NASA Contractor Report 3650



# Single Pilot IFR Accident Data Analysis

D. F. Harris and J. A. Morrisette

CONTRACT NAS1-16920
NOVEMBER 1982

NASA

NASA Contractor Report 3650

# Single Pilot IFR
# Accident Data Analysis

D. F. Harris and J. A. Morrisette
*Spectrum Technology Incorporated*
*Virginia Beach, Virginia*

Prepared for
Langley Research Center
under Contract NAS1-16920

NASA
National Aeronautics
and Space Administration

**Scientific and Technical**
**Information Branch**

1982

## TABLE OF CONTENTS

ACKNOWLEDGEMENT

The authors of this report would like to acknowledge the enthusiastic and energetic support of Mr. Roland T. Frederick of the NASA Langley Research Center Business Data Systems Division. Mr. Frederick's consistent willingness to respond to short fuzed requests for reduction and extraction of data from the NTSB accident data base was much appreciated and an invaluable aid in the timely completion of this report.

# INTRODUCTION

In 1978, aircraft accident data recorded and maintained by the National Transportation Safety Board (NTSB) were analyzed to determine what problems exist in the general aviation (GA) single pilot instrument flight rules (SPIFR) environment. The results of that analysis were based on the data from 1964 to 1975, and were used to help structure the NASA Langley Research Center SPIFR research program. Since the results of that analysis were published, GA SPIFR activity has continued to increase both in terms of numbers of flights and numbers of accidents, and the accident data from four additional years (1976-1979) have been added to the NTSB data base. The purpose of the research and analysis upon which this report is based was to determine what changes, if any, have occurred in trends and cause-effect relationships reported in the earlier study. The increasing numbers have been tied to measures of activity to produce accident rates which in turn were analyzed in terms of change. Where anomalies or unusually high accident rates were encountered, further analysis was conducted to isolate pertinent patterns of cause factors and/or experience levels of involved pilots.

The first section of the report reviews and examines SPIFR accidents in many of the same terms and formats used in the original study. Data from the 1964-1975 period were compared with data from the 1976-1979 time frame to determine what changes are occurring in the SPIFR arena of operations. SPIFR accidents are addressed and analyzed in terms of phase of flight, mission variables, and pilot experience. In general, there are no major surprises in this section as accident trends have remained fairly consistent over the years.

The second section of this report addresses the profiles of GA pilots in terms of their experience levels. The results of a recent survey conducted by NASA through Ohio State University provide a basis for comparing the typical GA SPIFR pilot with a profile of the pilot represented in the NTSB accident statistics data base. The profiles established in this section are used in the later sections to provide comparisons with experience characteristics of pilots involved in specific classes of accidents.

The impact of a few specific variables is examined in the third section of the report in an attempt to relate types of accidents to particular conditions. Type of aircraft, number of pilots, and type of terrain are tabulated by category of accident to see which impact upon what type of accidents.

The fourth section of the report explores day and night accident rates of the SPIFR pilot. Based upon a Federal Aviation Agency (FAA) survey of GA activity, actual day and night accident rates are calculated with some rather surprising results. Comparisons are presented between SPIFR and dual piloted IFR (DPIFR) accident rates for both day and night operations, and some of the specific characteristics of pilots involved in night accidents are addressed.

The final section presents the results of a comprehensive analysis of SPIFR collisions with the ground. Uncontrolled collisions are examined in depth and comparisons are presented between SPIFR landing, DPIFR landing, and SPIFR take-off/enroute phase accident statistics. Specific sub-sets of vertigo and icing related accidents are analyzed and compared for commonalities and diversities as are controlled day and night collisions with the ground/water.

The majority of this report concerns the SPIFR pilot in the approach/landing phase. Specifically, the 554 accidents analyzed in the majority of the report are all landing phase accidents and represent only one subset of the 1396 pilot error SPIFR accidents in the data base. The reader is invited to explore the many combinations of data in the myriad of charts and tables used in this effort and located following the text of this report. There are a number of nuances in those tables which provide food for thought, speculation, and detailed analysis which the authors of this report did not have the time nor the assets to address.

## PREVIOUS TRENDS RE-EXAMINED

One of the objectives of this report is to update selected tables and graphs that were originally published in NASA TM-78773 (reference A). Those tables and graphs are presented in essentially the same format as they were in the original report. The data has been updated to include the years 1976-1979, and where appropriate, columns have been added which present the percentage of the table data that is from accidents in the latter time period. The general methodology for interpreting indicated trends used throughout the analysis of the updated data is a straight forward check to see if the proportional increase in a particular subset of mishaps for 1976-1979 is distributed in the same manner as similar mishaps for the 1964-1975 data. In other words, did the number of accidents for each mission variable increase in the same proportion as the total increase in the total number of accidents. Given that 216 (39 percent) of the 554 total landing phase accidents occurred from 1976 to 1979, the number of accidents which are associated with each mission variable should reflect a similar increase of approximately 39 percent.

A 95 percent confidence interval was calculated for the proportion of accidents that were categorized for each mission variable over the 1976-1979 time frame. Naturally, the larger the number of accidents for a particular variable, the smaller the acceptable range for the confidence interval and the better the test. The estimate of the 1976-1979 proportion (P) for each mission variable was calculated as:

$$P = a \pm 1.96 \sqrt{\frac{a * (1-a)}{n}}$$

where $a = \frac{\text{number of accidents 1976-1979}}{\text{number of accidents 1964-1979}}$

If the confidence interval (P) contains the proportional increase of total accidents from 1976 through 1979, then we are 95 percent sure that the increase in accidents for the mission variable is consistent with the proportion of those type of accidents that occurred over the earlier periods. Those variables that failed the confidence level test became the subject for further investigation and discussion. The summaries below provide a brief overview of the updated tables.

Phase of Flight: From 1964 to 1979, NTSB accident data files reveal that 1396 pilot error accidents occurred for SPIFR operations covering all phases of flight and all flight plans. Figure 1 depicts the breakdown of these accidents by phase. The majority of accidents take place in the landing phase of flight. The largest proportion of fatal accidents as a proportion of total accidents are found in the enroute phase of flight. No fatal accidents took place in the static phase. Of the 1396 total accidents, 538 (39 percent) have taken place since 1975. The distribution of this increase over the various phases of flight is depicted graphically in Figure 1 and in the following table.

Table 1. Percentage Increase in Total Accidents by Phase for 1976-1979

| Phase | % of Total Accidents 1976-1979 | % of Fatal Accidents 1976-1979 |
|---|---|---|
| Taxi | 41 | 100 |
| Takeoff | 37 | 49 |
| Enroute | 40 | 39 |
| Landing | 38 | 40 |

Notice that each phase has had a proportionate increase in its share of accidents over the last 4 years under consideration. Fatal accident increases were in line for enroute and landing phase operations, while the increase in takeoff fatalities for 1976-1979 was somewhat larger than expected. The large percentage increase in fatal accidents for the taxi phase is relatively insignificant since only one fatal accident was reported for the entire 1964-1974 period.

The number of accidents by phase of flight and the number of general aviation IFR approaches is presented on a yearly basis in Figure 2. A linear regression is fitted to each set of data points in an effort to determine any basic trends. The slope for each line is presented in Table 2 both for the entire 16 year period and for the first 12 years so that the influence of the last 4 years may be isolated.

Table 2. Slopes of Linear Regression for Figure 2

| Phase | 1964-1975 | 1964-1979 |
|---|---|---|
| Taxi | .0455 | .1088 |
| Takeoff | .5559 | .6265 |
| Enroute | 1.937 | 2.794 |
| Landing | 3.5559 | 3.7927 |
| IFR Approaches | 71768 | 72332 |

The slopes in all cases are positive indicating increasing numbers of accidents or approaches over each time frame. Accidents occurring from 1976-1979, increase the slope of the regression lines for all cases. This shows that the number of accidents and approaches in the last 4 years increased at a rate higher than established from 1964-1975. The landing phase of flight possessed the highest slope showing that the rate of increase of accidents per year is highest for this phase. Rates of increase for the taxi and takeoff phase are very low. A test of the null hypothesis that the slopes of the taxi and takeoff phases are equal to zero against the alternative hypothesis that the slopes are not equal to zero for the 1964-1979 period was performed in an effort to determine with the given data that the regression lines have some rate of change other than zero. At a 95 percent confidence level, the null hypothesis could not be rejected. This indicates that with the data given, the low slopes of these two lines are not significantly different from zero. (i.e. There has been no change.)

Figure 3 is a yearly presentation of total single and dual pilot IFR accident rates, by phase of flight. The rate is expressed as accidents per 100,000 general aviation IFR approaches. All linear regression lines fitted to the data have a downward slope indicating fewer accidents for any given number of approaches. In Figure 2, the number of total approaches and accidents for each phase of flight was shown basically to be increasing. Figure 3 indicates the rate of increase of approaches has exceeded the increase in accidents for each year. This translates into a lower accident rate when approaches are used as an indicator of exposure level. Table 3 summarizes the slopes of the regression lines in Figure 3.

Table 3. Slopes of Linear Regression for Figure 3

| Phase | 1964-1975 | 1964-1979 |
|---|---|---|
| Taxi | -.0549 | -.0299 |
| Takeoff | -.0047 | -.0027 |
| Enroute | -.4457 | -.2698 |
| Landing | -.2404 | -.1904 |

The absolute value of the slopes for 1964-1975 are greater than for 1964-1979 for all phases. This indicates that the influence of the 1976-1979 period has been one of a higher accident rate than that established in the 1964-1975 period. Enroute phase accidents had the greatest rate of decrease. As in the case of Figure 2, the slopes for the taxi and takeoff phases are extremely low. Testing the null hypothesis that the slopes are equal to zero against the alternative that they are not equal to zero reuslted in the inability to reject the null hypothesis at a 95 percent confidence level. In other words, the taxi and takeoff accident rates have not shown a positive or negative change over the 1964-1979 period, while the landing and enroute phase accident rates have decreased.

Figure 4 isolates accident data on the landing phase and breaks them down by year into groups of single and dual piloted operations and further delineates between pilot error and nonpilot error accidents. Table 4 presents the slopes of the linear regression for each set of data.

Table 4. Slope of Linear Regression for Total Landing Phase Accidents in Figure 4

| Source | 1964-1975 | 1964-1979 |
|---|---|---|
| Single Pilot, Pilot Error | 3.3776 | 3.5662 |
| Dual Pilot, Pilot Error | 1.1853 | .90588 |
| Single Pilot, Non-Pilot Error | -.0315 | -.0632 |
| Dual Pilot, Non-Pilot Error | -.0490 | .0456 |

Two aspects of this table should be noted. First, the non-pilot error accident slopes are essentially equal to zero. The hypothesis that the slopes are equal to zero could not be rejected at the 95 percent confidence level. This shows that total non-pilot error related accidents have remained at a relatively constant total number over the 16 year period. Secondly, the total number of single piloted, pilot error related accidents increased at a greater rate than the dual piloted. From an overall standpoint, 90 percent of the single piloted accidents had pilot error as a listed cause/factor, while 83 percent of the dual piloted accidents had pilot error listed as a cause/factor. Of the total number of accidents, 25 percent were dual piloted.

Figure 5 presents an alternative view of Figure 4 by relating exposure levels to the total number of accidents. The general aviation IFR approaches are broken down into estimates of single operations and dual piloted operations for each of the 16 years as was done for the four previous figures. Total accident figures for each category are related to the appropriate approach figures for single or dual operations, to determine an accident rate per 100,000 approaches. The graph of these rates is presented in Figure 5. Slopes for each line are presented in Table 5.

Table 5. Slopes of Linear Regressions for Figure 5

| Type | 1964-1975 | 1964-1979 |
|---|---|---|
| Single Pilot, Pilot Error | .0099 | .0104 |
| Dual Pilot, Pilot Error | .0457 | -.0274 |
| Single Pilot, Non-Pilot Error | .1017 | -.0740 |
| Dual Pilot, Non-Pilot Error | -.0942 | -.0637 |

All lines involved have fairly small slopes. The hypothesis that the slopes were equal to zero could not be rejected for single and dual pilot, pilot error caused accidents. This implies that the two categories of accidents have had a constant accident rate over the past 16 years. The single and dual pilot, non-pilot error related accidents have a small negative slope and are statistically different from zero at a 95 percent confidence level. The impact of the 1976-1979 data is not consistent in how it affects the trends represented by the slopes of the first 12 years. It raised the single pilot, pilot error and dual pilot, non-pilot error slopes and lowered the other two trend lines.

Accidents in Terms of Mission Variables: Table 6 presents the distribution of SPIFR accidents in terms of obstruction to vision and mission variables at the crash site. As was evident in the previous report, fog continues to be the primary cause of poor visibility being present in 398 (72 percent) of the 554 accidents. Not surprisingly then, precipitation continued the previous trend being present with the fog again in just over half the cases (54 percent) which was the same percentage of occurrences of precipitation in all accidents. When tested to determine whether or not each of the categories have grown proportionately to the overall population, two mission variable proportions for accidents in 1976-1979 fell outside of the acceptable confidence interval. The number of accidents occurring in hilly terrain along with those in areas dense with trees both experienced a relative decrease, failing outside the low end of the confidence interval.

Table 7 provides the tabulation of SPIFR accidents in terms of what impact the condition of light has on selected mission variables. The proportion of accidents occurring at night has remained virtually unchanged since the previous study dropping from 53.7 to 53.1 percent. The proportion of accidents occurring during the day, dawn, and dusk periods also remained virtually unchanged. Specific accident rates for day and night accidents with comparisons between SPIFR and DPIFR (dual piloted IFR) operations is provided later in this report.

The breakdown of mission variables in Table 7 is the same as that in Table 6 with the exception of the obstruction to vision variables (fog and none) being added to the table. The results of tests for trends naturally would be the same for those variables previously tested. The new obstructions to vision category figures would not really require formal testing since at proportions of .40 and .39, we simply confirm our previous conclusion that the impact of fog remains unchanged.

Table 8 provides the data for SPIFR accidents in terms of how the various mission variables impact upon the phase of landing. Table 9 provides a breakdown of the proportional increases of the number of accidents in each phase of flight, and although some of the numbers reflect a 10 to 15 percent change, the changes for all phases of flight were found to be statistically insignificant at a 95 percent confidence interval with the exception of the accidents which occurred during initial approach and VFR go-around. The four accident briefs involved in the VFR go-around were reviewed, but there was no common denominator in those accidents which involved fuel starvation, an icing caused stall, and 2 delayed go-arounds. The initial approach phase trend change is addressed in the discussion on types of approaches below. The increases in accidents by mission variable were again the same as discussed for Table 6. In fact, all of the observations discussed in the 1964-1975 NASA study remain valid. Final approach is still by far the most frequent phase during which accidents take place. The final approach and missed approach phase accidents are still strongly related to low visibility. Almost 30 percent of the final approach and 39 percent of the missed approach accidents had visibility of one-half mile or less at the accident site. Fog was present in 72 percent of the accidents.

Of particular interest is how the condition of light relates to the phase of landing accident. The ratio of night/day accidents for each phase of landing is presented in Table 9 for the years 1964-1975 and 1964-1979 to provide an indication of how the 1976-1979 accidents influenced the total. Comparing the ratios in these two rows shows that the differences are relatively large for the missed approach, roll, final VFR approach, and VFR go-around. For the missed approach, final VFR phase of landing and VFR go-around, a shift toward more night occurrences has taken place since the ratios increased. In the case of the roll phase, a shift toward more accidents taking place during the day has occurred since the ratio is smaller.

The magnitudes of the ratios in Table 9 provide a measure of the relative difficulties that pilots face in the various phases of flight in conditions of darkness. The accidents on final approach occur three times more often at night than in day light and obviously provide an area for further analysis. The vast majority of these are classified as controlled or uncontrolled collisions with the ground and are analyzed in-depth later in this report. Interestingly, most of the remaining ratios fall under 1.0 which reflect more day time accidents than night. Although the latter is true in absolute terms, the relative occurrence of night accidents actually ranged from 8 to more than 20 times higher than day accidents over the 16 years considered based upon actual day to night IFR activity. Thus, one would have to adjust each of the ratios by the appropriate magnitude to determine the true picture of the relative difficulties by phase of operation. For our purposes in this section, the ratios remain unadjusted, still providing us with a good relative picture.

Table 10 provides the tabulation of the SPIFR accidents in terms of the type of approach flown as it relates to selected mission variables. The only mission variable not previously discussed which failed to relfect a proportional increase in accidents was the initial phase of an approach. It reflected a statistically significant lower proportion of accidents for the later time period than for the 1964-1975 period. The specific reason for the relative decrease can be related to a combination of changes in other areas that may not be statistically significant by themselves, but combine to reflect a favorable rate change in the initial phase. First, referring back to Table 8, we find the number of initial phase accidents in mountainous terrain was lower than expected, reflecting a mountainous to level ratio of 1 to 1 (12 accidents in mountainous terrain and 12 in level terrain) where that ratio was 5 to 4 based on the earlier data. Secondly, there was a 4 percent increase in the number of accidents during precision approaches over non-precision approaches flown which most likely reflects a continuing shift away from non-precision in favor of precision approaches. The demands on the pilot in the initial approach phase are significantly reduced in the precision approaches. Since the actual number of each type of approach flown could not be found for either time period, speculation of the trend of increased precision approaches is based upon the comparison of the proportion of accidents that occurred by approach type. Of interest in that arena were the following specific changes:

1. A 4 percent decrease in accidents during VOR-only approaches which was offset by a 3 percent increase in VOR with DME.

2. A 4 percent decrease in localizer-only approach accidents matched by a 4 percent increase in ILS (without advisory) approach accidents.

3. A 1 percent decrease in ASR-only accidents which was matched by a 1 percent increase in ILS (with advisory) approach accidents.

Accidents in Terms of Pilot Experience: A pilot's experience may be measured in a number of categories which represent proficiency levels. Consequently, when expressing accident rates in terms of pilot experience, there are a number of relationships and methodologies that can be used. Tables 11,12,13, and 14 address SPIFR accidents in terms of total pilot hours, actual instrument time, time in the last 90 days, and time in type of aircraft. Although the tables are presented to provide indications of changes in experience to accident relationships published in the earlier SPIFR accident study (reference A), the authors have chosen a slightly different measure of accident rates than the Reference A which used accidents per 100,000 pilots for each experience level.

Accidents of the type addressed in this study must, by the constraints established, have pilot error as a cause/factor. If one is trying to relate pilot experience to accidents, there is a certain amount of merit in using the direct relationship of accidents to the number of pilots at any given experience level. However, let us consider the following scenario:

Out of a group of 5 pilots, each with 100 hours of flight time, one pilot has an accident. Over the same period, 1 of a group of 3 pilots each with 5000 hours has an accident. Measured in terms of accidents per pilot, the 100 hour group has an accident rate of .2 while the more experienced group has an accident rate of .33. However, if we consider that the total exposure of the lesser experienced pilots is 500 hours as opposed to the other group's 15,000 hours, we might want to reassess our measure. We could say that in terms of accidents per hours of exposure or experience, the lesser experienced group has an accident rate of 2.0 accidents per 1000 flight hours while the more experienced group has a rate of .07 accidents per 1000 flight hours.

Which of the above accident rates provide the "best" measure of the impact of pilot proficiency on accident rates? There are a number of other factors which undoubtedly should be considered. Particularly germane is whether or not the accident that the experienced pilot has is his first? That is, if he also had an accident in his first 100 hours, our measure of accidents per hour of exposure loses some accuracy. In short, the authors have concluded that there is no ideal measure of accident rate that can be computed with the data that is currently available on the GA pilot. Tables 11, 12, and 13 present accident rates in terms of hours of exposure. The main factor in deciding to use this measure was that there are very few differences in the actual proportions of accidents that occur at different experience levels. Thus, rather than duplicating the results of the previous report, we have chosen to present the data in a new light which in essence reflects a decreasing rate with experience. We do not proclaim this measure to be the most accurate but we do find it more intuitively appealing than measuring rates in terms of accidents per group. In other words, there is little doubt in the author's mind which aircraft he would board as a passenger in night IFR conditions if one were piloted by a pilot with 3000 hours and the other by a neophyte. However, for analysis purposes, it is important to keep in mind that when using total hours as the basis for rate determination, hours of exposure include all pilots as opposed to only SPIFR pilots.

In order to arrive at a number of accidents per 10,000 flight hours, estimates for the total number of GA pilots were obtained from the <u>FAA Statistical Handbook of Aviation 1980</u> (reference B). The proportion of pilots that currently exist at each experience level was extracted from the data contained in the <u>Study to Determine the IFR Operational Profile of the General Aviation Single Pilot</u> (reference C). The total hours of exposure for each bin is the product of the number of pilots and the mean of the experience level covered. The number of hours used for the mean of the highest experience levels which are open ended (e.g. >300 or >15,000, etc.), were the means of the responses of the NASA GA pilot survey (reference C) which were in the specified range.

The important point in the interpretation of the rates presented is that we are interested in trends and indications of trouble spots. Thus, the relationship of the rates is the critical part of the tables, and that should not be greatly affected by the implicit assumptions that we have made but know to be inaccurate. The assumptions do not reflect actual conditions in that the distribution of pilots and experience levels was not constant over the entire 16 year period, and that all GA pilots do not necessarily fly single pilot IFR. Additionally, as mentioned on the previous page, total pilot time is not necessarily proportional to instrument time. Thus the reader is asked to use the accident rates more for their relative than actual values.

