

ORIENTATION-ERROR ACCIDENTS IN REGULAR ARMY UH-1 AIRCRAFT  
DURING FISCAL YEAR 1969: RELATIVE INCIDENCE AND COST

W. Carroll Hixson, Jorma I. Niven, and Emil Spezia



U. S. ARMY AEROMEDICAL RESEARCH LABORATORY  
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| <p>This report is the third in a longitudinal series of reports dealing with the magnitude of the pilot disorientation/vertigo accident problem in Regular Army UH-1 helicopter operations. Incidence and cost data presented for fiscal year 1969 include a total of 46 major and minor orientation-error accidents (16 of which were fatal), resulting in 39 fatalities, 67 nonfatal injuries, and \$8,130,297 aircraft damage.</p> |                                                                             |                                    |

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| Aviation medicine    |        |    |        |    |        |    |
| Aviation safety      |        |    |        |    |        |    |
| Aircraft accidents   |        |    |        |    |        |    |
| Pilot disorientation |        |    |        |    |        |    |
| Vertigo              |        |    |        |    |        |    |
| UH-1 helicopters     |        |    |        |    |        |    |

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U. S. Army Aeromedical Research Laboratory

Approved by  
Ashton Graybiel, M.D.  
Assistant for Scientific Programs

Released by  
Captain N. W. Allebach, MC USN  
Officer in Charge

28 August 1972

NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY  
NAVAL AEROSPACE MEDICAL INSTITUTE  
NAVAL AEROSPACE AND REGIONAL MEDICAL CENTER  
PENSACOLA, FLORIDA 32512

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## SUMMARY PAGE

### THE PROBLEM

From the military mission viewpoint, the amount of research effort to be expended on the solution of a given aviation medicine problem must be keyed to the operational cost of the problem. Therefore, a necessary first step in the development of a solution is the assimilation of data that define the magnitude of the problem. Though orientation-error accidents involving pilot disorientation and vertigo have been long recognized to exist, little quantitative data are available to describe the actual incidence and cost of such accidents in Army aviation.

### FINDINGS

To initiate the action necessary to establish the magnitude of the orientation-error problem in Army aviation, an interservice research program was organized under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory, the U. S. Army Agency for Aviation Safety, and the Naval Aerospace Medical Research Laboratory. The first task was the construction of an operational definition of an orientation-error accident. The assimilation of data pertaining to the incidence and cause of such accidents and their actual and relative costs in terms of fatalities, injuries, and aircraft damage was then set as the working objective of the program. Accordingly, the decision was made to implement a five-year longitudinal study of all major and minor orientation-error accidents involving Regular Army flight operations beginning with fiscal year 1967. Findings are being summarized on a fiscal-year basis in three separate lines of reports: The first line is devoted to defining the over-all magnitude of the orientation-error problem in all aircraft types; the second line to the presentation of similar incidence and cost data for accidents involving only the UH-1 aircraft, the predominant rotary wing aircraft in the Army inventory; and the third line to the description of the various causal factors found to be present in the major UH-1 orientation-error accidents.

This specific report is the third in the series dealing with the magnitude of the orientation-error problem in UH-1 aircraft. Incidence and cost data are presented for all major and minor orientation-error accidents involving Regular Army UH-1 flight operations that were detected in the search of the fiscal year 1969 accident files.

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The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

## ACKNOWLEDGMENTS

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## INTRODUCTION

To investigate the operational role of pilot disorientation and vertigo in all orientation-error types of aircraft accidents, the authors have organized an interservice research program under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory (USAARL), the U. S. Army Agency for Aviation Safety (USAAAVS), and the Naval Aerospace Medical Research Laboratory (NAMRL). Since few quantified data were available to describe the actual magnitude of the orientation-error problem in Regular Army flight operations, the decision was made to conduct a five-year longitudinal study, beginning with fiscal year 1967, of all Army aircraft accidents that involved an erroneous judgment of aircraft motion or attitude on the part of the pilot. Two separate, but related, project objectives were set for the longitudinal study. The first was to extract and assimilate data from the USAAAVS master aircraft-accident files which would define the actual and relative cost of orientation-error accidents to Regular Army flight operations. These data, by defining the operational magnitude of the problem, would then serve to define the extent of the research support that should be devoted to its solution. The second working objective was to extract data on a case-history basis which would describe the various pilot/aircraft/mission/environment factors found to be present in each of the orientation-error accidents. Assimilation and analysis of these data over the study period would result in better knowledge of the most common operational causes of orientation-error accidents and thus point out those research directions which offer the greatest potential toward the reduction of accident incidence.

