major airline, for 1976-1985 and 1987-1988 as a function of age) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time > 700 |
| | Total Flight Time > 2,000 |
| | Pilot Certificates = "A" or "AI" |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 1 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Recent Flight Time > 700 |
| | Total Flight Time > 2,000 |
| | Employer code:<br>ASA; TPA; AAL; BNF; CAL; DAL; EAL; MWA; NWA; PDA; PAI; SWA; TWA; UAL; USA |
| Pilot Certificate | Pilot Certificate Ratings:<br>AALL; AAMEL; AAMELC; AAMES; AASEL; AASES; BAMEL |

**Table B-6B.** Figure 5-6 (Accident rates for all Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours, who had an ATP rating, and who were employed by a major airline, for 1976-1985 and 1987-1988 as a function of age) Spreadsheet

| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate |
|---|---|---|---|
| 30-34 | 6,910,366 | 6 | 0.09 |
| 35-39 | 11,765,684 | 3 | 0.03 |
| 40-44 | 15,024,225 | 9 | 0.06 |
| 45-49 | 15,488,962 | 11 | 0.07 |
| 50-54 | 11,881,263 | 7 | 0.06 |
| 55-59 | 8,612,907 | 5 | 0.06 |

**Table B-7A.** Figure 5-7 (Accident rates for all Class II pilots for the years 1976-1985 and 1987-1988 as a function of age) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 2 |
| | Pilot Age: 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69 |
| | Recent Flight Time > 0 |
| | Total Flight Time > 0 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 2 |
| | Pilot Age: 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69 |
| | Recent Flight Time > 0 |
| | Total Flight Time > 0 |

**Table B-7B.** Figure 5-7 (Accident rates for all Class II pilots for the years 1976-1985 and 1987-1988 as a function of age) Spreadsheet

| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate |
|---|---|---|---|
| 30-34 | 35,264,264 | 2,687 | 7.62 |
| 35-39 | 37,746,188 | 2,488 | 6.59 |
| 40-44 | 32,345,426 | 1,991 | 6.16 |
| 45-49 | 25,599,502 | 1,670 | 6.52 |
| 50-54 | 21,094,996 | 1,224 | 5.80 |
| 55-59 | 17,438,224 | 969 | 5.56 |
| 60-64 | 9,866,110 | 499 | 5.06 |
| 65-69 | 3,444,256 | 203 | 5.89 |

**Table B-8A.** Figure 5-8 (Accident rates for all Class III pilots for the years 1976-1985 and 1987-1988 as a function of age) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 3 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69 |
| | Recent Flight Time > 0 |
| | Total Flight Time > 0 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 3 |
| | Pilot Age:<br>30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69 |
| | Recent Flight Time > 0 |
| | Total Flight Time > 0 |

**Table B-8B.** Figure 5-8 (Accident rates for all Class III pilots for the years 1976-1985 and 1987-1988 as a function of age) Spreadsheet

| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate |
|---|---|---|---|
| 30-34 | 16,484,312 | 2,129 | 12.92 |
| 35-39 | 18,678,968 | 2,090 | 11.19 |
| 40-44 | 18,990,832 | 2,066 | 10.88 |
| 45-49 | 19,325,124 | 2,026 | 10.48 |
| 50-54 | 18,763,440 | 1,728 | 9.21 |
| 55-59 | 14,410,584 | 1,249 | 8.67 |
| 60-64 | 8,216,628 | 659 | 8.02 |
| 65-69 | 3,643,696 | 327 | 8.97 |

**Table B-9A.** Figure 5-9 (Accident rates for all Class III pilots with more than 500 total flight hours and more than 50 recent flight hours for the years 1976-1985 and 1987-1988 as a function of age) Database Query Parameters

| Database | Parameter |
| --- | --- |
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 3 |
| | Pilot Age: 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69 |
| | Recent Flight Time > 50 |
| | Total Flight Time > 500 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 3 |
| | Pilot Age: 30-34; 35-39; 40-44; 45-49; 50-54, 55-59; 60-64; 65-69 |
| | Recent Flight Time > 50 |
| | Total Flight Time > 500 |

**Table B-9B.** Figure 5-9 (Accident rates for all Class III pilots with more than 500 total flight hours and more than 50 recent flight hours for the years 1976-1985 and 1987-1988 as a function of age) Spreadsheet

| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate |
| --- | --- | --- | --- |
| 30-34 | 3,049,488 | 261 | 8.56 |
| 35-39 | 5,420,784 | 370 | 6.83 |
| 40-44 | 7,389,344 | 510 | 6.90 |
| 45-49 | 9,165,756 | 618 | 6.74 |
| 50-54 | 10,106,600 | 603 | 5.97 |
| 55-59 | 8,630,068 | 507 | 5.87 |
| 60-64 | 5,254,668 | 287 | 5.46 |
| 65-69 | 2,448,168 | 150 | 6.13 |

**Table B-10A.** Figure 5-10 (Accident rates for Class III pilots between the ages of 50 and 69 with more than 500 total flight hours and more than 50 recent flight hours for the years 1976-1985 and 1987-1988 as a function of age) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year = 1976-1988 |
| | Medical Class = 3 |
| | Pilot Age:<br>50-69 in one-year age steps |
| | Recent Flight Time > 50 |
| | Total Flight Time > 500 |
| Medical Examination | Medical Examination Year = 1976-1988 |
| | Medical Class = 3 |
| | Pilot Age:<br>50-69 in one-year age steps |
| | Recent Flight Time > 50 |
| | Total Flight Time > 500 |