Table 11 presents data on the SPIFR pilot factor landing phase accident rates in terms of the pilot's total time. Running 95 percent confidence level tests on the proportion of accidents in each bin that occurred during the 1976-1979 time frame resulted in acceptable ranges. That is, each included the overall proportional increase of 39 percent. Thus, it cannot be shown that there has been any change in the proportion of accidents experienced by any one group.

If one compares the trends displayed by the accident rates in the bottom row of Table 11 with Table XI in the earlier report, they will find that the tables present different pictures of the impact of experience levels on accident rates. (See above discussion on rates in this sub-section.) In terms of accidents per 10,000 hours, the accident rate continually declines as experience is gained in total flight time. Over the first 1000 hours, the rate tends to decrease geometrically, then from 1000 to 5000 hours there is a linear decrease of .004 per thousand hours of experience. From 5000 hours on, the rate appears to decrease linearly at approximately .001 per 5000 hours. One can only speculate that as in any field, experience will never completely eliminate human error (i.e. Murphy's Law is applicable to aviation just as it is to any other endeavor).

As noted on Table 11, the number of pilots in the GA population was adjusted for the number of pilots in the Ohio State survey who did not respond to the query on total flight hours. Similarly, adjustments were made and so noted on the tables discussed below.

Table 12 presents the data on the SPIFR accidents in terms of the pilot's total actual instrument hours. As was true with the amount of total flight experience a pilot has, it appears that the accident rate is extremely high for the neophyte instrument pilot (with less than 30 hours actual experience). Then, except for an aberration in the 30 to 59 hour bin, the accident rate per 10,000 hours decreases as a pilot becomes more experienced and consequently more proficient at instrument flight.

The overall proportion of SPIFR accidents which occurred in the 1976-1979 time period and reported the pilots actual instrument time was .37. The 95 percent confidence intervals computed for each bin for the estimated proportion of accidents occurring in that time frame all included .37. Thus, we are once again forced to conclude that there were no trend changes tied to pilot instrument proficiency.

Table 13 presents the data on SPIFR accidents in terms of the pilot's time in the last 90 days. Since there was no source available to directly provide the number of pilots for each bin in terms of the last 90 days' flight hours, the numbers were derived from the tables in the Ohio State survey that provided total time for the past 12 months. Those hours were assumed to be distributed normally so were divided by four. Once again, although total hours are not necessarily proportional to instrument hours, if the absolute accuracy is affected, the trend information should still be valid.

In terms of accidents per 10,000 hours, the same trend of the rate decreasing with additional experience is again evident. However, as one might expect, there is a slight reversal of the decreasing rate when a pilot has flown over 300 hours in the past 90 days. Amassing flight time at that rate would equate to flying 100 hours per month or at least 3.3 hours per day, 7 days a week. Such a sustained level of operations would be extremely taxing regardless of how the hours were actually distributed. Sooner or later fatigue is bound to have some impact upon the pilot's judgment and/or decision making process. The role fatigue plays in aviation has long been respected by the airlines as is evidenced by the rules and regulations in effect concerning maximum amounts of time crew members may log over given time intervals.

The 95 percent confidence interval tests for the proportional changes in accidents from Reference A failed to identify any changes for the accidents that reported time in the last 90 days, nor were any new trends identified for accidents in terms of time in type. The data for the latter is presented in Table 14. No attempt was made to identify or associate an accident rate with time in type since there is no known source for finding how much time the average pilot has in any specific aircraft type. One would expect the number of accidents to decrease to some extent with experience. Thus, the behavior described in the previous NASA report continues to be true as is the apparent requirement suggested by that report that pilots adjust their weather minimums to offset lack of total and/or recent experience in type. Justification of the need for this adjustment is reinforced later in the report when time in type is related to uncontrolled collisions.

Summary on Trends. The overall conclusion of the authors after compiling and analyzing the data to update the charts from the Reference A, is that SPIFR accident frequency, totals, causes, and trends have undergone little overall change since the previous study. Thus, the conclusions, conjecture, and recommendations of the original work remain as valid today as they did when written. With this in mind, conjecture on small nuances has been held to a minimum so that maximum effort could be devoted to more detailed analysis of factors associated with controlled and uncontrolled collisions with the ground/water.

## PILOT PROFILES

In an effort to determine if those pilots involved in SPIFR accidents differ from the entire general aviation population, a comparison of pilot instrument and total times between the two groups was performed. Characteristics of the typical general aviation pilot were obtained from reference C, "Study to Determine the IFR Operational Profile of the General Aviation Single Pilot". Data available from that survey and the SPIFR accidents enabled a comparison to be made of four areas which relate pilot experience and capabilities. The areas compared are total simulated instrument time, total actual instrument time, pilot time in the last 90 days, and total pilot time. For each of these areas, statistics are presented which compare the distribution of pilot experience in each category for the two populations.

Actual Instrument Time: Total actual intrument time for the pilot-in-command was reported for 371 of the 554 SPIFR accidents, while 1469 respondents in NASA GA survey reported a total actual instrument time of one hour or more. Statistics from an aggregated level are presented in Table 15.

Table 15. Total Actual Instrument Time Statistics

| | MEAN | STD. DEV. | MEDIAN | SET SIZE |
|---|---|---|---|---|
| GA Survey | 245.25 | 449.41 | 150 | 1469 |
| SPIFR Accidents | 320.23 | 499.84 | 150 | 371 |

Note that while the medians are equal, the means are widely divergent.

Letting $x_1$, $x_2$, $s_1$, $s_2$, $N_1$, and $N_2$ equal the means, standard deviations, and responses of the GA survey and the SPIFR accident data sets, a test was performed to determine if the difference between $x_1$ and $x_2$ is significant statistically or a result of randomness. Specifically, an absolute value of z greater than or equal to 1.96

where

$$Z = \frac{x_1 - x_2}{\sqrt{\frac{s_1}{N_1} + \frac{s_2}{N_2}}}$$

indicates failure to verify with a degree of certainty of 95 percent the null hypothesis that the means of the two populations are equal. In this case, Z=2.63 which results in the rejection of the null hypothesis.

The unequal distribution of times between the groups is more clearly depicted in Table 16. The percentage of pilots with actual instrument times less than 60 hours is consistently lower for the SPIFR accident data set. For more than 60 hours of time, the percentage of pilots for the SPIFR accident data set is equal to or greater than the general aviation population set. This results in the SPIFR accident group on average having a larger percentage of total actual instrument time.

Simulated Instrument Time: Simulated instrument time was reported for 294 or 53 percent of the SPIFR accident data set, while 1439 responses of greater than zero were reported in GA survey. The aggregated statistics are presented in Table 17 below.

Table 17. Total Simulated Instrument Time

| | MEAN | STD. DEV. | MEDIAN | SET SIZE |
|---|---|---|---|---|
| GA Survey | 166.04 | 280.28 | 75 | 1439 |
| SPIFR Accidents | 95.66 | 164.80 | 61 | 294 |

In this case, both the mean and median of the SPIFR accidents are lower than the same estimates of the general aviation population characteristics. Again let $x_1$ , $x_2$ , $s_1$ , $s_2$ , $N_1$ , and $N_2$ represent the means, standard deviations, and sample sizes for the NASA GA survey and the SPIFR accident data sets. Testing the null hypothesis that the two sample sizes are equal against the alternative that they are not, the value of Z as previously defined is equal to 5.80. this exceeds the critical value of 1.96 and the null hypothesis must be rejected at a confidence level of 95 percent.

Table 18 presents the actual distribution of respondents. Note that for less than 100 hours, the percentage of respondents for the SPIFR accident data set is consistently larger than the corresponding set for the GA survey. For more than 100 hours the reverse is true. Consequently, this results in the typical SPIFR accident characteristically having a smaller amount of total simulated instrument time associated with the pilot than for the general aviation population.

Pilot Time Last 90 Days: Pilot time over the last 90 days was reported for 447 or 81 percent of the SPIFR accidents. Pilot time for the general aviation population was estimated by taking one-fourth of the pilot total time in the last twelve months from the GA survey. The basic attributes of the two sets of data are delineated in Table 19.

Table 19. Pilot Time Last 90 Days

| | MEAN | STD. DEV. | MEDIAN | SET SIZE |
|---|---|---|---|---|
| GA Survey | 97.92 | 119.2 | 56.7 | 1551 |
| SPIFR Accidents | 98.47 | 85.9 | 71 | 447 |

The mean and median of the SPIFR accidents are greater than those of the GA Survey, although the relative magnitudes are not as great as those found in the previous two comparisons. Testing the null hypothesis that the difference between the two means is equal to zero against the alternative that their difference is not equal to zero, the Z value (as previously defined) is equal to .108558 which is less than the critical value of 1.96. This indicates that the difference between the two means is not statistically significant.

Table 20 presents a breakdown of the responses. At less than sixty hours, the SPIFR accident set percentage of responses was less than or equal to the GA Survey responses. At more than sixty hours the opposite is true. This indicates that the pilot involved in the SPIFR accident had more time in the last 90 days relative to those indicated by the GA Survey. The problem is that the percentage differences between the two groups within each time range is not large, and this lowers the level of confidence which may be made concerning significant deviations or trends between the distribution of respondents.

Total Pilot Time: The final category examined concerned the total time of the pilot for each of the two groups. For the SPI FR accident group, 549 or 99 percent of the accidents had a total time reported for the pilot. The GA Survey had 1578 respondents of total time greater than zero. Table 21 shows the aggregate statistics for the two groups under consideration.

Table 21. Total Pilot Time

| | MEAN | STD. DEV. | MEDIAN | SET SIZE |
|---|---|---|---|---|
| GA Survey | 3814.35 | 4961.08 | 2050 | 1578 |
| SPIFR Accidents | 3867.74 | 4456.86 | 2394 | 549 |

While the SPIFR accident mean and median are larger than the general aviation estimate, the degree of difference is not large. Testing the null hypothesis that the difference between the two means is equal to zero could not be rejected. An absolute value of Z greater than 1.96 was needed to reject the null hypothesis, and when Z was computed as previously defined, its value was .00103. Table 22 further emphasizes the similarity between the two groups. Note that the percentage of respondents for the two groups in each of the time bins showed no consistent trend between the bins. As a result, it is difficult to argue that the total time response distribution differs significantly between the two groups.

Summary: Based upon the results of this section, the indications are that the SPIFR pilot involved in one more more accidents (i.e. from the NTSB data) has comparable amounts of total flight hours and is as current in flight time over the previous 90 days as is the typical GA pilot. However, there appears to be statistically significant differences in the amount of instrument experience each of the two groups have. One logically would expect the differences between the groups to both be off in the same direction for simulated and actual instrument hours, but such is not the case. The actual instrument experience of the typical NTSB SPIFR pilot is greater than that of the general population GA pilot while the latter's simulated instrument experience is higher than the NTSB representative.

The authors are unable to explain the apparent dichotomy in the two categories of instrument hours. However, the subject is addressed in more detail later in this report in the discussion of pilot experience in day and night controlled collisions.

## ACCIDENT TYPES AND RELATIONSHIP TO AIRCRAFT TYPE, NUMBER OF PILOTS, AND TYPE OF TERRAIN

Type Aircraft Versus Accident Type: In an effort to determine if any one particular type of aircraft was particularly susceptible to a category of accident in SPIFR operations, Table 23 was compiled. Each accident type and its respective number of occurrences is broken down by aircraft type. Four aircraft types were used and are presented with their respective percentages of total accidents below:

Table 24. Aircraft Type and Percentage of Total SPIFR Accidents

| Aircraft Type | % of Total Accidents |
|---|---|
| Single engine fixed gear | 16 |
| Single engine retractable gear | 22 |
| Multi-engine piston | 57 |
| Turbo-prop | 5 |

Reference A presented a discussion on the fact that from 1964 to 1975, there were a disproportionately large number of twin engine aircraft SPIFR accidents relative to the percentage of twins involved in SPIFR operations. The conclusion in that report was that approximately 58 percent of SPIFR accidents occurred in twins although that class of aircraft was only involved in 45 percent of the SPIFR operations. If we logically include turbo-prop in the twin engine class and use the entire 16 years of NTSB data, we see that 62 percent of pilot caused SPIFR accidents have occurred in twins. However, not only has the percentage gone up 4 points, but according to the recent NASA GA survey, currently only 29.5 percent of the GA pilots fly in twin engine aircraft as an IFR single pilot. According to the FAA Statistical Handbook on Aviation for Calendar Year 1980 (reference B), there were 30.3 million single engine GA hours flown in 1979 as opposed to 8.6 million twin engine hours. Although those figures cover all GA operations, the proportion of twin time is 0.22 which certainly lends credence to the results of the NASA GA survey. Some of the problems of single versus twin engine accident rates and relevant factors are addressed in-depth in the discussion of collisions with the ground/water later in this report.

Using the data in Table 23, tests were performed to determine for each accident type whether or not the differences in the proportions of aircraft types involved in each category of accident are significant or whether they can be attributed to chance. A chi-square test of the null hypothesis that the proportions of aircraft types involved in a particular type of accident are statistically equal was performed. Four accident types failed the test at a significance level of 95 percent, indicating that the proportion of accidents by aircraft types are not statistically equal. The four categories that failed are gear collapsed, nose over/down, uncontrolled collisions and overshoot. The percentage of occurrence for each aircraft type of these accidents is presented below.

Table 25. Percentage of Total Accidents for Aircraft and Accident Types Failing Chi-Square Test

| | GEAR COLLAPSED | NOSE OVER/DOWN | UNCONTROLLED COLLISION | OVER-SHOOT |
|---|---|---|---|---|
| % of Single Engine Fixed Gear | 1.15 | 3.45 | 11.49 | 10.34 |
| % of Single Engine Retractable Gear | 0 | 0 | 10.57 | .81 |
| % of Multi-Engine Piston | 1.25 | 0 | 5.35 | 6.60 |
| % of Turbo-Prop | 7.70 | 0 | 0 | 0 |

For the gear collapsed accident type, the number of turbo-prop accidents is disproportionately high. Single engine fixed gear aircraft in the nose over/down type of accident have a larger proportion than expected. For the overshoot type of accident, single engine retractable gear and turbo-props have low proportions and single engine fixed gear and multi-engine piston have higher proportions. Finally, for uncontrolled collisions, single engine aircraft are more susceptible than multi-engine aircraft. Speculation on the reason for the anomalies in this data would all center around the proficiency of the pilots involved with the exception of the landing gear failures and nose-overs/downs. The section of this report on Collisions with the Ground/Water addresses proficiency. The landing gear failures in turbo-props reflects only two occurrences and the nose-overs are possibly related to single engine aircraft by the sheer number that have conventional as opposed to tricycle landing gear.

Single versus Dual Piloted Accident Types: In an effort to determine whether or not the number of pilots in an aircraft influences the type of accident, Table 26 was compiled. A chi-square test was performed to see if the differences between the two proportions for each accident type is statistically significant at a 95 percent confidence level or is due to chance. The right hand columns of Table 26 present the differences in the percentages between the two types of configurations. At the 95 percent confidence level, the chi-squared tests revealed that none of the proportions are statistically significant. Thus, we are forced to assume that aircraft accident categories are independent of whether the aircraft involved is single or dual piloted. This was further verified in the investigation of uncontrolled collisions with the ground and is addressed later in this report.

Type of Terrain Versus Accident Type: Of the 554 SPIFR accidents considered, 313 (or 56 percent) reported the type of terrain in which the accident occurred. As can be seen from Table 27 below, only 27 (or 9 percent) of the 313 accidents occurred in mountainous terrain.

Table 27. Total Mountainous and Non-Mountainous Accidents VS Accident Types

| | Controlled Collision | Uncontrolled Collision | Engine Failure/ Malfunction | Other |
|---|---|---|---|---|
| Mountainous | 24 | 1 | 1 | 1 |
| Non-Mountainous | 164 | 36 | 39 | 47 |

Unfortunately, a source could not be located which would allow a determination to be made on the amount of IFR activity that occurs in mountainous terrain. That fact coupled with the magnitude of the figures in row one of Table 27 made it impossible to conduct any statistical analysis of the relationship of terrain to accident types. As shown by the data in Table 27, the number of controlled collisions in proportion to the total number of accidents in mountainous terrain is obviously significant. (i.e. In mountainous terrain, 89 percent of the SPIFR pilot error accidents were controlled collisions as opposed to 57 percent for that proportion in nonmountainous terrain.)

## DAY VS NIGHT GENERAL AVIATION OPERATIONS

Introduction. A pilot who has sat at the controls of an aircraft while cruising over sparsely populated countryside on a moonless night knows that it is not the same as being in the same situation on a bright sunny day. The feeling can be compounded by real or sometimes imagined "night noises" from the power plant or by the briefest flicker of a warning light on the instrument console. However, many of the differences in a pilot's psychological outlook between day and night VFR are easily explainable in terms of security. The potential of a controlled ditching in the daytime does not have quite the trauma of a night ditching, nor does a well defined day horizon pose the additional workload that a pilot encounters on a hazy moonless night. There are other differences between day and night VFR, and most are just as easily explained as the foregoing. However, when one addresses the differences between day and night IFR operations, they are not as easily explainable. When a pilot is in actual instrument conditions in clouds whose bases are two or three hundred feet above the ground, his visual cues as well as options in emergency conditions are theoretically not a great deal different whether it is day or night. There is no horizon and he is at the mercy of fate in an emergency ditching regardless of whether it is daylight or dark. Psychologically, there are differences between day and night IFR, but based strictly on the simplistic physical aspects, one logically would expect comparable day and night accident statistics in the low ceiling/visibility environment.

The initial comparison between day and night accidents revealed a rather startling disparity between their absolute accident rates. Analysis efforts were directed towards determining what factors are predominant in specific types of night accidents and/or which factors produce such relatively high night accident rates. The discussion that follows is divided into three major sections. The first addresses how objective rates were calculated, and compares them between day, night, single, and dual piloted operations. The next two sections present the results of the data reduction and analysis concerning controlled and uncontrolled collisions with the ground.

Day Versus Night Rates: A previous section discussed the fact that the absolute number of night SPIFR accidents involving pilot error has increased over the past four years at essentially the same rate as that of day and total accidents. The significance of the numbers involved does not become very meaningful however, until they are converted to rates in the context of overall day and night activity. Unfortunately, there are not a large number of sources available which describe how many successful IFR flights or hours are flown in the day and/or night. Although the FAA maintains data on gross numbers of instrument approaches flown, the time of day and condition of light are not recorded.

However, during a literature review at the FAA's Technical Library in Washington, D.C., a report was found which provides a breakdown of hourly general aviation activity. This report, "General Aviation Pilot and Aircraft Activity Survey" (GAPAAS) by Susan J. Pinciaro (reference D) was produced by the FAA Office of Management Systems Information and Statistics Division. GAPAAS presents the results of a survey which was conducted by the FAA with the assistance of the Civil Air Patrol (CAP) for the purpose of acquiring current 1978 data on a wide range of general aviation characteristics. The survey was conducted at a statistically designed sample of 220 airports which are open to the public, and which represent a cross-section of airports with respect to FAA region and airport type. Although GAPAAS addressed many other general aviation topics, the results of the traffic activity efforts were specifically extracted and used by the authors of this report as a basis for estimating general aviation IFR activity in terms of approaches flown. The following paragraph provides a brief summary of the method used to convert the activity data from the FAA work to data germane to this project.

The GAPAAS activity tables are divided into three categories based on airport type. These are towered airports, non-towered airports with paved lighted runways, and unlighted and private airports. The GAPAAS estimates for the percentage of overall general aviation activity at the three airport types are:

| TOWERED | NON-TOWERED | OTHER |
|---|---|---|
| 29.61% | 50.81% | 19.58% |

Although there may be a small amount of activity at non-lighted airports during darkness using flare pots and/or aircraft landing lights, the authors assumed that nighttime activity only occurs at airports of the first two categories.

GAPAAS provides hourly estimates of activity during the time frame 0600-2059 for all public airports. The activity during the hours of 2100 to 0559 was given as 7 percent of the total activity during the period 0600-2059 for towered airports and 3 percent for airports in the non-towered paved lighted runway category. A determination of the hours constituting day and night operations was based upon the average sunset time over a calendar year (taking into account daylight savings time) as being 1850 which was rounded to 1900 hours. Daylight operations were then defined as those occurring between the hours of 0600 and 1859, and nighttime operations, those that occur between the hours of 1900 and 0559.

GAPAAS provides hourly estimates for the typical weekday and weekend. These were combined by a weighted average reflecting five weekdays and two weekend days in the week. From this, a breakdown by percentage of day versus night activity was obtained for each airport type and is presented in the following table.

Table 28. Percentage of Total General Aviation Activity

| Towered | | Non-Towered | | Other |
|---|---|---|---|---|
| Day | Night | Day | Night | |
| 24.39 | 5.22 | 43.53 | 7.28 | 19.58 |

These total estimates include air taxi and commuter air carrier. The following table breaks out flying in three broad categories in terms of purpose.

Table 29. Percentage of General Aviation, Air Taxi, and Commuter Air Carrier Activity from GAPAAS

| | Towered | Non-Towered | Other |
|---|---|---|---|
| General Aviation Day | 22.98 | 41.01 | 19.58 |
| General Aviation Night | 4.917 | 6.86 | |
| Air Taxi Day | 1.0 | 1.784 | |
| Air Taxi Night | .214 | .214 | |
| Commuter Air Carrier Day | .415 | .74 | |
| Commuter Air Carrier Night | .089 | .124 | |

Since the percentage of day versus night activity was desired for general aviation and air taxi only, the commuter air carrier activity was disregarded and the resulting overall levels of activity are as follows.