**Table B-10B.** Figure 5-10 (Accident rates for Class III pilots between the ages of 50 and 69 with more than 500 total flight hours and more than 50 recent flight hours for the years 1976-1985 and 1987-1988 as a function of age) Spreadsheet

| Pilot Age | Annualized Recent Time | Accident Count | Accident Rate |
|---|---|---|---|
| 50 | 2,004,992 | 105 | 5.24 |
| 51 | 1,998,476 | 132 | 6.61 |
| 52 | 2,065,376 | 126 | 6.10 |
| 53 | 2,002,584 | 133 | 6.64 |
| 54 | 2,035,172 | 107 | 5.26 |
| 55 | 1,931,404 | 119 | 6.16 |
| 56 | 1,880,172 | 110 | 5.85 |
| 57 | 1,718,264 | 103 | 5.99 |
| 58 | 1,613,868 | 88 | 5.45 |
| 59 | 1,486,360 | 87 | 5.85 |
| 60 | 1,312,312 | 85 | 6.48 |
| 61 | 1,191,620 | 62 | 5.20 |
| 62 | 1,013,704 | 52 | 5.13 |
| 63 | 927,036 | 38 | 4.10 |
| 64 | 809,996 | 50 | 6.17 |
| 65 | 679,204 | 34 | 5.01 |
| 66 | 568,724 | 34 | 5.98 |
| 67 | 479,816 | 37 | 7.71 |
| 68 | 389,636 | 24 | 6.16 |
| 69 | 330,788 | 21 | 6.35 |

**Table B-11A.** Figure 5-11 (Accident rates for Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours for the years 19[illegible] 1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year and Pilot Age Combinations:<br>1976 -- Age 26-30; 31-35; 36-40; 41-45; 46-50<br>1977 -- Age 27-31; 32-36; 37-41; 42-46; 47-51<br>1978 -- Age 28-32; 33-37; 38-42; 43-47; 48-52<br>1979 -- Age 29-33; 34-38; 39-43; 44-48; 49-53<br>1980 -- Age 30-34; 35-39; 40-44; 45-49; 50-54<br>1981 -- Age 31-35; 36-40; 41-45; 46-50; 51-55<br>1982 -- Age 32-36; 37-41; 42-46; 47-51; 52-56<br>1983 -- Age 33-37; 38-42; 43-47; 48-52; 53-57<br>1984 -- Age 34-38; 39-43; 44-48; 49-53; 54-58<br>1985 -- Age 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Medical Class = 1 |
| | Recent Flight Time > 700 |
| | Total Flight Time > 2,000 |
| Medical Examination | Medical Examination Year and Pilot Age Combinations:<br>1976 -- Age 26-30; 31-35; 36-40; 41-45; 46-50<br>1977 -- Age 27-31; 32-36; 37-41; 42-46; 47-51<br>1978 -- Age 28-32; 33-37; 38-42; 43-47; 48-52<br>1979 -- Age 29-33; 34-38; 39-43; 44-48; 49-53<br>1980 -- Age 30-34; 35-39; 40-44; 45-49; 50-54<br>1981 -- Age 31-35; 36-40; 41-45; 46-50; 51-55<br>1982 -- Age 32-36; 37-41; 42-46; 47-51; 52-56<br>1983 -- Age 33-37; 38-42; 43-47; 48-52; 53-57<br>1984 -- Age 34-38; 39-43; 44-48; 49-53; 54-58<br>1985 -- Age 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Medical Class = 1 |
| | Recent Flight Time > 700 |
| | Total Flight Time > 2,000 |

**Table B-11B.** Figure 5-11 (Accident rates for Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected) Spreadsheet

| Year | Birth Year (Pilot Age) | Recent Flight Time Totals | Accident Count | Accident Rate |
|---|---|---|---|---|
| 1976 | 1946-50 (26-30) | 1,282,718 | 21 | 1.64 |
| 1976 | 1941-45 (31-35) | 1,848,586 | 22 | 1.19 |
| 1976 | 1936-40 (36-40) | 2,107,671 | 16 | 0.76 |
| 1976 | 1931-35 (41-45) | 1,789,551 | 10 | 0.56 |
| 1976 | 1926-30 (46-50) | 1,174,220 | 4 | 0.34 |
| 1977 | 1946-50 (26-30) | 1,524,842 | 34 | 2.23 |
| 1977 | 1941-45 (31-35) | 2,008,595 | 17 | 0.85 |
| 1977 | 1936-40 (36-40) | 2,250,490 | 11 | 0.49 |
| 1977 | 1931-35 (41-45) | 1,886,066 | 5 | 0.27 |
| 1977 | 1926-30 (46-50) | 1,174,284 | 7 | 0.60 |
| 1978 | 1946-50 (26-30) | 1,804,094 | 30 | 1.66 |
| 1978 | 1941-45 (31-35) | 2,232,406 | 19 | 0.85 |
| 1978 | 1936-40 (36-40) | 2,462,137 | 12 | 0.49 |
| 1978 | 1931-35 (41-45) | 2,002,937 | 12 | 0.60 |
| 1978 | 1926-30 (46-50) | 1,233,583 | 6 | 0.49 |
| 1979 | 1946-50 (26-30) | 2,185,602 | 31 | 1.42 |
| 1979 | 1941-45 (31-35) | 2,504,728 | 18 | 0.72 |
| 1979 | 1936-40 (36-40) | 2,617,210 | 9 | 0.34 |
| 1979 | 1931-35 (41-45) | 2,095,368 | 8 | 0.38 |
| 1979 | 1926-30 (46-50) | 1,230,315 | 9 | 0.73 |
| 1980 | 1946-50 (26-30) | 2,336,362 | 34 | 1.46 |
| 1980 | 1941-45 (31-35) | 2,386,439 | 22 | 0.92 |
| 1980 | 1936-40 (36-40) | 2,531,144 | 7 | 0.28 |
| 1980 | 1931-35 (41-45) | 2,041,254 | 6 | 0.29 |
| 1980 | 1926-30 (46-50) | 1,151,415 | 2 | 0.17 |
| 1981 | 1946-50 (26-30) | 2,353,842 | 24 | 1.02 |
| 1981 | 1941-45 (31-35) | 2,273,752 | 12 | 0.53 |
| 1981 | 1936-40 (36-40) | 2,347,014 | 11 | 0.47 |
| 1981 | 1931-35 (41-45) | 1,917,546 | 6 | 0.31 |
| 1981 | 1926-30 (46-50) | 1,036,140 | 4 | 0.39 |
| 1982 | 1946-50 (26-30) | 2,275,248 | 19 | 0.84 |
| 1982 | 1941-45 (31-35) | 2,111,816 | 9 | 0.43 |
| 1982 | 1936-40 (36-40) | 2,248,276 | 9 | 0.40 |

| Year | Birth Year (Pilot Age) | Recent Flight Time Totals | Accident Count | Accident Rate |
|---|---|---|---|---|
| 1982 | 1926-30 (46-50) | 992,458 | 5 | 0.50 |
| 1983 | 1946-50 (26-30) | 2,377,316 | 13 | 0.55 |
| 1983 | 1941-45 (31-35) | 2,269,669 | 13 | 0.57 |
| 1983 | 1936-40 (36-40) | 2,410,256 | 16 | 0.66 |
| 1983 | 1931-35 (41-45) | 1,958,217 | 4 | 0.20 |
| 1983 | 1926-30 (46-50) | 1,024,058 | 7 | 0.68 |
| 1984 | 1946-50 (26-30) | 3,031,633 | 15 | 0.49 |
| 1984 | 1941-45 (31-35) | 2,648,838 | 15 | 0.57 |
| 1984 | 1936-40 (36-40) | 2,771,686 | 7 | 0.25 |
| 1984 | 1931-35 (41-45) | 2,247,937 | 6 | 0.27 |
| 1984 | 1926-30 (46-50) | 1,098,166 | 1 | 0.09 |
| 1985 | 1946-50 (26-30) | 3,319,334 | 8 | 0.24 |
| 1985 | 1941-45 (31-35) | 2,887,167 | 11 | 0.38 |
| 1985 | 1936-40 (36-40) | 2,977,187 | 6 | 0.20 |
| 1985 | 1931-35 (41-45) | 2,287,490 | 7 | 0.31 |
| 1985 | 1926-30 (46-50) | 1,032,529 | 8 | 0.77 |

**Table B-12A.** Figure 5-12 (Accident rates for Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year and Pilot Age Combinations:<br>1976 -- Age 26-30; 31-35; 36-40; 41-45; 46-50<br>1977 -- Age 27-31; 32-36; 37-41; 42-46; 47-51<br>1978 -- Age 28-32; 33-37; 38-42; 43-47; 48-52<br>1979 -- Age 29-33; 34-38; 39-43; 44-48; 49-53<br>1980 -- Age 30-34; 35-39; 40-44; 45-49; 50-54<br>1981 -- Age 31-35; 36-40; 41-45; 46-50; 51-55<br>1982 -- Age 32-36; 37-41; 42-46; 47-51; 52-56<br>1983 -- Age 33-37; 38-42; 43-47; 48-52; 53-57<br>1984 -- Age 34-38; 39-43; 44-48; 49-53; 54-58<br>1985 -- Age 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Medical Class = 1 |
| | Recent Flight Time > 700 |
| | Total Flight Time > 2,000 |
| Medical Examination | Medical Examination Year and Pilot Age Combinations:<br>1976 -- Age 26-30; 31-35; 36-40; 41-45; 46-50<br>1977 -- Age 27-31; 32-36; 37-41; 42-46; 47-51<br>1978 -- Age 28-32; 33-37; 38-42; 43-47; 48-52<br>1979 -- Age 29-33; 34-38; 39-43; 44-48; 49-53<br>1980 -- Age 30-34; 35-39; 40-44; 45-49; 50-54<br>1981 -- Age 31-35; 36-40; 41-45; 46-50; 51-55<br>1982 -- Age 32-36; 37-41; 42-46; 47-51; 52-56<br>1983 -- Age 33-37; 38-42; 43-47; 48-52; 53-57<br>1984 -- Age 34-38; 39-43; 44-48; 49-53; 54-58<br>1985 -- Age 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Medical Class = 1 |
| | Recent Flight Time > 700 |
| | Total Flight Time > 2,000 |