Table 30. General Aviation and Air Taxi Activity Percentage by Day and Night

| | Day | Night |
|---|---|---|
| General Aviation | 87.6 | 12.4 |
| Air Taxi | 84.4 | 15.6 |

These figures were applied to total instrument approaches flown (reference B) to estimate day versus night figures for the two categories. Prior to 1972, air taxi figures were included in those for general aviation. Where applicable, general aviation data over the 1964-1971 time frame were adjusted to remove the air taxi influence. This was done by assuming that air taxi operations constituted the same percentage of general aviation operations over the 1964-1971 period as in the known 1972-1979 period. Thus, the end result used as the estimator for day versus night activity for this report is the assumption that 87.6 percent of general aviation approaches are flown during the day.

Based upon an activity ratio of 87.6 to 12.4, tables were compiled to provide direct comparisons between day and night accident rates in terms of thousands of IFR approaches flown. Naturally, there is room for debate upon the absolute accuracy of the day/night estimator. Sampling methods used in the GAPAAS survey, assumptions that IFR operations remain proportional to combined VFR and IFR operations, and the propensity to fly in night IFR conditions alluded to in the NASA GA survey are but a few of the factors that may bias the estimator one way or the other. However, the important point is that the accident rates were analyzed on an annual basis, so that even if bias exists, it should remain constant so that trends are realistically reflected.

In order to compare single piloted to dual piloted rates, another estimator was required. In this case, the results of the NASA GA survey were used. Respondents who did most of their flying with two qualified pilots on board were considered to be dual piloted and the remainder considered to be single piloted. The percentages in each category were 72% single piloted and 28% dual piloted.

Accident rates were calculated for IFR landing phase accidents involving pilot error in terms of the number of instrument approaches flown each year as reported in the "FAA Statistical Handbook of Aviation" series. The rates are broken down into single and dual piloted operations by day and night using the ratios described in the preceding paragraphs. The basic data and accident rates are presented in Tables 31 and 32 for single and dual piloted aircraft, respectively. The magnitude of night landing accident rates when compared to daytime rates accentuates the severity of the problems involved with night IFR operations. Table 33 presents a matrix of ratios between the various types of accident rates. As can be seen by the average ratios, the disproportionate number of night accidents is not peculiar to single piloted aircraft as both dual and single piloted aircraft have experienced slightly over 10 times as many accidents at night in terms of approaches flown as have occurred during the day over the 16 years studied. There have been relatively more SPIFR accidents overall as can be seen again by the average ratios in Table 33. (i.e. The SPIFR rates have been on the average 1.26 and 1.67 times higher than DPIFR rates for day and night, respectively.)

In an effort to determine whether the problem is getting better or worse, a linear regression was used to fit each of the accident rate sets to straight lines. The plotted regression lines were purposely omitted from this report since the majority of the fits were very poor. For the full sixteen years of data, the SPIFR and DPIFR lines had negative slopes for night rates (-.025 and -.013, respectively) and practically a 0 slope (.0007 for both) when day rates were fitted. The value of R squared never exceeded .16 indicating the lack of fit between data. However, when the data were broken down into two segments which covered the periods of 1964-75 and 1976-79, there was a significant change in the picture. Although rates for the earlier time period continued to correlate poorly, the curves for both single and dual piloted night rates over the later time frame reflected a very definite increase in rates with relatively better fits. From 1976 through 1979, the curves reflected positive slopes of .026 and .041 for SPIFR and DPIFR night rates with R squared being .56 and .70, respectively. The daytime rates again reflected poor fits with R squared less than .1 in both cases and slopes of .003 in both cases. Table 34 contains the values for the slopes and R squared for all cases.

Regardless of how much credence one gives to the statistics discussed above, or to the methodology used to derive the actual accident rates, there is no doubt that night IFR operations pose some very serious problems. In an effort to "zero in" on some of the problems associated with night IFR approaches, a detailed analysis was conducted on two sub-sets of those accidents in hopes of determining what unique phenomenon is or are responsible for the night rate being over 10 times the day rate when theoretically the circumstances are the same but for the amount of ambient light. Detailed analyses were conducted on controlled collisions with the ground and/or objects on the ground and on uncontrolled collisions with the ground/water. The analyses and results are discussed in the following section of this report.

The NASA GA survey hypothesized that operational problems experienced by the SPIFR pilot are independent of experience level. Prior to breaking down the data for specific accident types, an overall tabulation was made to see if total flight experience is related to night landing phase SPIFR pilot error accidents any differently than to day and/or all SPIFR pilot error landing phase accidents. Table 35 presents the tabulated results of that effort. Although the problems encountered by all pilots may be similar, indications are that the less experienced pilot has slightly more difficulty handling the night environment.

As can be seen from Table 35, pilots with 1000 or more hours of total flight experience have almost exactly half of this type mishap in the day and half at night. (The fact that exposure time is less at night and absolute rates are higher does not affect the proportion of day vs night occurrences so was disregarded in this table.) Pilots with less than 1000 hours seem to have slightly more accidents at night than in the daylight. Specific proportions are 51 and 56 percent, respectively, for night compared to day accidents for the group with over 1000 and less than 1000 hours, respectively.

Ideally, one should consider the proportion of day to night accidents in terms of accumulated night time. However, the amount of night time a pilot has is seldom reported upon in the NTSB data base for daylight accidents. Thus, a meaningful proportion of day to night accidents could not be established based on accumulated night time. However, the fact that the group of pilots with 600 to 1000 total hours had 61 percent of their accidents at night opens the door to an interesting hypothesis as explained below.

Generally speaking, a pilot with a new instrument rating is not likely to start right into challenging night IFR weather until he has built his confidence on day VFR and IFR instrument experience. Thus, one could hypothesize that the group in Table 35 with less than 400 hours is likely exposed to very few night IFR operations. If we then consider the next two groups (400-999) as representative of the low end of the experience spectrum, we find that almost 60 percent of their accidents involving pilot factor in the landing SPIFR environment occur at night. Thus, we can hypothesize that although the problems encountered remain the same, total flight experience does in fact influence a pilot's ability to cope with the additional burdens of night IFR operations.

Ideally, the findings above should be verified by comparing pilot's instrument and night time for day versus night accidents. Those figures were tabulated but had to be disregarded due to the high number of accident reports that did not include that data. Night time was seldom included in a day accident report, and total instrument time was included in 10 percent more night than day accident reports. In short, the best that can be done is the above hypothesis based upon total flight time which was reported for all accidents.

## CONTROLLED/UNCONTROLLED COLLISIONS

Introduction: Of the 554 accidents that occurred between 1964 and 1979 that involved pilot error in a landing phase SPIFR environment, 255 were classified as a controlled collision with the ground/water or some other object growing from or resting on the ground. Additionally, there were 40 uncontrolled collisions with the ground/water and 48 stall accidents. Together, these three types of accidents made up 62 percent of the mishaps in the defined subset. This group of accidents was segregated from the data base and analyzed in detail in an attempt to correlate a cause and/or pilot characteristic with the accident type, but more specifically, to try to determine factors that may be unique to night accidents. All controlled collisions with the ground/water, trees, or any other stationary object were put into a group that is henceforth referred to simply as controlled collisions. All stall type accidents were reviewed on a case by case basis, and those that involved a spin or uncontrolled flight and/or uncontrolled collision with the ground were grouped with the other uncontrolled collisions. Only 27 of the 48 stall accidents were used as the remainder fell into the stall-mush category which occurred almost exclusively in the latter stages of final approach and/or landing when airspeed became too low to sustain flight due to unfamiliarity with the aircraft, icing, inattention, etc. The assumption that most occurred after visual contact was made led the authors to exclude those from both controlled and uncontrolled collisions.

Uncontrolled Collisions: The initial subset of accidents considered for this part of the analysis was a group of 67 accidents which met the criteria used previously in this report. (i.e. SPIFR landing phase with pilot error as one of the cause factors.) However, it soon became apparent that to do the analysis justice, other data should be compared to the initial analysis results. Thus, two additional groups of accident statistics were analyzed and used for comparison. One group contained all dual pilot accidents which met the same criteria as the single piloted subset, and the second group included all SPIFR take-off and enroute accidents that listed spatial disorientation and/or icing as a cause factor and resulted in an uncontrolled collision with the ground/water. For purposes of the following discussion, the three groups will be addressed as SPIFR landing, DPIFR landing, and SPIFR enroute.

As was discussed in Ref. A, the major causes of uncontrolled collisions continues to be spatial disorientation (vertigo) and/or icing. For analysis purposes, the uncontrolled collision accidents were grouped into three subsets; vertigo, icing, and other. The latter was used when neither of the former were listed as cause factors even through one or the other was insinuated. (There were repeated occurrences of reports that simply said the pilot lost control at too low an altitude to effect a recovery.) When spatial disorientation was listed as a cause factor along with icing and/or turbulence, the accident was not included as a vertigo caused accident. This method of accountability was used in an attempt to keep the vertigo subset as a reflection of situations where there were minimal external influencing factors.

Of the 67 SPIFR landing phase accidents, 26 (38.8 percent) were attributed to vertigo, 23 (34.3 percent) to icing, and the remaining 18 (26.9 percent) to other causes. Table 36 presents the breakdown of those figures along with the same data for SPIFR enroute and DPIFR landing phase accidents.

Vertigo Caused Uncontrolled Collisions: As can be extracted from Table 36, vertigo as the primary cause factor accounts for 43.4 percent of all SPIFR uncontrolled collisions with the ground when pilot error is a factor. Enroute DPIFR data were not available but it can be seen that over half of the DPIFR uncontrolled collisions are due to vertigo. This class of accident warranted detailed analysis for two very disturbing reasons. First, the accident is generally pimarily caused by human error, so should be correctable to some extent. The second cause for concern is the sad injury statistics associated with this set of accidents. Of the 56 SPIFR accidents, there was only one accident without fatalities and that outcome appears to be the result of extreme luck or good fortune. (i.e. The pilot hit a hillside in the fog while experiencing vertigo and all 4 aircraft occupants escaped injury.) In the remaining 55 accidents, there were only 3 with survivors, with the overall statistics being 142 fatalities and 6 serious injuries. A detailed examination of factors involved revealed the following facts/statistics on vertigo caused uncontrolled collisions.

Note: DPIFR vertigo related accidents were omitted from most of the discussion in the remainder of this subsection due to the small sample size. i.e. 9 landing phase accidents over 16 years.

1. Condition of Light: As presented in Table 37, 73 percent of the SPIFR landing phase vertigo accidents occurred at night while 60 percent of the DPIFR accidents in that category occurred at night. However, during climb-out and enroute operations, only 35 percent of the vertigo accidents occurred at night.

2. Total Instrument Time Versus Condition of Light: As presented in Table 38, of the 14 SPIFR vertigo induced night accidents in the landing phase with recorded total instrument time, 10 involved pilots with less than 60 hours of actual instrument time. Only 2 of the 5 day mishaps in that category involved pilots with less than 60 hours of actual instrument time. For the

enroute accidents, 5 of the 6 reported instrument times for the night mishaps fell in the less than 60 actual instrument hour category. The day enroute SPIFR accidents were more evenly distributed but still had 5 of the 11 occurring in the less than 60 hour category.

3. Time in Type Versus Condition of Light: As shown by Table 39, 4 of the 6 night enroute mishaps reporting time in type for enroute accidents involved pilots with less than 50 hours in type. Day time landing phase mishaps tended to reflect slightly more time in type, but all 9 reported involved pilots with less than 200 hours in type. Pilots with more than 500 hours in type accounted for 5 day enroute mishaps and 5 night landing mishaps. There were no day landing mishaps nor night enroute mishaps involving the over 500 hours in type group.

4. Total Flight Time Versus Condition of Light: Table 40 presents the tabulation of total flight hours accumulated by the pilots involved in day and night mishaps. Occurrences seem to be relatively evenly distributed over the spectrum of experience levels over the first 3000 hours of flight experience.

5. Total Night Time Versus Night Mishaps: Table 41 presents the distribution of pilot night time for those mishaps which occurred at night. Once again, the lower experience ranges have more occurrences than the higher experience ranges. (12 had less than 100 hours of night time and 4 between 100 and 200 out of the 22 incidents which reported night time.)

6. Experience Profile: Table 42 presents a comparison between experience levels of the typical pilot from the GA pilot survey, the NTSB SPIFR landing phase pilot factor accident population, the SPIFR vertigo landing phase population, and the SPIFR vertigo enroute population. As would be expected from the data presented in paragraphs 1 through 5 above, the average pilot involved in vertigo induced accidents is less experienced than the overall populations. The most significant difference in pilot experience appears in the realm of total actual instrument time. Where the median for both of the larger populations is 150 hours, the median for both of the vertigo populations is slightly less than one-third as much experience in actual instrument conditions. (i.e. Just under 50 hours versus 150.) The proportions of simulated time indicate that simulated instrument experience is less important since the medians are fairly consistent except for the fact that all three populations based upon the accident data base are reflecting less time than the GA survey average simulated median. The total flight time medians indicate that the pilot involved in the vertigo accident have roughly half the number of hours that their contemporaries have in the other two populations. Finally, time in the last 90 days appears to be more independent although the vertigo medians are again lower than those in the larger populations.

Vertigo Accident Discussion and Conclusions: The statistics summarized in paragraphs 1 through 6 above and presented in Tables 37 through 42 indicate that pilot experience levels in general are definitely related to the occurrence of vertigo induced accidents. Actual instrument experience and total flight hours appear to be the most critical experience factors when compared to other populations. Indications are that night time and time in type are also important factors in vertigo induced accidents, especially those that occur at night. However, the data for the last categories were not available from the general population of general aviation for comparison.

An important point for the reader to remember is that the statistics and tables relevant to this discussion on vertigo are based on the NTSB data base and consequently are subject to some amount of inaccuracy based upon unknown and/or unreported data. An additional point is the fact that pilots of different experience levels are exposed to the elements at different rates based upon total experience and their propensity to fly under more demanding instrument conditions. The effect of experience is graphically illustrated in Table 42. All of the means in that table are significantly greater than the medians. This reflects the fact that there are more pilots in the lower experience levels than in the higher levels and that the former naturally have more accidents. But it also indicates that in terms of total hours of exposure, the inexperienced pilot has more accidents than the experienced pilot. The reader is invited to use the data to address theories that are not addressed elsewhere in this report.

In addition to tabulating and analyzing the numbers involved in this section, the accident brief for every SPIFR vertigo caused mishap was reviewed for the contents of investigator comments. Since those comments are sometimes of a speculative nature and purely subjective, tabulation was not attempted. However, there were areas that warrant comment and provide substance for future investigation. Thus, the authors offer the following comments for the reader's evaluation and consideration.

1. A large number of accidents contained a comment alluding to the fact that the pilot continued flight into conditions that exceeded his capabilities. It seems rather obvious that an accident would not have occurred if this were not the case, so on the surface the comment does not appear to add anything to an accident brief. The point to ponder is not whether or not the remark is redundant, but more importantly, how does a pilot know when he is about to exceed his capabilities? Obviously, the only way to answer such a question is after the fact. Whether or not there is a mishap is the only real measure of whether one has overstepped their capabilities. Education of the GA pilot appears to be a continuing need in the area of statistics which will more

concretely marry experience levels to accident conditions.

2. A second area where education and reinforcement could be used is on the subject of physiology connected with vertigo. There were repeated cases of vertigo being induced when the pilot was temporarily distracted from his instrument scan. Two specific cases concerned pilots having to change transponder settings. In both cases the pilot lost control of the aircraft and became fatalities of their own error. The GA pilot should be reminded on a continuing basis of the effects of sudden and/or rapid head movements when there is no visual reference to the horizon.

3. Of particular concern to this author are those accidents where the pilot reported his attitude gyro becoming unreliable. One cannot help but speculate that in many cases where a pilot reported his gyro becoming unreliable (as opposed to it failing completely) whether in fact the situation existed where the pilot was beginning to pay more heed to erroneous signals from his inner ear than to the total picture his instruments provided. Most gyros have an OFF flag that appears when the instrument loses power or is not providing reliable information. A short case history of an incident that fell short of being an accident should illustrate this point.

> A relatively new military aviator in a single engine single seat jet commenced a GCA at NAS Oceana, Virginia. The GCA was required due to a fog bank which had formed with the base at 300 feet and tops at 1500 feet. The attitude gyro in the aircraft had a history of tending to precess in long extended turns. The aircraft gear and flaps were lowered while simultaneously beginning a descent from 1500 to 1200 feet. As the aircraft entered the clouds, the gyro indicated a slow roll commencing to the left while the pilot's "inner ear" was reporting wings level or a slow roll to the right. The pilot's reaction was to assume the gyro was in the process of failing. A transition to partial panel instrument flying was unsuccessful due to the needleball and directional gyro now giving erratic indications. The aircraft broke out of the bottom of the 300 foot overcast nose low and in a steep bank. A recovery was made short of the tree tops and the aircraft reentered the cloud layer at 100 percent power and climbing. Almost immediately, the aircraft came out the top of the overcast with the rudder-shaker (stall-warning device) shuddering, indicating an impending stall. Fortunately, there was no weather above the fog bank and the aviator had time to cross check the gyro horizon with the visual horizon and to see that there was absolutely nothing wrong with the instrument. A relatively uneventful GCA was completed by a shaken, but much wiser aviator.

Since that aviator happens to be one of the authors of this report, he cannot help but wonder how many other neophyte aviators have naively written off a gyro as inoperative because they did not understand the mechanics of the instrument and/or its built-in safety features. Food for thought is how should a controller react to a pilot report that their gyro is "becoming unreliable?" Or how do we educate the new GA aviator to heed his instruments and their operational indications?

4. Other miscellaneous comments relative to vertigo related accidents not surprisingly included indications that the pilot lost control when making the transition from VFR to IFR conditions, was terminating an extended flight (12 hours in one case and 10 hours in another), and a case where the pilot was flying in night IFR conditions without having flown for six months.

5. It is the opinion of the authors that the problem is most likely more severe than accident rates indicate. The basis for this statement is that weather conditions at the scene of the reported accidents had to be IFR (less than 1000 foot ceiling and/or less than 3 miles visibility) to be included in the reported subset. One cannot help but wonder how many cases of vertigo end in a visual recovery beneath a cloud layer.

Icing Caused Uncontrolled Collisions: After vertigo as a cause factor for SPIFR accidents involving pilot error comes icing. As can be seen in Table 36, icing is a primary cause factor in about one-third of the landing phase uncontrolled collisions and about 17 percent of the enroute accidents of this type. The same set of variables as was discussed in the previous section on vertigo was examined to see if icing accidents might be related to specific levels of pilot experience. The experience levels in general are much more evenly distributed for icing related uncontrolled collision, but the sample sizes are much smaller and consequently statistical inferences become less meaningful.

Table 43 presents the experience level statistics for pilots involved in icing related uncontrolled collisions by landing and enroute phases. The statistics for the NASA GA pilot survey and overall SPIFR landing phase populations are repeated in Table 43 for comparitive purposes. The reader is cautioned to note the sample sizes before assigning too much weight to the results.

Table 44 is a summary of pilot experience levels for the SPIFR uncontrolled collisions in the landing phase which is structured for a comparison between vertigo and icing related mishaps. The impact of actual instrument and night time is difficult to compare due to the large number of unreported amounts of night time in the icing area. Time in type and total flight hours appear to have relatively equal distributions with the icing incidents in general occurring to pilots with slightly more experience in both categories.

An interesting observation in the review of data was that only 2 of the 23 icing caused accidents involved single engine fixed gear aircraft as opposed to 9 of 26 vertigo landing accidents occurring in that aircraft class. Retractable gear single engine accounted for 9 icing incidents but only 5 vertigo incidents. Twin engine incidents were roughly the same with 11 icing and 10 vertigo incidents. As would be expected, the jet engine classes accounted for only 1 incident in each category which could in part be explained by the altitudes at which they cruise, the better instrumentation in the more expensive aircraft, and fewer aircraft in the GA community. Graphically, the breakdown of aircraft types was:

| | Icing | Vertigo |
|---|---|---|
| Single Engine Fixed Gear | 2 | 9 |
| Single Engine Retractable Gear | 9 | 5 |
| Twin Engine Piston | 11 | 10 |
| Turboprop/Jet | 1 | 1 |

A review of the icing uncontrolled collision accident briefs confirmed that the vast majority of the accidents were attributed to poor judgment of the pilot. In 18 of the 23 incidents, the weather was classified as "substantially the same as briefed." In two cases, it was classified as "considerably worse than briefed" but the pilot continued to press on in both situations with no de-icing equipment.

In general, it appears that the severest of accidents caused by icing (i.e. uncontrolled collisions with the ground) are preventable mainly through pilot education and the development of low cost deicing equipment.

Controlled Collisions: As was discussed in the introduction to this section, controlled collisions with the ground, trees, or other objects on the ground account for the largest single group of accidents in the SPIFR landing phase with pilot error as a factor. This section of the report explores the circumstances peculiar to various types of accidents within this group, concentrating on the SPIFR night controlled collisions to isolate trends and/or pertinent contributory factors. The tables related to this section, 45 through 54, not only contain the data to support the discussion in this section, but also contain some amplifying data that is not directly addressed. The latter are provided so that others may conduct independent analysis of some of the relationships that the authors either judged as statistically unsupportable or that were not within the scope of the project.