**Table B-12B.** Figure 5-12 (Accident rates for Class I pilots with more than 2,000 total flight hours and more than 700 recent flight hours for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected) Spreadsheet

| Year | Birth Year (Pilot Age) | Recent Flight Time Totals | Accident Count | Accident Rate |
|---|---|---|---|---|
| 1976 | 1946-50 (26-30) | 1,282,718 | 21 | 1.64 |
| 1976 | 1941-45 (31-35) | 1,848,586 | 22 | 1.19 |
| 1976 | 1936-40 (36-40) | 2,107,671 | 16 | 0.76 |
| 1976 | 1931-35 (41-45) | 1,789,551 | 10 | 0.56 |
| 1976 | 1926-30 (46-50) | 1,174,220 | 4 | 0.34 |
| 1977 | 1946-50 (26-30) | 1,524,842 | 34 | 2.23 |
| 1977 | 1941-45 (31-35) | 2,008,595 | 17 | 0.85 |
| 1977 | 1936-40 (36-40) | 2,250,490 | 11 | 0.49 |
| 1977 | 1931-35 (41-45) | 1,886,066 | 5 | 0.27 |
| 1977 | 1926-30 (46-50) | 1,174,284 | 7 | 0.60 |
| 1978 | 1946-50 (26-30) | 1,804,094 | 30 | 1.66 |
| 1978 | 1941-45 (31-35) | 2,232,406 | 19 | 0.85 |
| 1978 | 1936-40 (36-40) | 2,462,137 | 12 | 0.49 |
| 1978 | 1931-35 (41-45) | 2,002,937 | 12 | 0.60 |
| 1978 | 1926-30 (46-50) | 1,233,583 | 6 | 0.49 |
| 1979 | 1946-50 (26-30) | 2,185,602 | 31 | 1.42 |
| 1979 | 1941-45 (31-35) | 2,504,728 | 18 | 0.72 |
| 1979 | 1936-40 (36-40) | 2,617,210 | 9 | 0.34 |
| 1979 | 1931-35 (41-45) | 2,095,368 | 8 | 0.38 |
| 1979 | 1926-30 (46-50) | 1,230,315 | 9 | 0.73 |
| 1980 | 1946-50 (26-30) | 2,336,362 | 34 | 1.46 |
| 1980 | 1941-45 (31-35) | 2,386,439 | 22 | 0.92 |
| 1980 | 1936-40 (36-40) | 2,531,144 | 7 | 0.28 |
| 1980 | 1931-35 (41-45) | 2,041,254 | 6 | 0.29 |
| 1980 | 1926-30 (46-50) | 1,151,415 | 2 | 0.17 |
| 1981 | 1946-50 (26-30) | 2,353,842 | 24 | 1.02 |
| 1981 | 1941-45 (31-35) | 2,273,752 | 12 | 0.53 |
| 1981 | 1936-40 (36-40) | 2,347,014 | 11 | 0.47 |
| 1981 | 1931-35 (41-45) | 1,917,546 | 6 | 0.31 |
| 1981 | 1926-30 (46-50) | 1,036,140 | 4 | 0.39 |
| 1982 | 1946-50 (26-30) | 2,275,248 | 19 | 0.84 |
| 1982 | 1941-45 (31-35) | 2,111,816 | 9 | 0.43 |
| 1982 | 1936-40 (36-40) | 2,248,276 | 9 | 0.40 |
| 1982 | 1931-35 (41-45) | 1,867,412 | 3 | 0.16 |

| Year | Birth Year (Pilot Age) | Recent Flight Time Totals | Accident Count | Accident Rate |
|---|---|---|---|---|
| 1983 | 1946-50 (26-30) | 2,377,316 | 13 | 0.55 |
| 1983 | 1941-45 (31-35) | 2,269,669 | 13 | 0.57 |
| 1983 | 1936-40 (36-40) | 2,410,256 | 16 | 0.66 |
| 1983 | 1931-35 (41-45) | 1,958,217 | 4 | 0.20 |
| 1983 | 1926-30 (46-50) | 1,024,058 | 7 | 0.68 |
| 1984 | 1946-50 (26-30) | 3,031,633 | 15 | 0.49 |
| 1984 | 1941-45 (31-35) | 2,648,838 | 15 | 0.57 |
| 1984 | 1936-40 (36-40) | 2,771,686 | 7 | 0.25 |
| 1984 | 1931-35 (41-45) | 2,247,937 | 6 | 0.27 |
| 1984 | 1926-30 (46-50) | 1,098,166 | 1 | 0.09 |
| 1985 | 1946-50 (26-30) | 3,319,334 | 8 | 0.24 |
| 1985 | 1941-45 (31-35) | 2,887,167 | 11 | 0.38 |
| 1985 | 1936-40 (36-40) | 2,977,187 | 6 | 0.20 |
| 1985 | 1931-35 (41-45) | 2,287,490 | 7 | 0.31 |
| 1985 | 1926-30 (46-50) | 1,032,529 | 8 | 0.77 |

**Table B-13A.** Figure 5-13 (Accident rates for Class III pilots with more than 500 total flight hours and more than 50 recent flight hours for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year and Pilot Age Combinations:<br>1976 -- Age 26-30; 31-35; 36-40; 41-45; 46-50<br>1977 -- Age 27-31; 32-36; 37-41; 42-46; 47-51<br>1978 -- Age 28-32; 33-37; 38-42; 43-47; 48-52<br>1979 -- Age 29-33; 34-38; 39-43; 44-48; 49-53<br>1980 -- Age 30-34; 35-39; 40-44; 45-49; 50-54<br>1981 -- Age 31-35; 36-40; 41-45; 46-50; 51-55<br>1982 -- Age 32-36; 37-41; 42-46; 47-51; 52-56<br>1983 -- Age 33-37; 38-42; 43-47; 48-52; 53-57<br>1984 -- Age 34-38; 39-43; 44-48; 49-53; 54-58<br>1985 -- Age 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Medical Class = 3 |
| | Recent Flight Time > 50 |
| | Total Flight Time > 500 |
| Medical Examination | Medical Examination Year and Pilot Age Combinations:<br>1976 -- Age 26-30; 31-35; 36-40; 41-45; 46-50<br>1977 -- Age 27-31; 32-36; 37-41; 42-46; 47-51<br>1978 -- Age 28-32; 33-37; 38-42; 43-47; 48-52<br>1979 -- Age 29-33; 34-38; 39-43; 44-48; 49-53<br>1980 -- Age 30-34; 35-39; 40-44; 45-49; 50-54<br>1981 -- Age 31-35; 36-40; 41-45; 46-50; 51-55<br>1982 -- Age 32-36; 37-41; 42-46; 47-51; 52-56<br>1983 -- Age 33-37; 38-42; 43-47; 48-52; 53-57<br>1984 -- Age 34-38; 39-43; 44-48; 49-53; 54-58<br>1985 -- Age 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Medical Class = 1 |
| | Recent Flight Time > 50 |
| | Total Flight Time > 500 |

**Table B-13B.** Figure 5-13 (Accident rates for Class III pilots with more than 500 total flight hours and more than 50 recent flight hours for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected) Spreadsheet

| Year | Birth Year (Pilot Age) | Recent Flight Time Totals | Accident Count | Accident Rate |
|---|---|---|---|---|
| 1976 | 1946-50 (26-30) | 113,000 | 17 | 15.04 |
| 1976 | 1941-45 (31-35) | 276,072 | 28 | 10.14 |
| 1976 | 1936-40 (36-40) | 435,580 | 37 | 8.49 |
| 1976 | 1931-35 (41-45) | 641,452 | 61 | 9.51 |
| 1976 | 1926-30 (46-50) | 952,892 | 78 | 8.19 |
| 1976 | 1921-25 (51-55) | 908,928 | 58 | 6.38 |
| 1976 | 1916-20 (56-60) | 533,160 | 41 | 7.69 |
| 1977 | 1946-50 (26-30) | 152,764 | 23 | 15.06 |
| 1977 | 1941-45 (31-35) | 337,336 | 20 | 5.93 |
| 1977 | 1936-40 (36-40) | 492,856 | 42 | 8.52 |
| 1977 | 1931-35 (41-45) | 692,096 | 48 | 6.94 |
| 1977 | 1926-30 (46-50) | 957,608 | 80 | 8.35 |
| 1977 | 1921-25 (51-55) | 842,008 | 68 | 8.08 |
| 1977 | 1916-20 (56-60) | 475,348 | 35 | 7.36 |
| 1978 | 1946-50 (26-30) | 201,708 | 18 | 8.92 |
| 1978 | 1941-45 (31-35) | 406,176 | 47 | 11.57 |
| 1978 | 1936-40 (36-40) | 542,308 | 35 | 6.45 |
| 1978 | 1931-35 (41-45) | 755,236 | 57 | 7.55 |
| 1978 | 1926-30 (46-50) | 1,041,196 | 73 | 7.01 |
| 1978 | 1921-25 (51-55) | 892,744 | 75 | 8.40 |
| 1978 | 1916-20 (56-60) | 485,636 | 16 | 3.29 |
| 1979 | 1946-50 (26-30) | 259,240 | 23 | 8.87 |
| 1979 | 1941-45 (31-35) | 467,012 | 34 | 7.28 |
| 1979 | 1936-40 (36-40) | 585,052 | 46 | 7.86 |
| 1979 | 1931-35 (41-45) | 793,128 | 59 | 7.44 |
| 1979 | 1926-30 (46-50) | 989,096 | 61 | 6.17 |
| 1979 | 1921-25 (51-55) | 816,496 | 47 | 5.76 |
| 1979 | 1916-20 (56-60) | 431,544 | 23 | 5.33 |
| 1980 | 1946-50 (26-30) | 288,420 | 30 | 10.40 |
| 1980 | 1941-45 (31-35) | 499,036 | 44 | 8.82 |
| 1980 | 1936-40 (36-40) | 641,804 | 54 | 8.41 |
| 1980 | 1931-35 (41-45) | 778,156 | 52 | 6.68 |
| 1980 | 1926-30 (46-50) | 980,608 | 56 | 5.71 |
| 1980 | 1921-25 (51-55) | 771,856 | 32 | 4.15 |