Rather than presenting a broad brush analysis of all uncontrolled collisions and attempting to relate patterns between day, night, single pilot, and dual pilot operation, efforts were concentrated on determining in more detail what factors are the most germane and/or critical in night SPIFR uncontrolled collisions in the landing phase which involve pilot error. Based upon the results of the earlier NASA SPIFR report (reference A) along with the tables and discussion presented in this section of the report, it appears safe to assume that night SPIFR operations in the landing phase are the most demanding with which most general aviation pilots have to contend. Intuitively, it seems logical to assume that the problems faced in the night SPIFR instrument approach are simply an extension of the same evolution during day light. However, the fact that breaking out between layers of clouds and/or beneath an overcast at night does not provide a visual reference to lessen the pressures on the pilot demands higher levels of performance and concentration. Additional problems with vertigo inducing aircraft and/or ground lighting reflections in clouds as well as the problems associated with cockpit lighting, trying to read an approach plate, dial in frequencies on poorly lit dials, etc. all contribute to higher physical and psychological demands at night. There are other factors such as the effects of darkness on depth perception and peripheral vision. Due to these burdens and complications, it seems logical that problems which may be simply an irritant or potential accident cause in the day light should be magnified and easier to detect in an analysis of night time operations. The serious day light problems should be all the more prevalent in the more demanding night time environment.

If the above assumptions are true, we might expect to find some of the same trends and patterns in daylight mishaps as we do at night, but the experience levels of the pilots involved in similar situations should be lower in daylight. i.e. The more demanding night environment will overcome higher experience levels that would keep a pilot out of trouble in daylight. Table 45 presents a summary of the medians of various measures of pilot experience for SPIFR and DPIFR accidents that involved pilot error in the landing phase of operations. Medians were used for the comparison to try to minimize the effect of the exceptionally high experience levels that bias the means.

The results of Table 45 are by no means conclusive evidence that all of the assumptions made in the preceding two paragraphs are absolute truths. However, the indications are sufficient enough in the authors' opinions to justify a more in-depth analysis of the controlled collision at night in hopes of identifying significant problem areas.

SPIFR Night Controlled Collisions: There were 173 SPIFR landing phase night controlled collisions involving pilot error in the NTSB data base for the period 1964-1979. Although the proportion of this type of accidents that occurred since 1975 is 3 percent lower than that for the total set of SPIFR accidents considered, the distribution of those accidents does not provide cause for optimism. During the years 1976 through 1979, the numbers of SPIFR night controlled collisions were 6, 12, 21 and 23, respectively. Table 46 presents these numbers in terms of accidents per 1000 night approaches flown (from Table 31) and compares those rates to overall night SPIFR rates. Our earlier discussion on day versus night rates indicated the night accident rate was increasing, and as can be seen in Table 46, the proportions of the night accidents that are classified as controlled collisions are also increasing.

In an attempt to identify which factors are significant and/or inter-related, each night controlled collision accident brief was reviewed and a cause factor was assigned based upon a combination of the formal cause factor assigned by the accident investigator and a review of the secondary causes and investigator comments. The cause factors into which all accidents were divided are:

1. Improper IFR procedures
2. Icing related
3. Pilot distracted/diverted attention
4. Suspect instruments misread
5. Faulty instrument
6. Descended below minimums
7. Misjudged altitude
8. Aircraft not properly equipped
9. Did not fly published approach
10. Conditions exceeded pilot's capabilities
11. Pilot incapacitated
12. Vertigo

Subjective assignments to a category were necessary in some instances. For instance, if a plane crashed due to ice on the windshield because the windshield de-icers were inoperative, the incident could be assigned to either category 2 or 8. To facilitate an analysis of the interaction of pilot experience and weather conditions with cause factors, subjective classifications were made based upon which factor appeared to be of the most significance by the facts and comments in the accident brief.

The right most columns of Table 47 provide a simple tabulation of all of the night controlled collisions by cause factor along with the way the accidents were distributed for the 1964-1975 and 1976-1979 time periods. There are four very significant changes in the data for the two time periods which are reflected in cause factor categories 3, 4, 6 and 10. (i.e. Distracted/Diverted Attention, Suspect Misread Instrument, Descended Below Minimums, and Pilot Exceeded Capabilities) Before addressing the significance of those changes, it should be mentioned that the major cause of the changes could relate to a combination of the way the accidents were classified and a possible change in NTSB investigator philosophies about comments on their accident brief. More specifically, practically all of the accidents reviewed were attributed to improper IFR procedures as the primary cause. If the comment section exlained the improper procedure or operation in terms such as the pilot momentarily being distracted or flying below minimums, that incident was classified in categories 3 or 6, respectively. Thus, category 1 (Improper IFR Procedures) is more generic and was used when the brief lacked secondary causes and comments.

In light of the cause factor classification methodology, we can only speculate about the large changes in categories 3, 4, 6 and 10. Using the most conservative approach, let us hypothesize that trends remained constant after 1975, and that those accidents that were caused by one of the four categories (3, 4, 6 or 10) simply were not so annotated in the comments section by the investigator. If our hypothesis is correct, the sums of categories 1, 3, 4, 6 and 10 for the two time periods should have a ratio similar to the ratio for the total accidents for the same periods, assuming also that trends have continued unchanged. In fact, the ratios are .339 and .358 for the sums and totals, respectively. The acceptance range at a confidence level of 95 percent for the overall proportional occurrences of accidents is .25 to .42. Since .358 falls well inside of this range, indications are that there has been no change in the relative number of occurrences of the combined categories. To identify if any actual trends are actually occurring in the causes of night controlled collisions, and to relate those trends to pilot characteristics, the cause factors in question were re-examined and then regrouped to allow for the probable change in the accident brief comments. (i.e. The reticence of investigators in later years to include remarks about the pilot continuing below minimums.)

The four categories 3, 4, 6 and 10 (distracted/diverted attention, suspect misread instruments, descended below minimums, and pilot exceeded capability) all lend themselves to speculative comments after an aircraft has crashed in below minimums weather, especially if there are no indications of mechanical or other human failure. Therefore, two additional tests were made to gain more information on the change in the number of accidents attributed to "descending below minimums". The first test involved relating the occurrences of this group of causes to accidents where the weather was known to be below minimums and the second test was made relative to fatal accidents.

There were 31 accidents in the 1964-1975 period that occurred in below minimums weather and 11 in the 1976-1979 period. Table 47 presents a breakdown of the accidents that occurred below minimums in each time period for each of the cause factors. If the occurrences in categories 3, 4, 6, 10 are assumed to be based upon conjecture of the investigator and are all summed into the generic group (1) of improper IFR procedures, the ratio of Improper IFR Procedure accidents in 1976-1979 is 8/11 or .73. Based upon the population of 42 accidents, we find that the overall proportion of 35/42 or .83 is within a 95 percent confidence interval (.47-.99).

Applying the same logic and methodology to the fatal night collisions which are also presented in Table 47, we have a population of 85 and a ratio for our group of categories 3, 4, 6, 10 of 21/34 or .62 for the later time period. The overall ratio for the fatal accidents for the two time periods is 58/85 or .68 and falls well within the 95 percent confidence interval range of 0.45 to .78.

Based upon the results of these two tests, the probability that a change in reporting procedures could be the cause for the apparent shift of accident causes for those accidents that occur in below minimums weather as well as in the case of fatal accidents falls well within a 95 percent confidence interval. In other words, we cannot say the shift is not due solely to reporting procedures.

To reflect cause factor trends in more of an operational context, the cause factor list was regrouped as follows:

1. Improper IFR Procedure - Includes distracted/ diverted attention, suspect instruments misread, descended below minimums, and pilot did not fly published approach.

2. Aircraft Not Properly Equipped - Includes faulty instruments and lack of proper de-icing equipment.

3. Misjudged Altitude - A unique category of pilot error that occurs after visual contact is made.

4. Pilot Incapacitated - The total population of 5 includes heart attack, hypoxia, and vertigo.

Essentially the groups represent human error in instrument conditions, mechanical error, human error in visual conditions, and an act of God. Table 48 simply confirms that the period of 1976 through 1979 has not undergone any significant changes in cause factor patterns. Pilots continue to fly into the ground at night and the vast majority of such mishaps (71 percent in 1976-1979) remain attributable to improper IFR procedures which cover a wide variety of sins. Although there appears to have been a major shift in accident reporting procedures, the actual causes do not appear to have changed significantly any from the 1964-1975 period. It is difficult to say for sure that descending below minimums continues as the leading element within the improper procedures category. However, based upon the fact that to contact the ground, a pilot would have to descend below minimums when the weather is below minimums, and since 5 accidents in those conditions were attributed solely to improper procedure (Table 47), it is fairly safe to assume that such was the case.

Pilot Experience vs Night/Day Controlled Collisions: Table 49 provides a summary of the number of night controlled collisions in terms of various measures of a pilot's proficiency or experience. Table 50 provides the same data for day controlled collisions. Table 51 presents a combination of 49 and 50 in percentages of accidents reported. There are many nuances in the data presented in these particular tables about which one could do a great deal of speculating. The reader is cautioned to pay particular attention to the range of hours covered by each of the bins before drawing any hasty conclusions. Table 46 and 47 present the first 100 hours of experience in 4 bins to see how the figures on the very inexperienced pilot behave, and at the high end of the tables, figures include thousands of hours. Two points the authors of this report felt worthy of comments are:

1. Simulated Instrument Experience: As shown in Table 51, 85 percent of the night uncontrolled collisions upon which simulated instrument time was reported fell in the 0-100 hours bin as did 73 percent of the day mishaps. Within that 100 hours, both day and night accident rates peaked out in the 40 to 60 hour bracket. In Table 52, which presents a comparison of pilot profiles for day and night uncontrolled collisions, it can be seen that the median simulated times for pilots involved in day and night uncontrolled collisions are equal at 59. This is down slightly from the entire SPIFR data base, and down significantly for the "typical GA pilot" derived from the GA survey data base. Even though the relationship of simulated hours to uncontrolled collision rates is not that far out of line from the GA profile, it appears as though the hours of simulated instruments is disproportionately small when compared to actual actual instrument hours.

   Table 53 was compiled to compare simulated instrument experience with aircraft types. The authors hypothesized that perhaps the small single engine aircraft would skew the distribution of simulated hours possibly due to many solo flights and/or the passenger seat(s) not situated well for look-out purposes. As can be seen in Table 53, twin engine pilots, in general, did not have any more simulated time than the single engine pilots.

2. Time in Type for Single Engine versus Twin Engine: According to the data in Reference C, 70.5 percent of the GA pilots fly in single engine aircraft as IFR pilots. Over the 16 years represented in the NTSB data, 151 of the 239 controlled collisions occurred in twin engine aircraft. That means that twin aircraft (includes turboprop) accounted for 63.2 percent of this type of SPIFR mishap, or rephrased 29.5 percent of the aircraft account for 63.2 percent of the controlled collisions attributed to pilot factor in the landing phase. Upon arriving at this percentage, the authors hypothesized that this was attributable to the higher workload demanded from the SPIFR pilot in twins as suggested by the previous NASA research. (Reference A) If this were the case, one would expect the accident rate at night to be higher than in the day, particularly if our earlier hypothesis on night demands being an important factor in higher rates holds true.

   Interestingly, the proportion of twin controlled collision accidents decreases at night. Whether the proportion changes due to relatively more single engine accidents at night or due to less twin accidents is not clear, but the figures are consistent. The proportion of controlled collisions that occurred in single and twin engine aircraft is as shown below in Table 54. The

   Table 54. Proportion of Twin Uncontrolled Collisions

| | 1964-1979 | 1976-1979 |
|---|---|---|
| Twin Day/All Day | .71 | .72 |
| Twin Night/All Night | .60 | .61 |

   proportion of overall accidents in all phases and all light conditions for twins was demonstrated to be .62. Table 55 presents the distribution of the time in type for experience levels for day and night controlled collisions by single and twin engine aircraft. There is a definite increase in the proportion of single engine mishaps at experience levels of less than 100 hours and the distribution of time in type for twins remains fairly consistent from day to night. However the best we can do is speculate that the apparent decrease in the overall ratio of night twin engine mishaps is due more to an increase in inexperienced pilots in single engine mishaps. (Based upon the proportions of single and twin day accidents, computing 95 percent confidence intervals against which to check the night proportions give us ranges of .60 to .82 and .18 to .40 for the respective proportions of .60 and .39 which does not help in the determination of which has what impact.)

Visibility in Controlled Collisions: Table 56 presents a summary of the reported visibility broken down for day and night single and dual piloted controlled collision accidents. The first four rows of the table present the absolute number of accidents for each reported visibility while the bottom four rows tabulate the occurrences by percentages. Except for day dual piloted accidents, the percentage of accidents that occur when the existing visibility is 2 miles is greater than the number that occur with 1 mile reported visibility. The cumulative number that occur with less than one mile visibility approaches 50 percent for all of the categories except night SPIFR controlled collisions. The latter happen most frequently with 1 to 2 miles visibility as do night DPIFR mishaps.

In an attempt to establish a relationship between the crash site and the location of the airport, a table was compiled to see how many controlled collisions occur within sight of the destination airport. Table 57 provides a comparison of the number of day and night SPIFR accidents where the visibility is greater or less than the distance of the crash from the airport. One would logically expect relatively few pilots to fly into the ground if the airport were in sight. When the visibility is less than 1 mile, 28 percent of day and 31 percent of night controlled collisions occur with the distance of the crash from the airport being less than the visibility, i.e., within visual range of the airport. At visibilities of 1 mile and greater, 57 percent of the day and 62 percent of the night controlled collisions occur within theoretical sight of the airport.

The reasons for flying into the ground with the airport in sight are explainable in some instances where there was icing involved or the pilot misjudged his altitude after transitioning to visual flight. Other possibilities may be gleened from table 58 which presents a matrix of accident causes and approach types for night controlled collisions.

A possible contributing factor to those occurrences where the aircraft is within visual range of the airport could be the type of lighting for night instrument approaches. Unfortunately, few accident reports contained data on lighting. Seventy-one accidents after 1975 included runway lighting information. The data prior to 1975 were discarded since if lighting data were included at all, they included only the intensity of the lights and not the type. None of the reports included data on approach lighting. The only correlation that could be made for certain about the effects of runway lighting is when it was a cause factor. There were two cases where the pilot could not or failed to actuate the pilot actuated runway lights, 3 cases of the aircraft crashing into the lights, and 2 cases where the lights were covered by a snow bank. Of the 15 aircraft that flew into trees and had reports that included data on the runway lights, 8 were outside of visual range of the airport, and of the rest, only 3 aircraft unexplainably flew into the trees with no influencing factor such as icing or the pilot misjudging his altitude. One of the 3 had medium intensity runway lights in addition to high intensity. The remaining two had high intensity lighting only.

## CLOSING COMMENTS

Ideally, one would like to close a report with a list of important conclusions and recommendations. However, the authors feel that the nature of the results of this analysis do not lend themselves to objective stand-alone statements. This report covers a wide range of topics, and has identified many factors and experience traits that are indicative of trends and/or patterns which relate to accident types and causes. However, we feel that the reader should interpret identified trends and factors within the context of the analysis and related topics with which they are presented. The following paragraphs present some of the general findings of this effort.

Of the 554 SPIFR pilot error landing accidents which were analyzed in detail, 39 percent occurred after Reference A was published. However, there were no significant changes from the original findings in the relationships of mission variables to the accidents in the later time period. The absolute number of accidents is increasing but when compared to the higher numbers of activity, the rate is decreasing. Worthy of note is the fact that this accident rate over the last four years of data has been decreasing more slowly. (i.e. The overall picture is brighter each year but the gains being made are smaller.)

In an analysis of these accidents by phase of landing, it was found that there were statistically fewer accidents in the the initial approach phase after 1975 which is most likely attributable to fewer non-precision approaches being flown. The final approach phase still accounts for most landing phase SPIFR accidents with three times as many occurring at night as do in the daylight.

The fact that so many more final approach accidents occur at night rather than in the daylight led to a concerted effort to quantify day and night accident rates. The aviation community has long known that the number of accidents that occur during day and night has been about the same over the years. However, it was found that 87.6 percent of GA activity occurs during daylight and 12.4 percent in darkness. The startling conclusion of this report is that the night accident rates for both single and dual piloted aircraft are over 10 times greater than the day rates.

Statistical profiles were compiled for the typical GA pilot in the NASA Survey and the typical pilot involved in the 554 accidents analyzed. These profiles were compared to profiles of the pilots involved in sub-sets of accidents to determine the importance of experience levels. Essentially, these efforts ended up documenting the intuitive assumption that the lesser experienced pilot is more likely to be involved in a SPIFR pilot error accident. The degree to which this is true was especially significant in the analysis of vertigo related uncontrolled collisions with the ground, and not as important to icing related accidents. In the case of the latter, a low cost reliable anti-icing or deicing device appears to be needed in the GA community.

Throughout the report, many subjects are discussed which lend themselves to further analysis and speculation. The authors sincerely hope that the efforts represented on these pages provide seeds for future research which will help reduce the GA accident rate. Two general areas which are suggested for closer scrutinization are:

1. The impact of simulated instrument time upon the likelihood of a SPIFR accident. Specifically, one would very much like to know how much impact reporting procedures in the NTSB accident briefs effect the statistics discussed in this report relating to simulated instrument time. Why are the levels of simulated instrument time that appear for the SPIFR pilots in the NTSB data base and the NASA single pilot GA survey as diverse as they are?

2. The disparity between day and night SPIFR accident rates. Out of 5,416 SPVFR accidents from 1964 to 1975 which involved pilot error, only 14 percent occurred at night. Based upon our estimate of night time activity (12.8 percent of overall activity) derived from the "General Aviation Pilot and Aircraft Activity Survey", it appears that SPVFR accident rates are unaffected by the condition of light while SPIFR approach/landing phase accident rates are magnified by 10 fold.

SUMMARY

National Transportation Safety Board general aviation (GA) aircraft accident data for the years 1964 to 1979 were examined for single pilot instrument flight rule (SPIFR) accidents caused by pilot error. The 1396 accidents found were analysed to determine the relationship of SPIFR accident types to phase of flight, pilot experience, and mission variables such as condition of light, ceiling, visibility, and type of approach. An estimate of GA day and night activity was made in order to estimate actual day and night accident rates.

The results of the data analysis indicate that about 50 percent of the SPIFR accidents occurred during the landing phase of flight, 40 percent occurred during the enroute phase, and 10 percent occurred during the taxi/takeoff phases. Fog was present in 72 percent of the landing phase accidents and of those accidents 54 percent occurred in visibilities of 1 mile or less.

Experienced pilots tended to have a lower accident rate than less experienced pilots. This trend was expecially significant with vertigo related accidents and much less significant with icing related accidents.

The estimate of day GA activity was 87.6 percent of all GA activity and night activity was 12.4 percent. Based on these estimates and the number of day and night accidents the night accident rate was judged to be 10 times the day accident rate.

When approach types were examined 33 percent of the landing phase accidents occurred during VOR or VOR/DME approaches, 8 percent occurred during NDB approaches. Over twice as many accidents occurred during straight in ILS approaches with no radar advisories available as during straight in ILS approaches with radar advisories.