| Year | Birth Year (Pilot Age) | Recent Flight Time Totals | Accident Count | Accident Rate |
|---|---|---|---|---|
| 1981 | 1946-50 (26-30) | 326,332 | 29 | 8.89 |
| 1981 | 1941-45 (31-35) | 551,736 | 39 | 7.07 |
| 1981 | 1936-40 (36-40) | 659,432 | 50 | 7.58 |
| 1981 | 1931-35 (41-45) | 792,120 | 55 | 6.94 |
| 1981 | 1926-30 (46-50) | 889,928 | 47 | 5.28 |
| 1981 | 1921-25 (51-55) | 718,364 | 43 | 5.99 |
| 1981 | 1916-20 (56-60) | 363,160 | 26 | 7.16 |
| 1982 | 1946-50 (26-30) | 339,900 | 20 | 5.88 |
| 1982 | 1941-45 (31-35) | 531,600 | 30 | 5.64 |
| 1982 | 1936-40 (36-40) | 626,276 | 30 | 4.79 |
| 1982 | 1931-35 (41-45) | 701,172 | 48 | 6.85 |
| 1982 | 1926-30 (46-50) | 830,064 | 45 | 5.42 |
| 1982 | 1921-25 (51-55) | 635,812 | 23 | 3.62 |
| 1982 | 1916-20 (56-60) | 301,164 | 21 | 6.97 |
| 1983 | 1946-50 (26-30) | 369,504 | 20 | 5.41 |
| 1983 | 1941-45 (31-35) | 567,128 | 35 | 6.17 |
| 1983 | 1936-40 (36-40) | 625,012 | 32 | 5.12 |
| 1983 | 1931-35 (41-45) | 701,628 | 53 | 7.55 |
| 1983 | 1926-30 (46-50) | 796,996 | 46 | 5.77 |
| 1983 | 1921-25 (51-55) | 590,112 | 41 | 6.95 |
| 1983 | 1916-20 (56-60) | 274,024 | 14 | 5.11 |
| 1984 | 1946-50 (26-30) | 359,596 | 23 | 6.40 |
| 1984 | 1941-45 (31-35) | 571,236 | 43 | 7.53 |
| 1984 | 1936-40 (36-40) | 650,932 | 37 | 5.68 |
| 1984 | 1931-35 (41-45) | 680,036 | 33 | 4.85 |
| 1984 | 1926-30 (46-50) | 741,160 | 48 | 6.48 |
| 1984 | 1921-25 (51-55) | 537,404 | 28 | 5.21 |
| 1984 | 1916-20 (56-60) | 244,376 | 17 | 6.96 |
| 1985 | 1946-50 (26-30) | 456,216 | 27 | 5.92 |
| 1985 | 1941-45 (31-35) | 614,916 | 37 | 6.02 |
| 1985 | 1936-40 (36-40) | 672,324 | 40 | 5.95 |
| 1985 | 1931-35 (41-45) | 701,448 | 40 | 5.70 |
| 1985 | 1926-30 (46-50) | 752,564 | 42 | 5.58 |
| 1985 | 1921-25 (51-55) | 516,316 | 28 | 5.42 |
| 1985 | 1916-20 (56-60) | 242,592 | 8 | 3.30 |

**Table B-14A.** Figure 5-14 (Accident rates for Class III pilots with more than 500 total flight hours and more than 50 recent flight hours for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected) Database Query Parameters

| Database | Parameter |
|---|---|
| Accident | Accident/Incident=Accident |
| | Accident Year and Pilot Age Combinations:<br>1976 -- Age 26-30; 31-35; 36-40; 41-45; 46-50<br>1977 -- Age 27-31; 32-36; 37-41; 42-46; 47-51<br>1978 -- Age 28-32; 33-37; 38-42; 43-47; 48-52<br>1979 -- Age 29-33; 34-38; 39-43; 44-48; 49-53<br>1980 -- Age 30-34; 35-39; 40-44; 45-49; 50-54<br>1981 -- Age 31-35; 36-40; 41-45; 46-50; 51-55<br>1982 -- Age 32-36; 37-41; 42-46; 47-51; 52-56<br>1983 -- Age 33-37; 38-42; 43-47; 48-52; 53-57<br>1984 -- Age 34-38; 39-43; 44-48; 49-53; 54-58<br>1985 -- Age 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Medical Class = 3 |
| | Recent Flight Time > 50 |
| | Total Flight Time > 500 |
| Medical Examination | Medical Examination Year and Pilot Age Combinations:<br>1976 -- Age 26-30; 31-35; 36-40; 41-45; 46-50<br>1977 -- Age 27-31; 32-36; 37-41; 42-46; 47-51<br>1978 -- Age 28-32; 33-37; 38-42; 43-47; 48-52<br>1979 -- Age 29-33; 34-38; 39-43; 44-48; 49-53<br>1980 -- Age 30-34; 35-39; 40-44; 45-49; 50-54<br>1981 -- Age 31-35; 36-40; 41-45; 46-50; 51-55<br>1982 -- Age 32-36; 37-41; 42-46; 47-51; 52-56<br>1983 -- Age 33-37; 38-42; 43-47; 48-52; 53-57<br>1984 -- Age 34-38; 39-43; 44-48; 49-53; 54-58<br>1985 -- Age 35-39; 40-44; 45-49; 50-54; 55-59 |
| | Medical Class = 1 |
| | Recent Flight Time > 50 |
| | Total Flight Time > 500 |

**Table B-14B.** Figure 5-14 (Accident rates for Class III pilots with more than 500 total flight hours and more than 50 recent flight hours for the years 1976-1985 and 1987-1988 as a function of date of birth and of the year in which the data were collected) Spreadsheet

| Year | Birth Year (Pilot Age) | Recent Flight Time Totals | Accident Count | Accident Rate |
|---|---|---|---|---|
| 1976 | 1946-50 (26-30) | 113,000 | 17 | 15.04 |
| 1976 | 1941-45 (31-35) | 276,072 | 28 | 10.14 |
| 1976 | 1936-40 (36-40) | 435,580 | 37 | 8.49 |
| 1976 | 1931-35 (41-45) | 641,452 | 61 | 9.51 |
| 1976 | 1926-30 (46-50) | 952,892 | 78 | 8.19 |
| 1976 | 1921-25 (51-55) | 908,928 | 58 | 6.38 |
| 1976 | 1916-20 (56-60) | 533,160 | 41 | 7.69 |
| 1977 | 1946-50 (26-30) | 152,764 | 23 | 15.06 |
| 1977 | 1941-45 (31-35) | 337,336 | 20 | 5.93 |
| 1977 | 1936-40 (36-40) | 492,856 | 42 | 8.52 |
| 1977 | 1931-35 (41-45) | 692,096 | 48 | 6.94 |
| 1977 | 1926-30 (46-50) | 957,608 | 80 | 8.35 |
| 1977 | 1921-25 (51-55) | 842,008 | 68 | 8.08 |
| 1977 | 1916-20 (56-60) | 475,348 | 35 | 7.36 |
| 1978 | 1946-50 (26-30) | 201,708 | 18 | 8.92 |
| 1978 | 1941-45 (31-35) | 406,176 | 47 | 11.57 |
| 1978 | 1936-40 (36-40) | 542,308 | 35 | 6.45 |
| 1978 | 1931-35 (41-45) | 755,236 | 57 | 7.55 |
| 1978 | 1926-30 (46-50) | 1,041,196 | 73 | 7.01 |
| 1978 | 1921-25 (51-55) | 892,744 | 75 | 8.40 |
| 1978 | 1916-20 (56-60) | 485,636 | 16 | 3.29 |
| 1979 | 1946-50 (26-30) | 259,240 | 23 | 8.87 |
| 1979 | 1941-45 (31-35) | 467,012 | 34 | 7.28 |
| 1979 | 1936-40 (36-40) | 585,052 | 46 | 7.86 |
| 1979 | 1931-35 (41-45) | 793,128 | 59 | 7.44 |
| 1979 | 1926-30 (46-50) | 989,096 | 61 | 6.17 |
| 1979 | 1921-25 (51-55) | 816,496 | 47 | 5.76 |
| 1979 | 1916-20 (56-60) | 431,544 | 23 | 5.33 |
| 1980 | 1946-50 (26-30) | 288,420 | 30 | 10.40 |
| 1980 | 1941-45 (31-35) | 499,036 | 44 | 8.82 |
| 1980 | 1936-40 (36-40) | 641,804 | 54 | 8.41 |
| 1980 | 1931-35 (41-45) | 778,156 | 52 | 6.68 |
| 1980 | 1926-30 (46-50) | 980,608 | 56 | 5.71 |
| 1980 | 1921-25 (51-55) | 771,856 | 32 | 4.15 |

| Year | Birth Year (Pilot Age) | Recent Flight Time Totals | Accident Count | Accident Rate |
|---|---|---|---|---|
| 1981 | 1946-50 (26-30) | 326,332 | 29 | 8.89 |
| 1981 | 1941-45 (31-35) | 551,736 | 39 | 7.07 |
| 1981 | 1936-40 (36-40) | 659,432 | 50 | 7.58 |
| 1981 | 1931-35 (41-45) | 792,120 | 55 | 6.94 |
| 1981 | 1926-30 (46-50) | 889,928 | 47 | 5.28 |
| 1981 | 1921-25 (51-55) | 718,364 | 43 | 5.99 |
| 1981 | 1916-20 (56-60) | 363,160 | 26 | 7.16 |
| 1982 | 1946-50 (26-30) | 339,900 | 20 | 5.88 |
| 1982 | 1941-45 (31-35) | 531,600 | 30 | 5.64 |
| 1982 | 1936-40 (36-40) | 626,276 | 30 | 4.79 |
| 1982 | 1931-35 (41-45) | 701,172 | 48 | 6.85 |
| 1982 | 1926-30 (46-50) | 830,064 | 45 | 5.42 |
| 1982 | 1921-25 (51-55) | 635,812 | 23 | 3.62 |
| 1982 | 1916-20 (56-60) | 301,164 | 21 | 6.97 |
| 1983 | 1946-50 (26-30) | 369,504 | 20 | 5.41 |
| 1983 | 1941-45 (31-35) | 567,128 | 35 | 6.17 |
| 1983 | 1936-40 (36-40) | 625,012 | 32 | 5.12 |
| 1983 | 1931-35 (41-45) | 701,628 | 53 | 7.55 |
| 1983 | 1926-30 (46-50) | 796,996 | 46 | 5.77 |
| 1983 | 1921-25 (51-55) | 590,112 | 41 | 6.95 |
| 1983 | 1916-20 (56-60) | 274,024 | 14 | 5.11 |
| 1984 | 1946-50 (26-30) | 359,596 | 23 | 6.40 |
| 1984 | 1941-45 (31-35) | 571,236 | 43 | 7.53 |
| 1984 | 1936-40 (36-40) | 650,932 | 37 | 5.68 |
| 1984 | 1931-35 (41-45) | 680,036 | 33 | 4.85 |
| 1984 | 1926-30 (46-50) | 741,160 | 48 | 6.48 |
| 1984 | 1921-25 (51-55) | 537,404 | 28 | 5.21 |
| 1984 | 1916-20 (56-60) | 244,376 | 17 | 6.96 |
| 1985 | 1946-50 (26-30) | 456,216 | 27 | 5.92 |
| 1985 | 1941-45 (31-35) | 614,916 | 37 | 6.02 |
| 1985 | 1936-40 (36-40) | 672,324 | 40 | 5.95 |
| 1985 | 1931-35 (41-45) | 701,448 | 40 | 5.70 |
| 1985 | 1926-30 (46-50) | 752,564 | 42 | 5.58 |
| 1985 | 1921-25 (51-55) | 516,316 | 28 | 5.42 |
| 1985 | 1916-20 (56-60) | 242,592 | 8 | 3.30 |