APPENDIX A

FIGURES 1-5

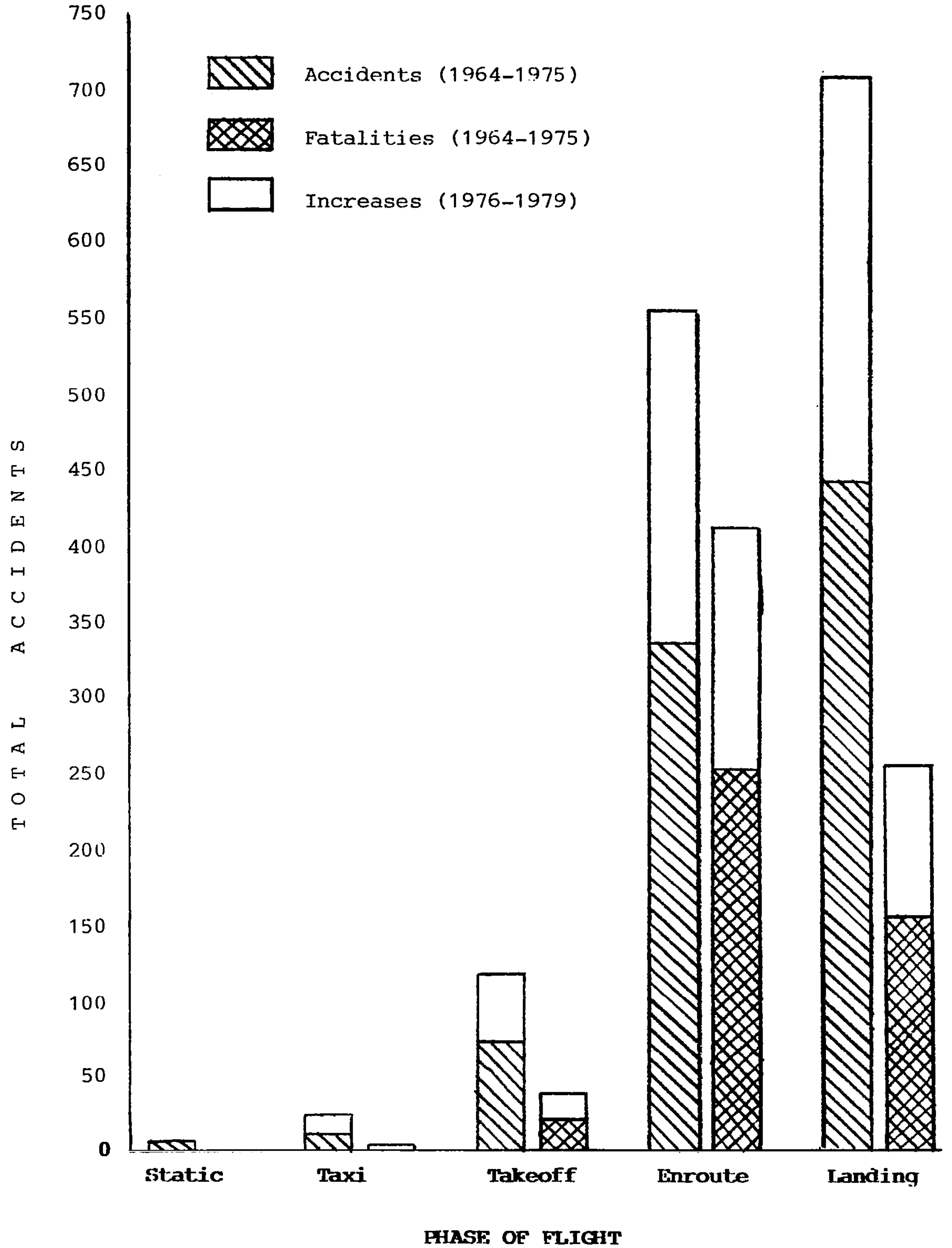


**Figure 1. SPIFR pilot error accidents 1964-1979, all flight plans.**

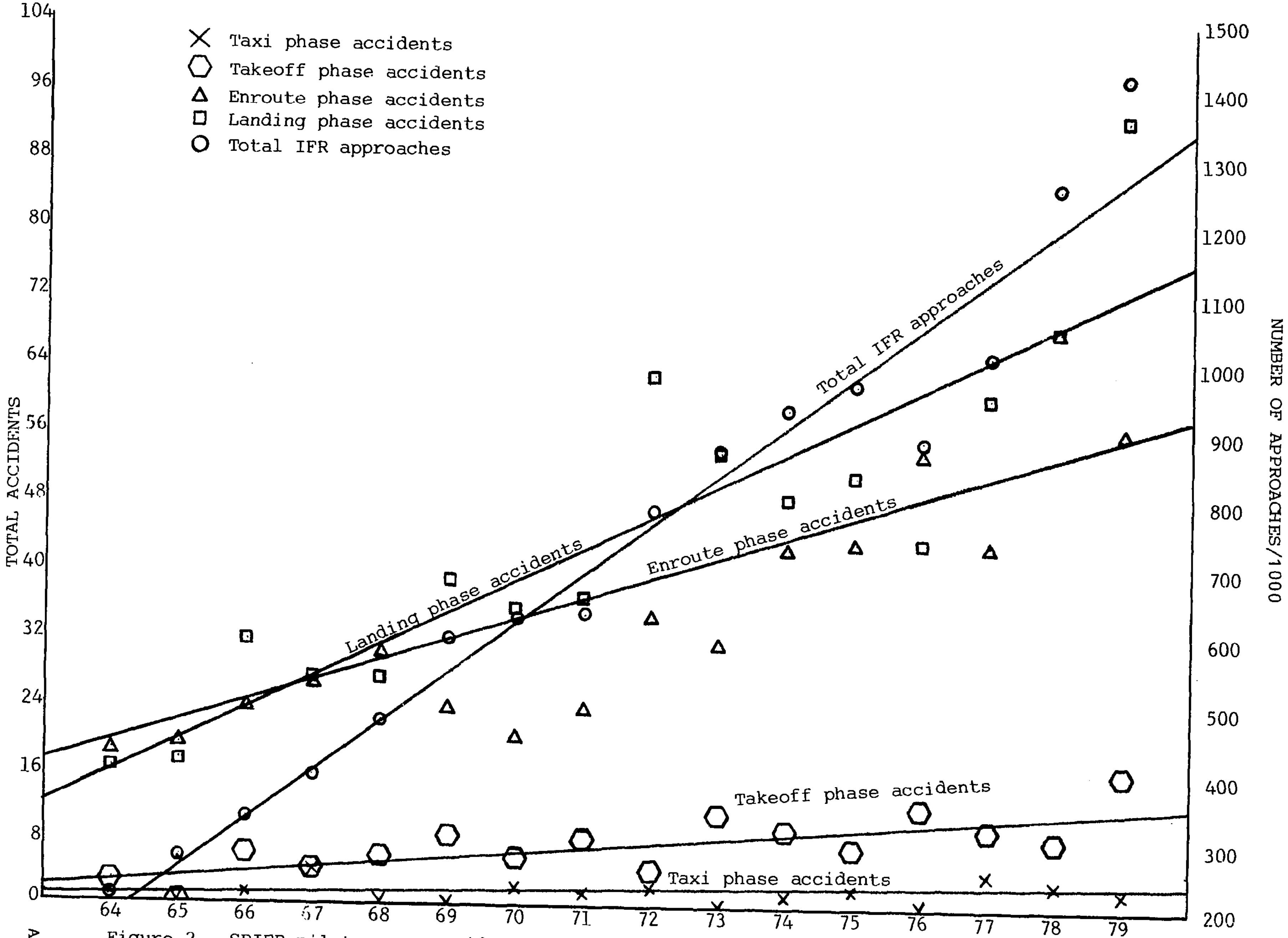


Figure 2. SPIFR pilot error accidents and IFR approaches fitted with linear regression lines.

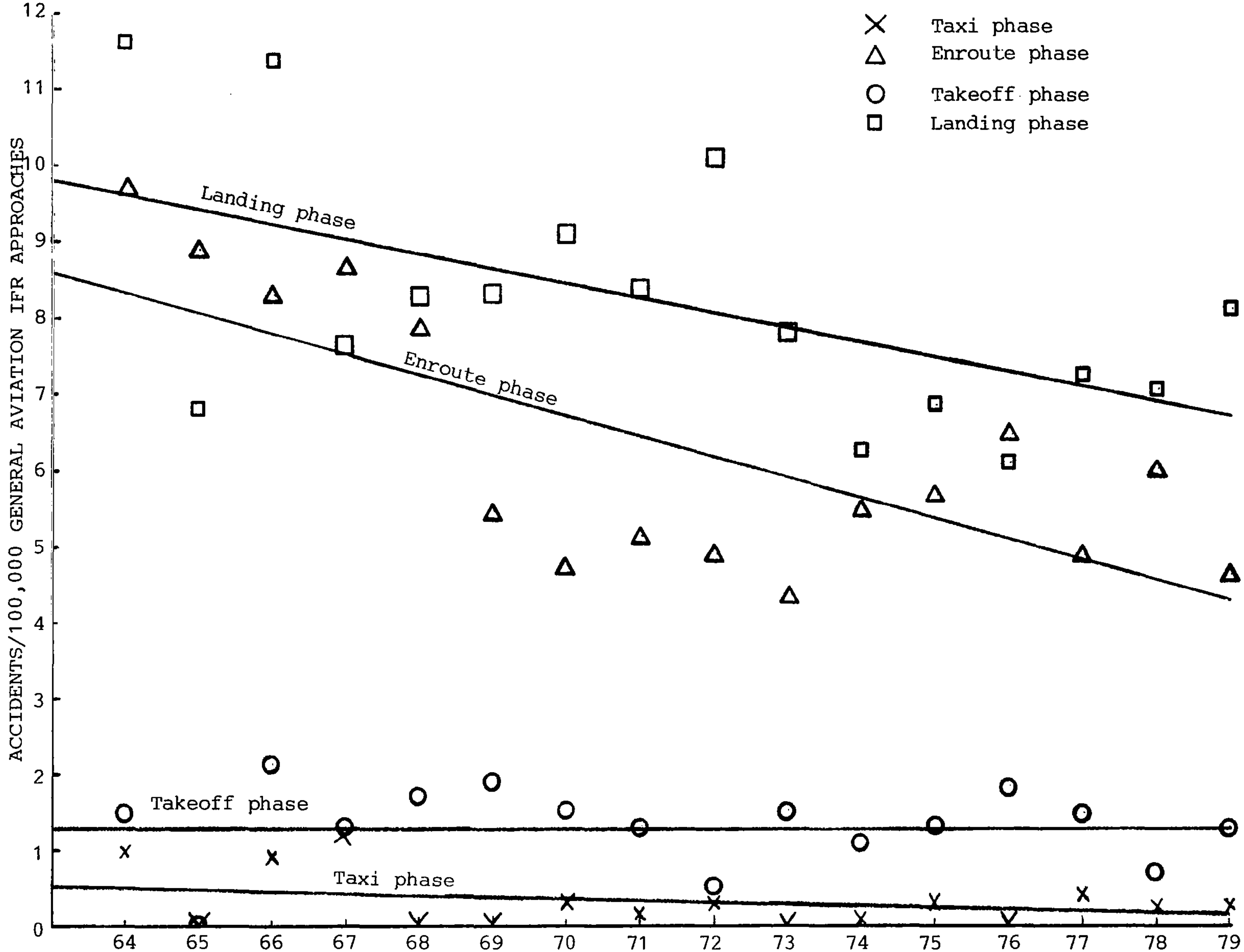


Figure 3. Single and dual piloted, pilot error accidents/100,000 approaches.

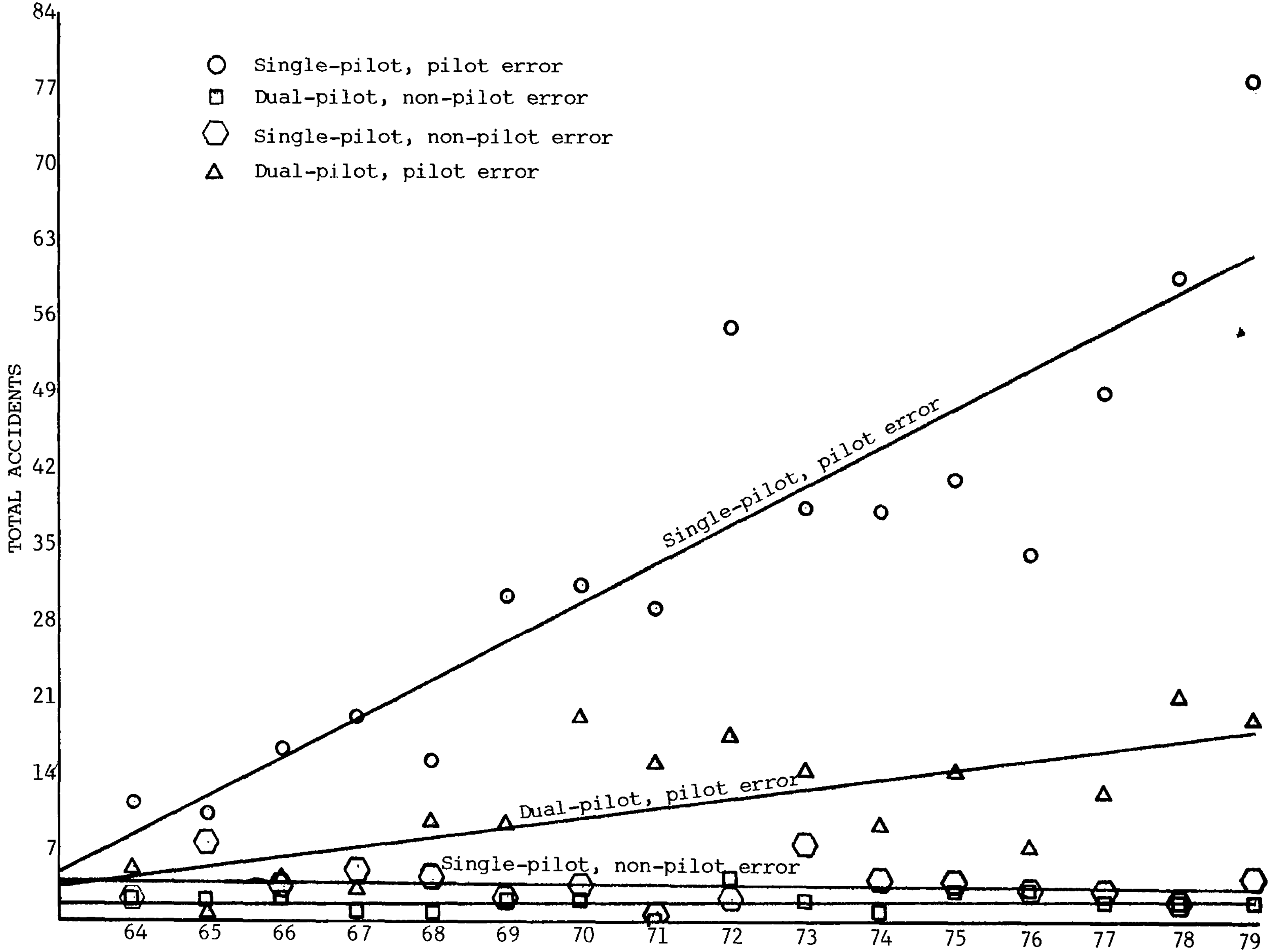




Figure 4. Total IFR flight plan landing phase accidents.

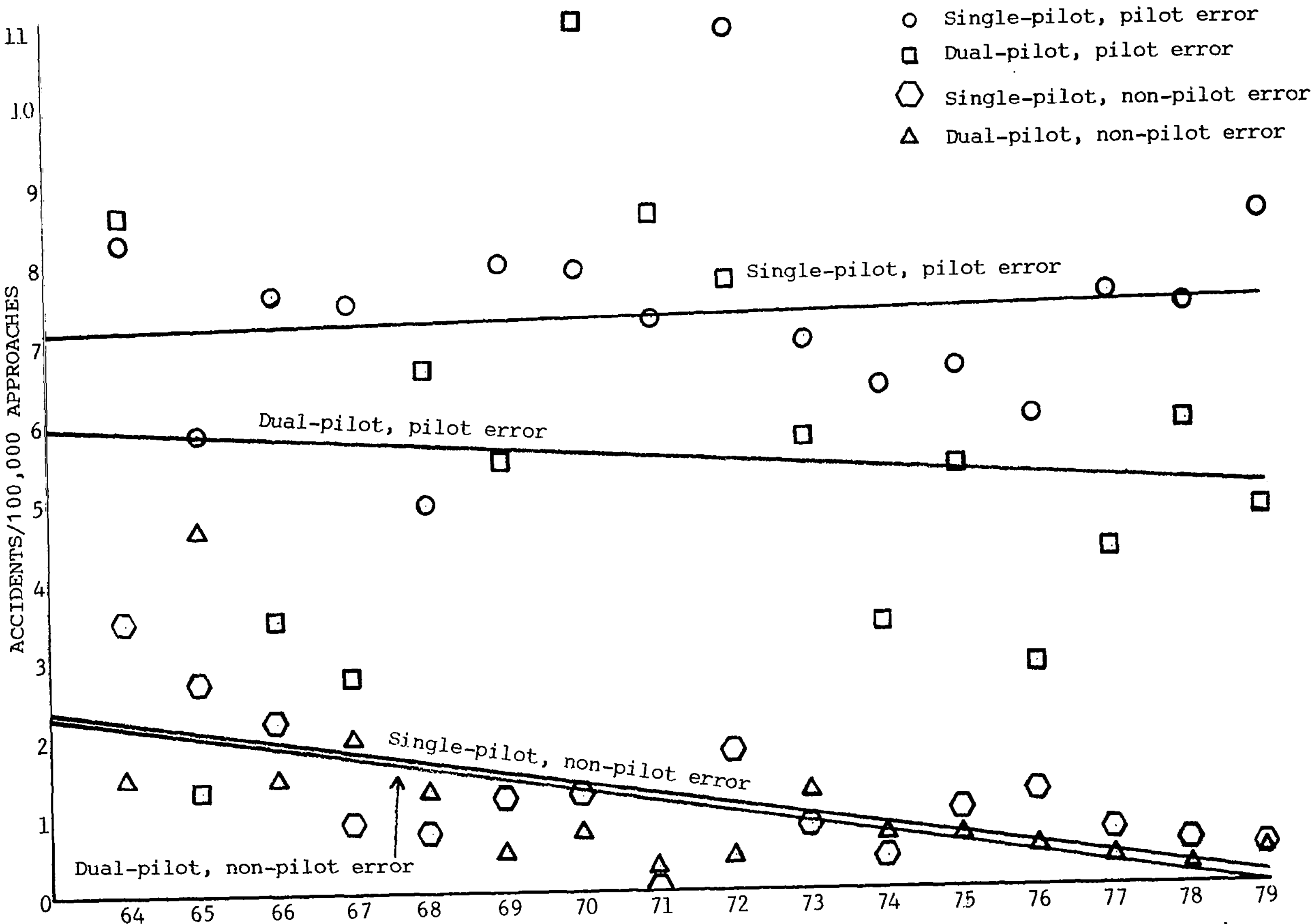


Figure 5. IFR flight plan landing phase accidents/100,000 general aviation IFR approaches.

APPENDIX B

TABLES 6-58

TABLE 6
SPIFR LANDING ACCIDENTS IN TERMS OF OBSTRUCTION TO VISION
AT THE ACCIDENT SITE AND SELECTED MISSION VARIABLES

| MISSION VARIABLES \ OBSTRUCTION TO VISION | FOG | HAZE | BLOWING SNOW | OTHER | NONE | TOTAL | PERCENT 1976-79 |
|---|---|---|---|---|---|---|---|
| TOTAL | 398 | 25 | 31 | 34 | 66 | 554 | 39 |
| INJURY INDEX | | | | | | | |
| NONE | 108 | 15 | 11 | 14 | 36 | 184 | 38 |
| MINOR | 52 | 5 | 8 | 5 | 5 | 75 | 44 |
| SERIOUS | 55 | 1 | 4 | 4 | 9 | 73 | 38 |
| FATAL | 183 | 4 | 8 | 11 | 16 | 222 | 39 |
| VISIBILITY | | | | | | | |
| ZERO | 11 | | 2 | 2 | 1 | 16 | 62 |
| 1/4 MILE | 47 | | 3 | 2 | 2 | 54 | 43 |
| 1/2 MILE | 39 | | 5 | 1 | 3 | 48 | 29 |
| 3/4 MILE | 32 | 2 | 2 | 1 | 3 | 40 | 42 |
| 1 MILE | 84 | 1 | 4 | 1 | 5 | 95 | 32 |
| 2 MILES | 112 | 7 | 6 | 8 | 10 | 143 | 40 |
| 3 MILES | 52 | 6 | 3 | 6 | 4 | 71 | 38 |
| 4 MILES | 10 | 5 | 2 | 4 | 2 | 23 | 48 |
| PRECIPITATION | | | | | | | |
| RAIN/DRIZZLE | 161 | 4 | | 10 | 17 | 192 | 33 |
| SNOW | 23 | 3 | 24 | 2 | 19 | 71 | 37 |
| FREEZING RAIN AND DRIZZLE | 29 | 1 | 1 | 1 | 3 | 35 | 40 |
| OTHER (INCL NONE) | 185 | 17 | 6 | 21 | 27 | 256 | 45 |
| TERRAIN | | | | | | | |
| MOUNTAINS | 23 | | 1 | 3 | 4 | 31 | 42 |
| HILLY | 34 | | 2 | 2 | 2 | 40 | 18 |
| ROLLING | 34 | 2 | 4 | 1 | 8 | 49 | 35 |
| LEVEL | 63 | 6 | 1 | 4 | 9 | 84 | 43 |
| DENSE W/TREES | 76 | | 1 | 4 | 5 | 86 | 23 |

TABLE 7
SPIFR LANDING ACCIDENTS IN TERMS OF CONDITION OF LIGHT
AND SELECTED MISSION VARIABLES

| MISSION VARIABLES \ CONDITION OF LIGHT | DAWN | DAY | DUSK | DARK | TOTAL | PERCENT 1976-79 |
|---|---|---|---|---|---|---|
| TOTAL | 10 | 223 | 27 | 294 | 554 | 39 |
| INJURY INDEX | | | | | | |
| NONE | 4 | 99 | 12 | 69 | 184 | 38 |
| MINOR | 1 | 26 | 3 | 45 | 75 | 44 |
| SERIOUS | | 22 | 4 | 47 | 73 | 38 |
| FATAL | 5 | 76 | 8 | 133 | 222 | 40 |
| VISIBILITY | | | | | | |
| ZERO | | 7 | | 9 | 16 | 62 |
| 1/4 MILE | 4 | 18 | 2 | 30 | 54 | 43 |
| 1/2 MILE | 1 | 13 | 2 | 32 | 48 | 29 |
| 3/4 MILE | | 21 | 1 | 18 | 40 | 42 |
| 1 MILE | 2 | 40 | 6 | 48 | 96 | 34 |
| 2 MILES | 2 | 64 | 7 | 70 | 143 | 40 |
| 3 MILES | | 26 | 5 | 40 | 71 | 38 |
| OVER 4 MILES | 1 | 30 | 3 | 43 | 77 | 49 |
| OBSTRUCT. TO VISION | | | | | | |
| FOG | 8 | 154 | 20 | 216 | 398 | 40 |
| NONE | 1 | 30 | 3 | 32 | 66 | 39 |
| PRECIPITATION | | | | | | |
| RAIN & DRIZZLE | 2 | 81 | 10 | 99 | 192 | 36 |
| SNOW | | 33 | 4 | 34 | 71 | 46 |
| FREEZING RAIN | | 12 | 1 | 22 | 35 | 40 |
| OTHER | 8 | 97 | 12 | 139 | 256 | 45 |
| TERRAIN | | | | | | |
| MOUNTAINS | | 19 | 3 | 9 | 31 | 42 |
| HILLY | | 14 | 1 | 25 | 40 | 17 |
| ROLLING | | 18 | 1 | 30 | 49 | 35 |
| LEVEL | 4 | 19 | 4 | 57 | 84 | 43 |
| DENSE W/TREES | 3 | 16 | 1 | 66 | 86 | 23 |

TABLE 8
*SPIFR LANDING ACCIDENTS IN TERMS OF PHASE OF LANDING*
AND SELECTED MISSION VARIABLES

| MISSION VARIABLES \ PHASE OF FLIGHT | FINAL IFR | INITIAL IFR | MISSED APPRCH | TRAFFIC PATTERN CIRCLING | LVL OFF TOUCH-DOWN | ROLL | FINAL VFR | GO AROUND VFR | OTHER | TOTAL | PERCENT 1976-79 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL | 224 | 75 | 41 | 16 | 107 | 46 | 26 | 5 | 14 | 554 | 39 |
| INJURY INDEX | | | | | | | | | | | |
| NONE | 26 | 10 | 8 | 2 | 84 | 42 | 9 | 3 | | 184 | 38 |
| MINOR | 34 | 6 | 3 | 4 | 16 | 4 | 6 | 1 | 1 | 75 | 44 |
| SERIOUS | 40 | 11 | 5 | 2 | 5 | | 7 | 1 | 2 | 73 | 38 |
| FATAL | 124 | 48 | 25 | 8 | 2 | | 4 | | 11 | 222 | 40 |
| VISIBILITY | | | | | | | | | | | |
| ZERO | 6 | 4 | 2 | | 2 | | 1 | | 1 | 16 | 62 |
| 1/4 MILE | 31 | 7 | 8 | 2 | 4 | 1 | | | 1 | 54 | 43 |
| 1/2 MILE | 25 | 8 | 6 | 1 | 4 | 1 | 1 | 1 | 1 | 48 | 29 |
| 3/4 MILE | 21 | 7 | 1 | 1 | 6 | 3 | | | 1 | 40 | 42 |
| 1 MILE | 42 | 10 | 11 | | 14 | 9 | 6 | 1 | 3 | 96 | 32 |
| 2 MILES | 52 | 14 | 7 | 2 | 44 | 16 | 4 | 1 | 3 | 143 | 40 |
| 3 MILES | 27 | 9 | 4 | 3 | 14 | 5 | 6 | 1 | 2 | 71 | 38 |
| OVER 4 MILES | 16 | 14 | 2 | 7 | 18 | 9 | 8 | 1 | 2 | 77 | 49 |
| COND. OF LIGHT | | | | | | | | | | | |
| NIGHT | 160 | 36 | 17 | 7 | 26 | 20 | 14 | 4 | 10 | 294 | 39 |
| DAY | 53 | 36 | 20 | 9 | 68 | 23 | 10 | 1 | 3 | 223 | 41 |
| DUSK & DAWN | 11 | 3 | 4 | | 13 | 3 | 2 | | 4 | 40 | 38 |
| OBSTRUCT. TO VIS. | | | | | | | | | | | |
| FOG | 191 | 49 | 36 | 8 | 61 | 22 | 14 | 4 | 13 | 398 | 40 |
| NONE | 12 | 12 | 1 | 4 | 19 | 12 | 5 | | 1 | 66 | 39 |
| TERRAIN | | | | | | | | | | | |
| MOUNTAINS | 12 | 12 | 3 | 1 | 1 | | | | 2 | 31 | 42 |
| HILLY | 23 | 10 | 4 | | | 1 | 1 | | 1 | 40 | 20 |
| ROLLING | 24 | 9 | 6 | 1 | 2 | 1 | 4 | | 2 | 49 | 33 |
| LEVEL | 49 | 12 | 8 | 4 | 1 | 1 | 6 | 1 | 2 | 84 | 43 |
| DENSE W/TREES | 59 | 18 | 4 | 1 | | | 3 | | 1 | 86 | 23 |
| BELOW MINS | 60 | 9 | 5 | 3 | 3 | 1 | | 1 | 6 | 88 | 29 |

TABLE 9
SPIFR LANDING ACCIDENTS AND RATIOS RELATING TO
TO PHASE OF INSTRUMENT APPROACH

| PHASE OF FLIGHT | FINAL IFR | INITIAL IFR | MISSED APPR | PATTRN CIRC | LEVEL TCHDWN | ROLL | FINAL VFR | GO-RND VFR | OTHER | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| TOTALS | | | | | | | | | | |
| 1964-1975* | 139 | 59 | 20 | 7 | 59 | 27 | 16 | 1 | 7 | 335 |
| 1964-1979 | 224 | 75 | 41 | 16 | 107 | 46 | 26 | 5 | 14 | 554 |
| PROPORTION OC-CURRED 1964-79 | .38 | .21 | .51 | .56 | .45 | .41 | .38 | .80 | .50 | .39 |
| NIGHT/DAY | | | | | | | | | | |
| 1964-1975 | 3.30 | 1.20 | .42 | .75 | .36 | 6.50 | 1.00 | 0.00 | 2.00 | 1.40 |
| 1964-1979 | 3.00 | 1.00 | .85 | .78 | .38 | .87 | 1.40 | 4.00 | 3.30 | 1.30 |

NOTE: Data extracted from original NASA SPIFR study (reference A)

TABLE 10
SPIFR LANDING ACCIDENTS IN TERMS OF TYPE OF APPROACH EXECUTED
AND SELECTED MISSION VARIABLES

| TYPE OF APPROACH / MISSION VARIABLES | PRECISION | | | | | NON-PRECISION | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | STRAIGHT-IN | | CIRCLING | | STRAIGHT-IN | | | | | | CIRCLING | | | | | | | | | |
| | PAR ONLY | ILS /ASR | ILS ONLY | ILS /ASR | ILS ONLY | VOR ONLY | VOR /DME | NDB ONLY | LOC /BC | LOC ONLY | ASR ONLY | VOR ONLY | VOR /DME | NDB ONLY | LOC ONLY | VIS - | OTH - | BLNK - | TOT - | % 76-79 |
| TOTAL | 1 | 59 | 104 | 5 | 6 | 75 | 12 | 31 | 10 | 16 | 11 | 48 | 7 | 4 | 1 | 6 | 36 | 121 | 554 | 39 |
| INJURY INDEX | | | | | | | | | | | | | | | | | | | | |
| NONE | | 10 | 28 | 2 | 2 | 21 | 3 | 5 | 4 | 5 | 2 | 15 | 1 | | 1 | 1 | 9 | 75 | 184 | 38 |
| MINOR | | 8 | 17 | | | 6 | 2 | 6 | 3 | 2 | 1 | 6 | 1 | 1 | | 3 | 6 | 13 | 75 | 44 |
| SERIOUS | | 7 | 14 | 2 | 1 | 16 | 2 | 3 | 1 | 3 | 1 | 5 | | 1 | | 1 | 2 | 14 | 73 | 38 |
| FATAL | 1 | 34 | 45 | 1 | 3 | 32 | 5 | 17 | 2 | 6 | 7 | 22 | 5 | 2 | | 1 | 19 | 19 | 222 | 40 |
| VISIBILITY | | | | | | | | | | | | | | | | | | | | |
| ZERO | | 1 | 5 | | | 1 | 1 | 1 | | 1 | | 1 | | | | | 2 | 3 | 16 | 62 |
| 1/4 MILE | | 8 | 11 | 1 | 1 | 7 | 3 | 8 | | | 2 | 3 | 2 | | | 1 | 2 | 5 | 54 | 43 |
| 1/2 MILE | | 8 | 13 | | | 7 | | 2 | 1 | 2 | 1 | 3 | 1 | | | | 6 | 4 | 48 | 29 |
| 3/4 MILE | | 5 | 13 | 1 | 1 | 6 | | 1 | | 1 | 3 | 3 | | | | 1 | 2 | 3 | 40 | 42 |
| 1 MILE | | 13 | 22 | 1 | | 12 | 2 | 3 | 5 | 4 | 2 | 9 | | | | 1 | 3 | 19 | 96 | 32 |
| 2 MILES | 1 | 12 | 20 | 1 | 3 | 20 | 3 | 6 | 3 | 4 | 2 | 15 | 2 | 2 | 1 | 2 | 12 | 34 | 143 | 40 |
| 3 MILES | | 4 | 10 | | 1 | 10 | 2 | 6 | 1 | 1 | 1 | 11 | 2 | 1 | | 1 | 3 | 17 | 71 | 38 |
| OVER 4 MILES | 1 | 6 | 9 | 1 | | 11 | 1 | 3 | | 3 | | 3 | | 1 | | | 5 | 33 | 77 | 49 |
| COND. OF LIGHT | | | | | | | | | | | | | | | | | | | | |
| NIGHT | | 40 | 65 | 3 | 2 | 41 | 8 | 23 | 3 | 9 | 7 | 22 | 4 | | | 4 | 17 | 46 | 294 | 39 |
| DAY | 2 | 17 | 28 | 1 | 3 | 31 | 3 | 7 | 6 | 7 | 4 | 23 | 3 | 3 | | 2 | 17 | 66 | 223 | 41 |
| DUSK/DAWN | | 2 | 11 | 1 | 1 | 3 | 1 | 1 | 1 | | | 3 | | 1 | 1 | | 2 | 9 | 37 | 38 |
| OBS. TO VISION | | | | | | | | | | | | | | | | | | | | |
| FOG | 2 | 42 | 85 | 4 | 4 | 56 | 9 | 25 | 7 | 13 | 10 | 34 | 7 | 3 | 1 | 5 | 24 | 67 | 398 | 40 |
| NONE | | 8 | 11 | | 1 | 9 | 1 | 1 | 1 | 2 | 1 | 1 | | 1 | | 1 | 2 | 26 | 66 | 39 |
| TERRAIN | | | | | | | | | | | | | | | | | | | | |
| MOUNTAINS | | 1 | 6 | | | 5 | 1 | 3 | | 2 | 1 | 3 | 1 | 2 | | 1 | 2 | 3 | 31 | 42 |
| HILLY/ROLLING | | 10 | 22 | | 1 | 14 | 3 | 5 | 1 | 1 | 2 | 8 | 2 | | | 1 | 7 | 12 | 89 | 27 |
| LEVEL | 1 | 10 | 21 | 1 | 1 | 9 | 2 | 6 | | 4 | 1 | 8 | | 1 | | | 3 | 16 | 84 | 43 |
| OTHERS | 1 | 38 | 55 | 4 | 4 | 47 | 6 | 17 | 9 | 9 | 7 | 29 | 4 | 1 | 1 | 4 | 24 | 90 | 350 | 42 |
| PHASE OF LANDING | | | | | | | | | | | | | | | | | | | | |
| INITIAL | | 9 | 16 | | | 14 | 1 | 7 | 3 | 2 | 1 | 7 | 1 | 1 | | | 2 | 11 | 75 | 21 |
| FINAL IFR | 1 | 32 | 58 | 4 | 3 | 31 | 8 | 17 | 3 | 6 | 5 | 20 | 5 | 1 | | 1 | 19 | 10 | 224 | 38 |
| LEVELOFF | | 7 | 12 | | 3 | 15 | 1 | 3 | 3 | 3 | 3 | 5 | | 1 | | 4 | 5 | 42 | 107 | 45 |
| TRAFFIC PTRN | | | | | | 3 | | 1 | | 1 | | 5 | | | | | 1 | 5 | 16 | 56 |
| MISSED APP. | 1 | 6 | 8 | | | 5 | 1 | 2 | | 1 | 2 | 2 | 1 | 1 | | | 2 | 9 | 41 | 51 |
| ROLL | | 3 | 5 | 1 | | | 1 | | 1 | 1 | | 2 | | | 1 | | 5 | 26 | 46 | 41 |
| OTHER | | 2 | 5 | | | 7 | | 1 | | 2 | | 7 | | | | 1 | 2 | 18 | 45 | 47 |

TABLE 11
SPIFR LANDING ACCIDENTS AND ACCIDENT RATES
IN TERMS OF PILOT'S TOTAL TIME

| TOTAL FLIGHT HRS | 200-399 | 400-599 | 600-999 | 1K-1.9K | 2K-2.9K | 3K-4.9K | 5K-9.9K | 10-15K | >15K | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| NO. OF ACCIDENTS 1964-1979 | 35 | 40 | 57 | 113 | 82 | 94 | 77 | 34 | 20 | 552 |
| NO. OF ACCIDENTS 1976-1979 | 18 | 16 | 22 | 53 | 31 | 31 | 28 | 13 | 6 | 218 |
| PERCENT OCCURRED 1976-1975 | .51 | .40 | .39 | .47 | .38 | .33 | .36 | .38 | .30 | .39 |
| IFR RATED PILOTS AS OF 12/31/79 | 15852 | 23303 | 34400 | 49460 | 30437 | 32927 | 38522 | 12682 | 11255 | 248838 |
| ACCIDENT RATE (PER 10000 HRS) | .074 | .034 | .021 | .015 | .011 | .007 | .003 | .002 | .001 | |

NOTE: 7769 Pilots not categorized to accomodate non-respondents and those with less than 200 hours.

TABLE 12
SPIFR LANDING ACCIDENTS AND ACCIDENT RATES
IN TERMS OF PILOT'S ACTUAL INSTRUMENT TIME

| ACTUAL INST. HRS | 01-29 | 30-59 | 60-99 | 100-199 | 200-299 | 300-599 | >599 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| NO. OF ACCIDENTS 1964-1979 | 70 | 36 | 37 | 71 | 54 | 51 | 52 | 371 |
| NO. OF ACCIDENTS 1976-1979 | 26 | 16 | 19 | 25 | 18 | 19 | 15 | 138 |
| PERCENT OCCURRED 1976-1979 | .37 | .44 | .53 | .35 | .33 | .37 | .29 | .37 |
| IFR RATED PILOTS AS OF 12/31/79 | 57704 | 43118 | 13000 | 41535 | 24732 | 31071 | 21718 | 232878 |
| ACCIDENT RATE (PER 10000 HRS) | .809 | .188 | .358 | .114 | .088 | .037 | .028 | |

NOTE: 23779 Pilots not categorized to accomodate non-respondents.

TABLE 13
SPIFR LANDING ACCIDENTS AND ACCIDENT RATES
IN TERMS OF PILOT TIME IN THE PAST 90 DAYS

| TIME IN LAST 90 DAYS (HRS) | 0-24 | 25-49 | 50-99 | 100-149 | 150-199 | 200-299 | >300 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| NO. OF ACCIDENTS 1964-1979 | 73 | 95 | 112 | 65 | 38 | 48 | 16 | 447 |
| NO. OF ACCIDENTS 1976-1979 | 34 | 46 | 48 | 22 | 16 | 18 | 4 | 188 |
| PERCENT OCCURRED 1976-1979 | .47 | .48 | .43 | .34 | .42 | .37 | .25 | .42 |
| IFR RATED PILOTS AS OF 12/31/79 | 68320 | 58334 | 52627 | 26314 | 19814 | 17595 | 2853 | 245878 |
| ACCIDENT RATE (PER 10000 HRS) | .85 | .43 | .29 | .20 | .11 | .11 | .14 | |

NOTE: 10779 Pilots not categorized to accomodate non-respondents.

TABLE 14
SPIFR LANDING ACCIDENTS IN TERMS OF
PILOT'S TIME IN TYPE OF AIRCRAFT

| TIME IN TYPE (HRS) | 0-19 | 20-49 | 50-99 | 100-299 | 300-600 | >600 | TOTAL |
|---|---|---|---|---|---|---|---|
| NO. OF ACCIDENTS 1964-1979 | 29 | 51 | 49 | 122 | 103 | 137 | 491 |
| NO. OF ACCIDENTS 1976-1979 | 9 | 19 | 22 | 55 | 32 | 58 | 195 |
| PERCENT OCCURRED 1976-1979 | .31 | .37 | .45 | .45 | .31 | .42 | |

TABLE 16
ACTUAL INSTRUMENT TIME: EXPERIENCE LEVELS OF NASA SURVEY RESPONDEES VERSUS PILOTS INVOLVED IN SPIFR ACCIDENTS

| ACTUAL INSTRUMENT HOURS | 1-19 | 20-39 | 40-59 | 60-79 | 80-99 | 100-199 | 200-299 | 300-399 | 400-799 | >799 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SURVEY RESPONSES | 236 | 195 | 164 | 75 | 48 | 262 | 156 | 88 | 151 | 94 | 1469 |
| PERCENTAGES | 16 | 13 | 11 | 5 | 3 | 18 | 11 | 6 | 10 | 6 | |
| SPIFR ACCIDENTS TOTAL NUMBER | 51 | 34 | 21 | 21 | 16 | 71 | 54 | 22 | 42 | 39 | 371 |
| PERCENTAGES | 14 | 9 | 6 | 6 | 4 | 19 | 15 | 6 | 11 | 11 | |

TABLE 18
SIMULATED INSTRUMENT TIME: EXPERIENCE LEVELS OF NASA SURVEY RESPONDEES VERSUS PILOTS INVOLVED IN SPIFR ACCIDENTS

| SIMULATED INSTRUMENT HOURS | 1-19 | 20-39 | 40-59 | 60-79 | 80-99 | 100-199 | 200-299 | 300-399 | 400-799 | >799 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SURVEY RESPONSES | 63 | 155 | 328 | 232 | 93 | 284 | 116 | 55 | 66 | 47 | 1439 |
| PERCENTAGES | 4 | 11 | 23 | 16 | 7 | 20 | 8 | 4 | 5 | 3 | |
| SPIFR ACCIDENTS TOTAL NUMBER | 26 | 35 | 80 | 59 | 34 | 36 | 10 | 4 | 7 | 3 | 294 |
| PERCENTAGES | 9 | 12 | 27 | 20 | 12 | 12 | 3 | 1 | 2 | 1 | |

TABLE 20
TOTAL PILOT TIME LAST 90 DAYS: EXPERIENCE LEVELS OF NASA SURVEY RESPONDEES VERSUS PILOTS INVOLVED IN SPIFR ACCIDENTS

| PILOT 90 DAY TOTAL TIME | 1-14 | 15-29 | 30-44 | 45-59 | 60-74 | 75-99 | 100-124 | 125-224 | 225-324 | >324 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SURVEY RESPONSES | 283 | 319 | 188 | 130 | 83 | 128 | 99 | 238 | 72 | 11 | 1551 |
| PERCENTAGES | 18 | 21 | 12 | 8 | 5 | 8 | 6 | 15 | 5 | 1 | |
| SPIFR ACCIDENTS TOTAL NUMBER | 24 | 74 | 55 | 33 | 44 | 50 | 42 | 75 | 41 | 9 | 447 |
| PERCENTAGES | 5 | 17 | 12 | 7 | 10 | 11 | 9 | 17 | 9 | 2 | |

TABLE 22
TOTAL PILOT TIME: EXPERIENCE LEVELS OF NASA SURVEY RESPONDEES
VERSUS PILOTS INVOLVED IN SPIFR ACCIDENTS

| PILOT TOTAL TIME | 1-499 | 500-999 | 1K-1.4K | 1.5K-1.9K | 2K-3.9K | 4K-5.9K | 6K-7.9K | 8K-11.9K | 12K-15.9K | >15.9K | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SURVEY RESPONSES | 180 | 292 | 161 | 151 | 329 | 147 | 113 | 87 | 63 | 55 | 1578 |
| PERCENTAGES | 11 | 19 | 10 | 10 | 21 | 9 | 7 | 6 | 4 | 4 | |
| SPIFR ACCIDENTS TOTAL NUMBER | 53 | 77 | 63 | 47 | 144 | 66 | 32 | 30 | 20 | 17 | 549 |
| PERCENTAGES | 10 | 14 | 12 | 9 | 26 | 12 | 6 | 5 | 4 | 3 | |

TABLE 23
SPIFR LANDING ACCIDENT TYPE VS AIRCRAFT TYPE

| | SINGLE ENGINE FIXED GEAR | SINGLE ENGINE RETRACT. GEAR | TWIN ENGINE PISTON | TURBO-PROP | TOTAL |
|---|---|---|---|---|---|
| ACCIDENT TYPES: | | | | | |
| GROUND/WATER LOOP/SWERVE | 6 | 2 | 20 | 1 | 29 |
| WHEELS UP | 0 | 6 | 9 | 2 | 17 |
| GEAR COLLAPSED | 1 | 0 | 4 | 2 | 7 |
| GEAR RETRACTED | 0 | 3 | 3 | 0 | 6 |
| HARD LANDING | 4 | 7 | 26 | 3 | 40 |
| NOSE OVER/DOWN | 3 | 0 | 0 | 0 | 3 |
| OVERSHOOT | 9 | 1 | 21 | 0 | 31 |
| UNDERSHOOT | 2 | 3 | 16 | 0 | 21 |
| CONTROLLED COLLISION | 37 | 61 | 144 | 13 | 255 |
| UNCONTROLLED COLLISION | 10 | 13 | 17 | 0 | 40 |
| STALL | 4 | 14 | 27 | 3 | 48 |
| ENG FAIL OR MALFUNCTION | 11 | 9 | 29 | 2 | 51 |
| OTHER | 0 | 4 | 2 | 0 | 6 |
| TOTAL | 87 | 123 | 318 | 26 | 554 |