**Table B-15A.** Figure 5-15 (Count of Class I pilots aged 36-40 with more than 2,000 total flight hours and more than 250 recent flight hours for the years 1976-1985) Database Query Parameters

| Database | Parameter |
|---|---|
| Medical Examination | Medical Class = 1 |
| | Recent Flight Time > 250 |
| | Total Flight Time > 2,000<br>Medical Examination Year and Pilot Age Combinations:<br>1976 -- Age 36-40<br>1977 -- Age 37-41<br>1978 -- Age 38-42<br>1979 -- Age 39-43<br>1980 -- Age 40-44<br>1981 -- Age 41-45<br>1982 -- Age 42-46<br>1983 -- Age 43-47<br>1984 -- Age 44-48<br>1985 -- Age 45-49 |

**Table B-15B.** Figure 5-15 (Count of Class I pilots aged 36-40 with more than 2,000 total flight hours and more than 250 recent flight hours for the years 1976-1985) Spreadsheet

| Years | Year 1 | Year 2 |
|---|---|---|
| 1976-77 | 11,580 | 9,254 |
| 1977-78 | 12,261 | 9,932 |
| 1978-79 | 13,582 | 11,202 |
| 1979-80 | 14,922 | 12,135 |
| 1980-81 | 15,078 | 12,218 |
| 1981-82 | 15,028 | 12,145 |
| 1982-83 | 14,789 | 11,974 |
| 1983-84 | 14,773 | 12,077 |
| 1984-85 | 15,367 | 12,774 |

**Table B-16A.** Figure 5-16 (Counts of Class I pilots aged 26-30 for the years 1976-1985 and 1987-1988 as a function of year) Database Query Parameters

| Database | Parameter |
|---|---|
| Medical Examination | Medical Class = 1 |
| | Recent Flight Time > = 0 |
| | Total Flight Time > = 0 |
| | Medical Examination Year and Pilot Age Combination: 1976-- Age 26-30 |
| Certificate Number | IF certificate number EXISTS in 1976 AND class I in 1977, increment 1977 Class I count. IF certificate number EXISTS in 1976 AND class II in 1977, increment 1977 Class II count. IF certificate number EXISTS in 1976 AND class III in 1977, increment 1977 Class III count. REPEAT above for years 1978 - 1988 (excluding 1986) |

**Table B-16B.** Figure 5-16 (Counts of Class I pilots aged 26-30 for the years 1976-1985 and 1987-1988 as a function of year) Spreadsheet

| Year | Overall Class I for year | Class I Attrition | Class I -- Class II | Class I -- III |
|---|---|---|---|---|
| 76 | 10,049 | 10,059 | 286 | 8 |
| 77 | 12,367 | 7,852 | 607 | 4 |
| 78 | 15,979 | 7,858 | 628 | 32 |
| 79 | 18,760 | 7,665 | 540 | 32 |
| 80 | 19,275 | 7,503 | 551 | 16 |
| 81 | 19,788 | 7,440 | 698 | 29 |
| 82 | 18,736 | 7,212 | 863 | 43 |
| 83 | 18,959 | 7,203 | 925 | 38 |
| 84 | 20,641 | 7,465 | 921 | 46 |
| 85 | 22,140 | 7,758 | 853 | 42 |
| 87 | 24,069 | 8,060 | 838 | 42 |
| 88 | 25,339 | 8,084 | 965 | 47 |

**Table B-17A.** Figure 5-17 (Counts of Class I pilots aged 46-50 for the years 1976-1985 and 1987-1988 as a function of year) Database Query Parameters

| Database | Parameter |
|---|---|
| Medical Examination | Medical Class = 1 |
| | Recent Flight Time > = 0 |
| | Total Flight Time > = 0 |
| | Medical Examination Year and Pilot Age Combination: 1976-- Age 46-50 |
| Certificate Number | IF certificate number EXISTS in 1976 AND class I in 1977, increment 1977 Class I count.<br>IF certificate number EXISTS in 1976 AND class II in 1977, increment 1977 Class II count.<br>IF certificate number EXISTS in 1976 AND class III in 1977, increment 1977 Class III count.<br><br>REPEAT above for years 1978 - 1988 (excluding 1986) |

**Table B-17B.** Figure 5-17 (Counts of Class I pilots aged 46-50 for the years 1976-1985 and 1987-1988 as a function of year) Spreadsheet

| Year | Overall Class I for year | Class I Attrition | Class I -- Class II | Class I -- III |
|---|---|---|---|---|
| 76 | 8,335 | 8,283 | 33 | 3 |
| 77 | 8,312 | 7,607 | 141 | 7 |
| 78 | 8,503 | 7,390 | 185 | 20 |
| 79 | 8,650 | 7,229 | 185 | 15 |
| 80 | 8,177 | 7,027 | 211 | 11 |
| 81 | 8,449 | 6,943 | 253 | 10 |
| 82 | 8,161 | 6,724 | 280 | 25 |
| 83 | 7,767 | 6,407 | 320 | 24 |
| 84 | 7,395 | 6,046 | 309 | 25 |
| 85 | 6,929 | 5,416 | 355 | 42 |
| 87 | 4,721 | 3,535 | 509 | 68 |
| 88 | 3,554 | 2,586 | 630 | 86 |



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