TABLE 26
SPIFR LANDING ACCIDENT TYPE VS SINGLE OR DUAL PILOTED

| | TOTAL ACCIDENTS SINGLE PILOT | TOTAL ACCIDENTS DUAL PILOT | PERCENTAGE SINGLE PILOT | PERCENTAGE DUAL PILOT |
|---|---|---|---|---|
| ACCIDENT TYPES: | | | | |
| GROUND/WATER LOOP/SWERVE | 29 | 16 | 5 | 9 |
| WHEELS UP | 17 | 4 | 3 | 2 |
| GEAR COLLAPSED | 7 | 3 | 1 | 2 |
| GEAR RETRACTED | 6 | 0 | 1 | 0 |
| HARD LANDING | 40 | 14 | 7 | 8 |
| NOSE OVER/DOWN | 3 | 2 | 1 | 1 |
| OVERSHOOT | 31 | 12 | 6 | 7 |
| UNDERSHOOT | 21 | 13 | 4 | 7 |
| CONTROLLED COLLISION | 255 | 74 | 46 | 41 |
| UNCONTROLLED COLLISION | 40 | 9 | 7 | 5 |
| STALL | 48 | 17 | 9 | 10 |
| ENG FAIL OR MALFUNCTION | 51 | 12 | 9 | 7 |
| OTHER | 6 | 3 | 1 | 1 |
| TOTAL | 554 | 179 | | |

TABLE 31
SINGLE PILOT LANDING PHASE ACCIDENT RATES IN TERMS OF ACCIDENTS PER 1000 INSTRUMENT APPROACHES FLOWN

| | ACCIDENTS | | | APPROACHES | | | ACCIDENT RATE | | |
|---|---|---|---|---|---|---|---|---|---|
| YEAR: | TOTAL | DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL | DAY | NIGHT |
| 1964 | 9 | 2 | 7 | 148760 | 129373 | 19387 | .061 | .015 | .361 |
| 1965 | 9 | 2 | 7 | 190910 | 166030 | 24880 | .047 | .012 | .281 |
| 1966 | 16 | 7 | 9 | 235135 | 204492 | 30643 | .068 | .034 | .294 |
| 1967 | 17 | 6 | 11 | 282901 | 246033 | 36868 | .060 | .024 | .298 |
| 1968 | 15 | 8 | 7 | 339266 | 295053 | 44213 | .044 | .027 | .158 |
| 1969 | 27 | 12 | 15 | 423288 | 368125 | 55163 | .064 | .033 | .272 |
| 1970 | 34 | 17 | 17 | 439212 | 382061 | 57251 | .077 | .044 | .297 |
| 1971 | 29 | 16 | 13 | 458095 | 399699 | 58396 | .063 | .041 | .223 |
| 1972 | 49 | 19 | 30 | 572669 | 499599 | 73070 | .086 | .039 | .411 |
| 1973 | 35 | 13 | 22 | 625880 | 544419 | 81461 | .056 | .024 | .270 |
| 1974 | 36 | 17 | 19 | 666440 | 579740 | 86700 | .054 | .029 | .219 |
| 1975 | 40 | 17 | 23 | 695592 | 604861 | 90731 | .058 | .028 | .253 |
| 1976 | 31 | 16 | 15 | 635921 | 553049 | 82872 | .049 | .029 | .181 |
| 1977 | 47 | 20 | 27 | 725730 | 631318 | 94412 | .065 | .031 | .286 |
| 1978 | 56 | 19 | 37 | 908117 | 789015 | 119102 | .062 | .024 | .311 |
| 1979 | 72 | 37 | 35 | 1023700 | 889576 | 134124 | .070 | .042 | .261 |
| TOTAL | 522 | 228 | 294 | 8371716 | 7282443 | 1089273 | .062 | .031 | .270 |

TABLE 32
DUAL PILOT LANDING PHASE ACCIDENT RATES IN TERMS OF
ACCIDENTS PER 1000 INSTRUMENT APPROACHES FLOWN

| | ACCIDENTS | | | APPROACHES | | | ACCIDENT RATE | | |
|---|---|---|---|---|---|---|---|---|---|
| YEAR: | TOTAL | DAY | NIGHT | TOTAL | DAY | NIGHT | TOTAL | DAY | NIGHT |
| 1964 | 6 | 1 | 5 | 57851 | 50312 | 7539 | .104 | .020 | .663 |
| 1965 | 1 | 0 | 1 | 74241 | 64567 | 9674 | .013 | 0.000 | .103 |
| 1966 | 4 | 2 | 2 | 91442 | 79525 | 11917 | .044 | .025 | .168 |
| 1967 | 3 | 2 | 1 | 110016 | 95679 | 14337 | .027 | .021 | .070 |
| 1968 | 9 | 2 | 7 | 131936 | 114742 | 17194 | .069 | .017 | .407 |
| 1969 | 8 | 3 | 5 | 164612 | 143160 | 21452 | .049 | .021 | .233 |
| 1970 | 18 | 10 | 8 | 170843 | 148579 | 22264 | .105 | .067 | .360 |
| 1971 | 14 | 6 | 8 | 174259 | 151550 | 22709 | .080 | .040 | .352 |
| 1972 | 15 | 9 | 6 | 218795 | 190379 | 28416 | .069 | .047 | .211 |
| 1973 | 11 | 7 | 4 | 243787 | 212108 | 31679 | .045 | .033 | .126 |
| 1974 | 9 | 3 | 6 | 259171 | 225455 | 33716 | .035 | .013 | .178 |
| 1975 | 14 | 5 | 9 | 270508 | 235224 | 35284 | .052 | .021 | .255 |
| 1976 | 6 | 4 | 2 | 247303 | 215075 | 32228 | .024 | .019 | .062 |
| 1977 | 11 | 5 | 6 | 282229 | 245513 | 36716 | .039 | .020 | .163 |
| 1978 | 21 | 15 | 6 | 353157 | 306839 | 46318 | .059 | .049 | .129 |
| 1979 | 18 | 7 | 11 | 398105 | 345946 | 52159 | .045 | .020 | .211 |
| TOTAL | 168 | 81 | 87 | 3248255 | 2824653 | 4236602 | .052 | .029 | .203 |

TABLE 33
RATIOS OF DAY TO NIGHT ACCIDENT RATES FOR
SPIFR AND DPIFR LANDING PHASE ACCIDENTS

| YEAR | SP(D)/DP(D) | SP(N)/DP(N) | SP(N)/SP(D) | DP(N)/DP(D) | ALL(N)/ALL(D) |
|---|---|---|---|---|---|
| 1964 | .75 | .54 | 24.1 | 33.1 | 26.2 |
| 1965 | | 2.73 | 23.4 | | 25.6 |
| 1966 | 1.36 | 1.75 | 8.6 | 6.7 | 8.9 |
| 1967 | 1.14 | 4.26 | 12.4 | 3.3 | 10.2 |
| 1968 | 1.59 | .39 | 5.8 | 23.9 | 9.4 |
| 1969 | 1.57 | 1.17 | 8.2 | 11.1 | 9.0 |
| 1970 | .66 | .82 | 6.7 | 5.3 | 6.1 |
| 1971 | 1.02 | .63 | 5.4 | 8.8 | 6.3 |
| 1972 | .83 | 1.95 | 10.5 | 4.5 | 8.6 |
| 1973 | .73 | 2.14 | 11.2 | 3.8 | 8.8 |
| 1974 | 2.23 | 1.23 | 7.5 | 13.7 | 8.3 |
| 1975 | 1.33 | .99 | 9.0 | 12.1 | 9.8 |
| 1976 | 1.53 | 2.92 | 6.2 | 3.3 | 5.6 |
| 1977 | 1.55 | 1.75 | 9.2 | 8.1 | 9.0 |
| 1978 | .49 | 2.41 | 12.9 | 2.6 | 8.4 |
| 1979 | 2.10 | 1.06 | 6.2 | 12.3 | 6.9 |
| MEAN | 1.26 | 1.67 | 10.5 | 10.2 | 10.4 |

TABLE 34
SUMMARY OF REGRESSION LINE SLOPES AND R-SQUARED VALUES FOR
DAY AND NIGHT ACCIDENT RATES IN TERMS OF 1000 APPROACHES

| | ALL YEARS | | 1964-1975 | | 1976-1979 | |
|---|---|---|---|---|---|---|
| | SLOPE | R-SQUARED | SLOPE | R-SQUARED | SLOPE | R-SQUARED |
| SPIFR DAY ACCIDENTS PER 1000 APPROACHES | .001 | .147 | .001 | .210 | .003 | .300 |
| SPIFR NIGHT ACCIDENTS PER 1000 APPROACHES | -.025 | .037 | -.004 | .050 | .026 | .350 |
| DPIFR DAY ACCIDENTS PER 1000 APPROACHES | .001 | .030 | .003 | .070 | .002 | .090 |
| DPIFR NIGHT ACCIDENTS PER 1000 APPROACHES | -.013 | .159 | -.012 | .070 | .041 | .720 |

TABLE 35
NUMBER OF TOTAL NIGHT ACCIDENTS IN TERMS OF
PILOT'S TOTAL FLIGHT HOURS

| PILOT TOTAL FLIGHT HOURS | 0-199 | 200-399 | 400-599 | 600-999 | 1K-1.9K | 2K-2.9K | 3K-4.9K | 5K-9.9K | 10K-14.9K | >15K | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NIGHT ACCIDENTS 1969-1975 | 1 | 11 | 9 | 13 | 23 | 29 | 32 | 23 | 11 | 6 | 158 |
| NIGHT ACCIDENTS 1976-1979 | 1 | 5 | 13 | 22 | 33 | 18 | 18 | 14 | 6 | 4 | 134 |
| OTHER (DAY/DAWN/DUSK) ACCIDENTS | 1 | 19 | 18 | 22 | 57 | 36 | 45 | 40 | 17 | 10 | 265 |
| PERCENT OCCURRED AT NIGHT | 66 | 46 | 55 | 61 | 50 | 56 | 52 | 48 | 50 | 50 | 52 |

TABLE 36
UNCONTROLLED COLLISIONS WITH GROUND/WATER IN TERMS OF VERTIGO AND ICING AS PRIMARY CAUSE FACTORS

| | VERTIGO | ICING | OTHER | TOTAL |
|---|---|---|---|---|
| SPIFR LANDING PHASE | 26 | 23 | 18 | 67 |
| DPIFR LANDING PHASE | 9 | 3 | 4 | 16 |
| SPIFR ENROUTE PHASE | 30 | 11 | 21 | 62 |
| TOTAL | 65 | 37 | 43 | 145 |

TABLE 37
VERTIGO INDUCED UNCONTROLLED COLLISIONS
WITH GROUND/WATER
CONDITION OF LIGHT VS. VARIOUS PHASES

| | DAY | | NIGHT | | DUSK/DAWN | | |
|---|---|---|---|---|---|---|---|
| | NO. | PERCENT | NO. | PERCENT | NO. | PERCENT | TOTAL |
| SPIFR LANDING PHASE | 5.0 | 19.2 | 19.0 | 73.1 | 2.0 | 7.7 | 26.0 |
| DPIFR LANDING PHASE | 6.0 | 40.0 | 9.0 | 60.0 | 0.0 | 0.0 | 15.0 |
| SPIFR ENROUTE PHASE | 17.0 | 58.6 | 10.0 | 34.5 | 2.0 | 6.9 | 29.0 |
| TOTAL | 28.0 | 40.0 | 38.0 | 54.3 | 4.0 | 5.7 | 70.0 |

TABLE 38
SPIFR VERTIGO INDUCED UNCONTROLLED COLLISIONS
WITH GROUND/WATER
CONDITION OF LIGHT VS. ACTUAL INSTRUMENT TIME

| ACTUAL INSTR. TIME | 0-9 | 10-19 | 20-39 | 40-59 | 60-99 | 100-199 | 200-299 | 300-499 | >500 | UNK |
|---|---|---|---|---|---|---|---|---|---|---|
| LANDING PHASE DAY | 1 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| NIGHT | 4 | 2 | 2 | 2 | 0 | 0 | 3 | 0 | 1 | 5 |
| ENROUTE PHASE DAY | 2 | 1 | 1 | 1 | 0 | 3 | 0 | 2 | 1 | 6 |
| NIGHT | 0 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 4 |

TABLE 39
SPIFR VERTIGO INDUCED UNCONTROLLED COLLISIONS
WITH GROUND/WATER
CONDITION OF LIGHT VS. TIME IN TYPE

| TOTAL TIME IN TYPE | 0-49 | 50-74 | 75-100 | 101-199 | 200-299 | 300-499 | 500-999 | >1000 |
|---|---|---|---|---|---|---|---|---|
| LANDING PHASE | | | | | | | | |
| DAY | 0 | 2 | 0 | 7 | 1 | 1 | 0 | 0 |
| NIGHT | 1 | 3 | 0 | 1 | 0 | 1 | 0 | 5 |
| ENROUTE PHASE | | | | | | | | |
| DAY | 2 | 2 | 1 | 3 | 0 | 1 | 4 | 1 |
| NIGHT | 4 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |

TABLE 40
SPIFR VERTIGO INDUCED UNCONTROLLED COLLISIONS
WITH GROUND/WATER
CONDITION OF LIGHT VS. TOTAL HOURS

| TOTAL TIME | 1-199 | 200-399 | 400-599 | 600-999 | 1-1.9K | 2-2.9K | >3.0K |
|---|---|---|---|---|---|---|---|
| LANDING PHASE | | | | | | | |
| DAY | 0 | 1 | 0 | 1 | 2 | 1 | 1 |
| NIGHT | 0 | 1 | 3 | 2 | 5 | 5 | 2 |
| ENROUTE PHASE | | | | | | | |
| DAY | 0 | 0 | 2 | 5 | 3 | 2 | 4 |
| NIGHT | 1 | 0 | 2 | 3 | 1 | 1 | 1 |

TABLE 41
SPIFR VERTIGO INDUCED UNCONTROLLED COLLISIONS
WITH GROUND/WATER
NIGHT ACCIDENTS VS. TOTAL NIGHT TIME

| TOTAL NIGHT TIME | 1-19 | 20-39 | 40-59 | 60-99 | 100-199 | 200-299 | 300-399 | >400 |
|---|---|---|---|---|---|---|---|---|
| LANDING PHASE | 2 | 3 | 0 | 2 | 4 | 0 | 3 | 2 |
| ENROUTE PHASE | 0 | 3 | 1 | 1 | 0 | 0 | 1 | 0 |
| TOTAL | 2 | 6 | 1 | 3 | 4 | 0 | 4 | 2 |

TABLE 42
SPIFR VERTIGO INDUCED UNCONTROLLED COLLISIONS WITH GROUND/WATER
STATISTICAL PROFILES

| | TOTAL HOURS | TIME LAST 90 DAYS | ACTUAL INSTRUMENT | SIMULATED INSTRUMENT |
|---|---|---|---|---|
| GA SURVEY RESPONSE PROFILE | | | | |
| MEAN | 3814 | 98 | 245 | 166 |
| STD. DEVIATION | 4961 | 119 | 449 | 280 |
| MEDIAN | 2051 | 57 | 150 | 75 |
| SPIFR TOTAL ACCIDENT PROFILE | | | | |
| MEAN | 3868 | 98 | 320 | 95 |
| STD. DEVIATION | 4457 | 86 | 499 | 164 |
| MEDIAN | 2394 | 71 | 150 | 61 |
| SPIFR LANDING PHASE VERTIGO | | | | |
| MEAN | 2582 | 73 | 189 | 101 |
| STD. DEVIATION | 3405 | 73 | 430 | 116 |
| MEDIAN | 1399 | 53 | 48 | 66 |
| SAMPLE SIZE | 26 | 20 | 20 | 16 |
| SPIFR ENROUTE PHASE VERTIGO | | | | |
| MEAN | 2802 | 59 | 128 | 63 |
| STD. DEVIATION | 4282 | 51 | 230 | 51 |
| MEDIAN | 975 | 38 | 48 | 63 |
| SAMPLE SIZE | 28 | 19 | 19 | 17 |

TABLE 43
SPIFR ICING INDUCED UNCONTROLLED COLLISIONS WITH GROUND/WATER
STATISTICAL PROFILES

| | TOTAL HOURS | TIME LAST 90 DAYS | ACTUAL INSTRUMENT | SIMULATED INSTRUMENT |
|---|---|---|---|---|
| GA SURVEY RESPONSE PROFILE | | | | |
| MEAN | 3814 | 98 | 245 | 166 |
| STD. DEVIATION | 4961 | 119 | 449 | 280 |
| MEDIAN | 2051 | 57 | 150 | 75 |
| SPIFR TOTAL ACCIDENT PROFILE | | | | |
| MEAN | 3868 | 98 | 320 | 95 |
| STD. DEVIATION | 4457 | 86 | 499 | 164 |
| MEDIAN | 2394 | 71 | 150 | 61 |
| SPIFR LANDING PHASE ICING | | | | |
| MEAN | 2413 | 79 | 168 | 70 |
| STD. DEVIATION | 2332 | 69 | 204 | 62 |
| MEDIAN | 1672 | 65 | 114 | 62 |
| SAMPLE SIZE | 22 | 17 | 13 | 8 |
| SPIFR ENROUTE PHASE ICING | | | | |
| MEAN | 2229 | 53 | 265 | 67 |
| STD. DEVIATION | 2240 | 88 | 223 | 52 |
| MEDIAN | 1367 | 27 | 219 | 55 |
| SAMPLE SIZE | 11 | 7 | 6 | 5 |

TABLE 44
SPIFR UNCONTROLLED COLLISIONS WITH GROUND/WATER IN THE LANDING PHASE IN TERMS OF PILOT EXPERIENCE

| HOURS | 0-49 | 50-99 | 100-199 | 200-299 | 300-399 | 400-499 | >500 | UNK |
|---|---|---|---|---|---|---|---|---|
| TIME IN TYPE | | | | | | | | |
| ICING | 3 | 1 | 4 | 0 | 2 | 0 | 9 | 4 |
| VERTIGO | 1 | 5 | 8 | 1 | 1 | 1 | 6 | 3 |
| ACTUAL INST HOURS | | | | | | | | |
| ICING | 5 | 1 | 4 | 1 | 1 | 0 | 1 | 10 |
| VERTIGO | 10 | 3 | 2 | 3 | 0 | 1 | 1 | 5 |
| NIGHT HOURS | | | | | | | | |
| ICING | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 17 |
| VERTIGO | 6 | 2 | 6 | 1 | 3 | 1 | 1 | 5 |
| TOTAL HOURS ** | | | | | | | | |
| ICING | 2 | 6 | 4 | 6 | 0 | 0 | 4 | 1 |
| VERTIGO | 4 | 5 | 7 | 5 | 2 | 0 | 3 | 0 |

**Total hours is in 10's of hours.

TABLE 45
SPIFR CONTROLLED COLLISIONS - MEDIANS

| | SPIFR | | DPIFR | |
|---|---|---|---|---|
| | DAY | NIGHT | DAY | NIGHT |
| CEILING HEIGHT | 500 | 300 | 400 | 300 |
| VISIBILITY | 1 | 1 | 1 | 1 |
| ACTUAL INSTRUMENT HOURS | 191.5 | 145.0 | 318.5 | 208.5 |
| SIM. INSTRUMENT HOURS | 59 | 59 | 105 | 72 |
| TOTAL NIGHT HOURS | 403 | 300 | 635 | 703 |
| TIME LAST 24 HOURS | 2 | 4 | 2 | 5 |
| TIME LAST 90 DAYS | 84.0 | 68.5 | 136.0 | 116.0 |
| TOTAL FLIGHT HOURS | 3134 | 2365 | 5771 | 3800 |
| TIME IN TYPE | 310 | 250 | 147 | 300 |
| PROXIMITY TO AIRPORT | 1.00 | 2.00 | 1.30 | .75 |

TABLE 46
SPIFR NIGHT CONTROLLED COLLISIONS DURING
LANDING PHASE FOR 1976-1979

| | 1976 | 1977 | 1978 | 1979 | 4 YR AVG |
|---|---|---|---|---|---|
| NIGHT APPROACHES FLOWN | 82872 | 94412 | 119102 | 134124 | 107600 |
| NIGHT CONTROLLED COLISIONS | 6 | 12 | 21 | 23 | 16 |
| RATE PER 1000 APPROACHES | .072 | .127 | .176 | .171 | .144 |
| OVERALL NIGHT ACCIDENT RATE/1000 APPROACHES | .181 | .286 | .311 | .261 | .259 |
| CONTROLLED COLLISION RATE/NIGHT RATE | .398 | .444 | .566 | .655 | .556 |

TABLE 47
SPIFR NIGHT CONTROLLED COLLISIONS, LANDING PHASE
CAUSE FACTOR COMPARISON

| CAUSE FACTOR: | WEATHER BELOW MINIMUMS 1964-1975 | 1976-1979 | FATAL ACCIDENTS 1964-1975 | 1976-1979 | ALL ACCIDENTS 1964-1975 | 1976-1979 |
|---|---|---|---|---|---|---|
| 1 IMPROPER IFR PROC. | 5 | 5 | 9 | 19 | 16 | 29 |
| 2 AIRCRAFT ICING | 0 | 0 | 3 | 2 | 9 | 6 |
| 3 DISTRACTED/DIVERTED ATTN | 0 | 0 | 1 | 0 | 7 | 0 |
| 4 SUSPECT MISREAD INST. | 2 | 1 | 4 | 0 | 9 | 1 |
| 5 FAULTY INSTRUMENT | 3 | 1 | 2 | 5 | 9 | 7 |
| 6 DESCENDED BELOW MINS | 20 | 1 | 21 | 0 | 44 | 4 |
| 7 MISJUDGED ALTITUDE | 0 | 0 | 1 | 2 | 5 | 2 |
| 8 A/C NOT PROPERLY EQUIPPED | 1 | 1 | 0 | 1 | 2 | 1 |
| 9 DIDN'T FLY PUB APPROACH | 0 | 1 | 5 | 3 | 5 | 4 |
| 10 PILOT EXCEEDED CAPABIL. | 0 | 1 | 2 | 2 | 2 | 6 |
| 11 PILOT INCAPACITATED | 0 | 0 | 2 | 1 | 2 | 1 |
| 12 VERTIGO | 0 | 0 | 1 | 1 | 1 | 1 |
| TOTAL | 31 | 11 | 51 | 36 | 111 | 62 |

TABLE 48 - SPIFR NIGHT CONTROLLED COLLISIONS
OPERATIONAL CAUSE FACTOR COMPARISON

| | IMPROPER IFR PROCEDURE | A/C NOT PROPERLY EQUIPPED | MISJUDGED ALTITUDE | PILOT INCAPACITATED | TOTAL |
|---|---|---|---|---|---|
| ACCIDENTS 1964-1975 | 83 | 20 | 5 | 3 | 111 |
| ACCIDENTS 1976-1979 | 44 | 14 | 2 | 2 | 62 |
| PROPORTION OCCURRING 1976-1979 | .346 | .412 | .286 | .400 | .358 |
| LOWER 95 PERCENT CONFIDENCE INTERVAL | .26 | .25 | .05 | .03 | |
| UPPER 95 PERCENT CONFIDENCE INTERVAL | .43 | .58 | .62 | .83 | |

TABLE 49
SPIFR NIGHT CONTROLLED COLLISIONS WITH GROUND/WATER
LANDING PHASE 1964-1979 - PILOT EXPERIENCE

| HOURS | 0-19 | 20-39 | 40-59 | 60-99 | 100-199 | 200-299 | 300-399 | 400-499 | 500-999 | >1000 |
|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL ACTUAL INSTRUMENT HOURS | 14 | 12 | 6 | 21 | 25 | 15 | 9 | 5 | 12 | 13 |
| TOTAL SIMULATED INSTRUMENT HOURS | 8 | 11 | 33 | 35 | 10 | 2 | 0 | 1 | 2 | 0 |
| TOTAL NIGHT FLIGHT HOURS | 6 | 5 | 6 | 10 | 27 | 10 | 13 | 8 | 23 | 23 |
| TOTAL TIME IN TYPE | 10 | 13 | 8 | 13 | 19 | 16 | 9 | 6 | 19 | 29 |
| | 0-199 | 200-399 | 400-599 | 600-999 | 1-1.4K | 15-1.9K | 2-2.9K | 3-4.9K | 5-9.9K | >10K |
| TOTAL FLIGHT HOURS | 1 | 8 | 14 | 19 | 20 | 15 | 20 | 30 | 28 | 14 |
| | 0-9 | 10-19 | 20-39 | 40-59 | 60-79 | 80-99 | 100-149 | 150-199 | 200-299 | >300 |
| TOTAL TIME LAST 90 DAYS | 3 | 12 | 18 | 23 | 20 | 11 | 16 | 10 | 19 | 6 |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8-9 | >10 |
| TOTAL TIME LAST 24 HOURS | 0 | 12 | 26 | 21 | 23 | 16 | 10 | 2 | 2 | 9 |

TABLE 50 - SPIFR DAY CONTROLLED COLLISIONS WITH GROUND/WATER
LANDING PHASE 1964-1979

| HOURS | 0-19 | 20-39 | 40-59 | 60-99 | 100-199 | 200-299 | 300-399 | 400-499 | 500-999 | >1000 |
|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL ACTUAL INSTRUMENT HOURS | 6 | 2 | 3 | 5 | 5 | 7 | 4 | 4 | 3 | 3 |
| TOTAL SIMULATED INSTRUMENT HOURS | 3 | 5 | 9 | 7 | 5 | 1 | 2 | 1 | 0 | 0 |
| TOTAL NIGHT FLIGHT HOURS | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 2 |
| TOTAL TIME IN TYPE | 1 | 6 | 0 | 3 | 9 | 6 | 5 | 3 | 9 | 11 |
| | 0-9 | 10-19 | 20-39 | 40-59 | 60-79 | 80-99 | 100-149 | 150-199 | 200-299 | >300 |
| TOTAL TIME LAST 90 DAYS | 1 | 1 | 11 | 5 | 6 | 6 | 10 | 6 | 2 | 2 |
| | 0-199 | 200-399 | 400-599 | 600-999 | 1-1.4K | 15-1.9K | 2-2.9K | 3-4.9K | 5-9.9K | >10K |
| TOTAL FLIGHT HOURS | 0 | 0 | 6 | 3 | 6 | 5 | 11 | 11 | 16 | 8 |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8-9 | >10 |
| TOTAL TIME LAST 24 HOURS | 0 | 8 | 13 | 6 | 3 | 2 | 2 | 2 | 0 | 0 |

TABLE 51
COMPARISON OF DAY AND NIGHT CONTROLLED COLLISIONS (C/C)
IN PERCENTAGES OF ACCIDENTS BY EXPERIENCE LEVEL.

| | 0-99 | 100-199 | 200-299 | 300-399 | 400-499 | 500-999 | >1000 | ACCDNTS |
|---|---|---|---|---|---|---|---|---|
| ACTUAL INST HOURS | | | | | | | | |
| NIGHT C/C | .40 | .19 | .11 | .07 | .04 | .09 | .10 | 132.00 |
| DAY C/C | .38 | .12 | .17 | .09 | .09 | .07 | .07 | 42.00 |
| SIMULATED INST HOURS | | | | | | | | |
| NIGHT C/C | .85 | .10 | .02 | 0.00 | .01 | .02 | 0.00 | 102.00 |
| DAY C/C | .73 | .15 | .03 | .06 | .03 | 0.00 | 0.00 | 33.00 |
| TIME IN TYPE | | | | | | | | |
| NIGHT C/C | .31 | .13 | .11 | .06 | .04 | .13 | .20 | 142.00 |
| DAY C/C | .19 | .17 | .11 | .09 | .06 | .17 | .21 | 53.00 |

| | 0-199 | 200-399 | 400-599 | 600-999 | 1.0K-1.4K | 1.5K-1.9K | 2.0K-2.9K | 3.0K-4.9K | 5.0K-9.9K | >10K | TOTAL ACCDNTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL HOURS | | | | | | | | | | | |
| NIGHT C/C | .01 | .05 | .08 | .11 | .12 | .09 | .12 | .18 | .17 | .08 | 169.00 |
| DAY C/C | 0.00 | 0.00 | .09 | .05 | .09 | .05 | .17 | .17 | .24 | .12 | 66.00 |

| | 0-9 | 10-19 | 20-39 | 40-59 | 60-79 | 80-99 | 100-149 | 150-199 | 200-299 | >300 | TOTAL ACCDNTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME LAST 90 DAYS | | | | | | | | | | | |
| NIGHT C/C | .02 | .09 | .13 | .17 | .14 | .08 | .12 | .07 | .14 | .04 | 138.00 |
| DAY C/C | .02 | .02 | .22 | .10 | .12 | .12 | .20 | .12 | .04 | .04 | 50.00 |

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8-9 | >10 | TOTAL ACCDNTS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME LAST 24 HOURS | | | | | | | | | | | |
| NIGHT C/C | 0.00 | .10 | .21 | .17 | .19 | .13 | .08 | .02 | .02 | .07 | 121.00 |
| DAY C/C | 0.00 | .22 | .36 | .17 | .08 | .06 | .06 | .06 | 0.00 | 0.00 | 36.00 |

TABLE 52 - SPIFR CONTROLLED COLLISIONS WITH GROUND/WATER STATISTICAL PROFILES.

| | TOTAL HOURS | TIME LAST 90 DAYS | ACTUAL INSTRUMENT | SIMULATED INSTRUMENT |
|---|---|---|---|---|
| GA SURVEY RESPONSE PROFILE | | | | |
| MEAN | 3814 | 98 | 245 | 166 |
| STD. DEVIATION | 4961 | 119 | 449 | 280 |
| MEDIAN | 2051 | 57 | 150 | 75 |
| SPIFR TOTAL ACCIDENT PROFILE | | | | |
| MEAN | 3868 | 98 | 320 | 95 |
| STD. DEVIATION | 4457 | 86 | 499 | 164 |
| MEDIAN | 2394 | 71 | 150 | 61 |
| NIGHT CONTROLLED COLLISIONS | | | | |
| MEAN | 3775 | 104 | 341 | 78 |
| STD. DEVIATION | 4464 | 90 | 545 | 87 |
| MEDIAN | 2365 | 69 | 145 | 59 |
| DAY CONTROLLED COLLISIONS | | | | |
| MEAN | 5041 | 97 | 276 | 101 |
| STD. DEVIATION | 4893 | 76 | 312 | 111 |
| MEDIAN | 3134 | 84 | 191 | 59 |

TABLE 53 - SPIFR SIMULATED INSTRUMENT HOURS VS TYPE OF AIRCRAFT (CONTROLLED COLLISIONS DAY AND NIGHT).

| SIMULATED INSTRUMENT TIME | 0-19 | 20-39 | 40-59 | 60-99 | 100-199 | 200-299 | 300-399 | 400-499 | >500 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|
| SINGLE ENGINE FIXED GEAR | 2 | 2 | 8 | 6 | 0 | 0 | 1 | 0 | 0 | 19 |
| SINGLE ENGINE RETRACTABLE GEAR | 4 | 3 | 14 | 14 | 2 | 2 | 0 | 0 | 0 | 39 |
| TWIN ENGINE PISTON | 8 | 10 | 23 | 25 | 12 | 2 | 1 | 2 | 1 | 84 |
| TURBO-PROP | 1 | 3 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 8 |
| TOTAL PERCENTAGE SINGLE ENGINE | .10 | .09 | .38 | .34 | .03 | .03 | .02 | 0.00 | 0.00 | 58.00 |
| TOTAL PERCENTAGE TWIN ENGINE | .10 | .15 | .26 | .28 | .15 | .02 | .01 | .02 | .01 | 92.00 |

TABLE 55 - CONTROLLED COLLISIONS: DAY/NIGHT SINGLE VERSUS TWIN ENGINE AIRCRAFT BY TIME IN TYPE

| HOURS | 0-19 | 20-39 | 40-59 | 60-99 | 100-199 | 200-299 | 300-399 | 400-499 | 500-999 | >1000 | REPORTED |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DAYTIME | | | | | | | | | | | |
| SINGLE ENGINE | 0.00 | .11 | 0.00 | .06 | .28 | .06 | .17 | 0.00 | .06 | .28 | 18.00 |
| TWIN ENGINE | .03 | .10 | 0.00 | .08 | .15 | .13 | .05 | .08 | .21 | .18 | 39.00 |
| NIGHTTIME | | | | | | | | | | | |
| SINGLE ENGINE | .07 | .13 | .10 | .10 | .11 | .13 | .07 | .03 | .11 | .15 | 61.00 |
| TWIN ENGINE | .07 | .06 | .03 | .08 | .14 | .10 | .07 | .05 | .15 | .24 | 86.00 |

| HOURS | 0-99 | 100-299 | 300-499 | 500-999 | >1000 |
|---|---|---|---|---|---|
| DAYTIME | | | | | |
| SINGLE ENGINE | .17 | .34 | .17 | .06 | .28 |
| TWIN ENGINE | .21 | .28 | .13 | .21 | .18 |
| NIGHTTIME | | | | | |
| SINGLE ENGINE | .40 | .24 | .10 | .11 | .15 |
| TWIN ENGINE | .24 | .24 | .12 | .15 | .24 |

TABLE 56: SPIFR NIGHT CONTROLLED COLLISIONS DURING THE LANDING PHASE VERSUS VISIBILITY

| VISIBILITY (MI) | 0 | .25 | .5 | .75 | 1 | 2 | 3 | 4 | 5 | >5 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| NIGHT SPIFR | 7 | 20 | 24 | 13 | 35 | 38 | 15 | 17 | 1 | 3 | 173 |
| DAY SPIFR | 5 | 14 | 6 | 5 | 10 | 14 | 9 | 0 | 0 | 2 | 65 |
| NIGHT DPIFR | 2 | 7 | 3 | 6 | 9 | 11 | 1 | 2 | 2 | 0 | 43 |
| DAY DPIFR | 3 | 3 | 3 | 2 | 6 | 2 | 2 | 1 | 2 | 0 | 24 |
| NIGHT SPIFR % | .04 | .12 | .14 | .07 | .20 | .22 | .09 | .10 | .01 | .02 | |
| DAY SPIFR % | .08 | .22 | .09 | .08 | .15 | .22 | .14 | 0.00 | 0.00 | .03 | |
| NIGHT DPIFR % | .05 | .19 | .08 | .16 | .24 | .30 | .03 | .05 | .05 | 0.00 | |
| DAY DPIFR % | .12 | .12 | .12 | .08 | .25 | .08 | .08 | .04 | .08 | 0.00 | |

TABLE 57
SPIFR NIGHT CONTROLLED COLLISIONS DURING THE LANDING PHASE
VISIBILITY VERSUS PROXIMITY TO AIRPORT

| VISIBILITY (MI) | 0 | .25 | .5 | .75 | 1 | 2 | 3 | 4 | 5 | >5 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DAY SPIFR WITHIN AIRPORT SIGHT | 1 | 2 | 3 | 2 | 8 | 7 | 3 | 0 | 0 | 2 | 28 |
| DAY SPIFR VISIBILITY LESS THAN DISTANCE | 4 | 12 | 3 | 3 | 2 | 7 | 6 | 0 | 0 | 0 | 37 |
| NIGHT SPIFR WITHIN AIRPORT SIGHT | 1 | 8 | 6 | 5 | 19 | 25 | 10 | 4 | 8 | 1 | 87 |
| NIGHT SPIFR VISIBILITY LESS THAN DISTANCE | 6 | 12 | 18 | 8 | 16 | 13 | 5 | 5 | 0 | 2 | 85 |

TABLE 58
SPIFR NIGHT CONTROLLED COLLISIONS DURING THE LANDING PHASE
CAUSE FACTOR VERSUS TYPE OF APPROACH

| CAUSE FACTOR: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOR/TVOR STRAIGHT-IN | 2 | 3 | 1 | 2 | 3 | 13 | 1 | 0 | 2 | 2 | 0 | 0 | 29 |
| VOR/TVOR CIRCLING | 2 | 1 | 1 | 2 | 1 | 4 | 1 | 0 | 1 | 0 | 0 | 0 | 13 |
| VOR/DME STRAIGHT-IN | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 5 |
| VOR/DME CIRCLING | 2 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| ADF STRAIGHT-IN | 6 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 1 | 1 | 0 | 0 | 13 |
| LOC STRAIGHT-IN | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| ILS STRAIGHT-IN(NO ADVISORY) | 14 | 3 | 2 | 3 | 4 | 12 | 1 | 0 | 1 | 1 | 1 | 2 | 44 |
| ILS CIRC(NO ADVISORY) | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| ILS STRAIGHT-IN(W/ADVISORY) | 6 | 1 | 0 | 2 | 2 | 4 | 1 | 0 | 2 | 1 | 1 | 0 | 20 |
| ILS CIRC(W/ADVISORY) | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| ILS BACK COURSE | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| ASR APPROACH | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 5 |
| VISUAL APPROACH | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| OTHER | 2 | 1 | 1 | 1 | 1 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 11 |
| TOTAL | 38 | 13 | 6 | 10 | 14 | 47 | 8 | 2 | 8 | 6 | 2 | 2 | 156 |

CAUSE FACTOR CODES:

1. Improper IFR procedures
2. Icing related
3. Pilot distracted/diverted attention
4. Suspect instrument misread
5. Faulty instrument
6. Descended below minimums
7. Misjudged altitude
8. A/c not properly equipped
9. Did not fly published approach
10. Conditions exceeded pilot's capabilites
11. Pilot incapacitated
12. Spatial disorientation (Vertigo)

# APPENDIX C

# REFERENCES

# REFERENCES


A. Forsyth, Donna L. and John D. Shaughnessy: Single Pilot IFR Operating Problems Determined from Accident Data Analysis. NASA TM-78773,1978.

B. Federal Aviation Agency: Statistical Handbook of Aviation, Calender years 1964-1980; U.S. Department of Transportation.

C. Weislogel, G. S. and G. C. Chapman: Study to Determine the IFR Operational Profile of the General Aviation Single Pilot. NASA CR-165805,1982.

D. Federal Aviation Agency: General Aviation Pilot and Aircraft Activity Summary 1979. U.S. Department of Transportation.

E. Federal Aviation Agency: General Aviation Activity and Avionics Survey; Annual Summary Report 1977-80. U.S. Department of Transportation.

F. Weislogel, G. S. and ASRS Office Staff: Operational Problems Experienced by Single Pilots in Instrument Meteorological Conditions. NASA CR-168837,1981.

G. Federal Aviation Agency: Palo Alto Airport Tower Operations; March 1977; U.S. Department of Transportation; FAA-AVP-77-21.

H. Goldman, Donald: Development of a Technique for Estimating Annual Instrument Approaches (AIA's); June 1976; Mitre Corporation; McClean, Virginia; MTR-7265.

I. Benjamin, Henry: Pilot Accident Potential as Related to Total Flight Experience and Recency and Frequency of Flying;1974; Naval Postgraduate School, Monterey, California.

J. Newman, R. L. and D. L. Quam: Pilot Reaction to Attitude Gyro Failure - a Flight Experiment"; Canadian Aeronautics and Space Journal, Vol 26, 1980, pp. 303-310.

K. Quinby, G. F.: General Aviation Operating Requirements for the 1980's; Society of Automotive Engineers, International Air Transportation Meeting; Cincinatti, Ohio; May 20-22,1980.

L. Toepel, W. O.: Requirements for Short Instrument Runways; Ortung and Navigation (German); No. 2, 1979, pp. 266-271.

M. Finnegan, J. P.: Transfer of a Computer Assisted Instrument Procedures Trainer to Flight; Human Factors Society, Annual Meeting, San Francisco, California; October 17-20, 1977.

N. Brunner, D.: Measures for Enhancing Safety in General Aviation in the Areas of Air Traffic Control, Navigation, and Meteorology; Ortung and Navigation (German); No. 4, 1976, pp. 99-108.

O. Allen, R. and W. Roberts: Aspects of Structural Safety in General Aviation Airplanes; Society of Automotive Engineers National Business Aircraft Meeting; Wichita, Kansas; March 15-17, 1972.

P. Colomy, J. R.: Meteorological Input to General Aviation Pilot Training. Proceedings, 3rd Annual Workshop on Meteorlogical and Environmental Inputs to Aviation Systems, D.W. Camp and W. Frost, eds., NASA CP-2104, FAA-RD-79-49, 1979, pp. 30-36.

Q. Bolz, E. H. and J. E. Eisele: General Aviation IFR Operational Problems. NASA CR-159022,1979.

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| NASA CR-3650 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| SINGLE PILOT IFR ACCIDENT DATA ANALYSIS | November 1982 |
| | 6. Performing Organization Code |



| 7. Author(s) | 8. Performing Organization Report No. |
|---|---|
| D.F. Harris and J.A. Morrisette | |
| 9. Performing Organization Name and Address<br>Spectrum Technology Incorporated<br>P.O. Box 846<br>Virginia Beach, VA 23451 | 10. Work Unit No. |
| | 11. Contract or Grant No.<br>NAS1-16920 |





| 12. Sponsoring Agency Name and Address | 13. Type of Report and Period Covered |
|---|---|
| National Aeronautics and Space Administration<br>Washington, D.C. 20546 | Contractor Report |
| | 14. Sponsoring Agency Code |

15. Supplementary Notes

Langley technical monitor: David A. Hinton
Final Report



16. Abstract


The aircraft accident data recorded and maintained by the National Transportation Safety Board (NTSB) for 1964-1979 were analyzed to determine what problems exist in the general aviation (GA) single pilot instrument flight rules (SPIFR) environment. A previous study conducted in 1978 for the years 1964-1975 provided a basis for comparison.

The purpose of the research and analysis upon which this report is based was to determine what changes, if any, have occurred in trends and cause-effect relationships reported in the earlier study. The increasing numbers have been tied to measures of activity to produce accident rates which in turn were analyzed in terms of change. Where anomalies or unusually high accident rates were encountered, further analysis was conducted to isolate pertinent patterns of cause factors and/or experience levels of involved pilots. The bulk of the effort addresses accidents in the landing phase of operations.

Detailed analysis was performed on controlled/uncontrolled collisions and their unique attributes delineated. Estimates of day vs. night general aviation activity and accident rates were obtained.




| 17. Key Words (Suggested by Author(s)) | 18. Distribution Statement |
|---|---|
| IFR<br>General Aviation<br>Accident Analysis | Unclassified - Unlimited<br><br>Subject Category 03 |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 108 | A06 |

For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1982