The results of the longitudinal study are being summarized in three separate lines of reports, with one report in each line prepared for each fiscal year of the five-year study. The first line of reports (for example, refs. 1, 4, and 7) is devoted to defining the incidence and cost of all major and minor orientation-error accidents involving all aircraft types, fixed wing as well as rotary wing, that occurred in Regular Army flight operations for each fiscal year. Since the UH-1 "Huey" helicopter has been, and is, the predominant aircraft in the Army rotary wing inventory, the second line of reports (for example, refs. 2 and 5) is devoted to defining the magnitude of the orientation-error accident problem in only this aircraft. The layout and format of this line of reports are almost identical to those of the first line. The third line of reports (for example, refs. 3 and 6) deals exclusively with the various causal factors found to be present in all of the major UH-1 orientation-error accidents. Typical data to be presented include phase of flight, time of day, type of mission, pilot experience, physiological factors, psychological factors, facility factors, environmental factors, and the like.

This specific report is the third in the series dealing with the magnitude of the orientation-error problem in UH-1 aircraft. Incidence and cost data are presented for all major and minor orientation-error accidents involving Regular Army UH-1 flight operations that were detected in the search of the fiscal year 1969 accident files. In addition, corresponding cost data are presented for both all accident types, regardless of cause, and for pilot-error accident types so as to better establish the relative magnitude of the UH-1 orientation-error accident problem.

## PROCEDURE

A basic requirement for the commencement of this study was a workable definition of the class of accident to be defined as involving orientation error. The reader is referred to previous reports (refs. 1-3) for a comprehensive definition and discussion of its rationale. Briefly, orientation is considered to involve the correct determination of the dynamic position and attitude of an aircraft in three-dimensional space. The key word here is dynamic, which implies that full knowledge of the motion as well as static attitude and position is required to define its instantaneous spatial orientation. Accordingly, a pilot is considered to have made an orientation error whenever his perception of the motion and attitude of his aircraft differs from the true motion or attitude; i.e., the true orientation of the aircraft. An orientation-error accident is then defined as one that occurs as a result of an incorrect control or power action taken by a pilot (or a correct action not taken) due to his incorrect perception of the true orientation of his aircraft.

With this definition of orientation-error accidents serving as a classification reference, an experienced classifier read all briefs in the USAAVS master accident files and selected all major and minor accidents of this type occurring during fiscal year 1969. For redundancy, the entire accident files were also searched by sifting the coded summaries that USAAVS prepares for each accident for a wide range of indicator terms.

The authors then reviewed the accident briefs independently for the purpose of establishing whether or not an orientation-error accident classification would result. In addition, the comprehensive master file on each suspect accident was obtained and reviewed. Whenever there was serious question as to the contribution of orientation error to the accident or where equally weighted alternative causal factors were present, then the accident was not included in the classification. The net effect of this policy is to give a conservative estimate of the magnitude of the orientation-error accident problem.

## RESULTS AND DISCUSSION

To place the operational significance of UH-1 orientation-error accidents in proper perspective, it is necessary to have at least a cursory understanding of the incidence and cost of UH-1 aircraft accidents in general. As with the previous UH-1 reports (refs. 2 and 5) this is accomplished as follows: The lead section below is devoted to describing the over-all cost of all Regular Army UH-1 aircraft accidents, regardless of type or location, that occurred during fiscal year 1969. In a second section, equivalent data in a nearly identical format are presented to isolate those UH-1 accidents in the first section that were classified by USAAVS as involving one or more pilot-error factors. Incidence and cost statistics pertaining to UH-1 orientation-error accidents only are then presented in a third section. By using these three sets of data as independent references, it then becomes possible to derive some quantitative insight into the relative, as well as actual, cost of UH-1 orientation-error accidents in Regular Army flight operations. Selected comparative relationships are presented in the last section of the report.

To facilitate the point-by-point comparison of these fiscal year 1969 UH-1 data with corresponding data derived for other fiscal years of the longitudinal study, the layout and numbering of all tables and figures in this report follows identically those used in the previous UH-1 reports (refs. 2 and 5).

## ALL TYPES OF UH-1 AIRCRAFT ACCIDENTS

The data presented in this section describe the incidence and cost of all major and minor UH-1 helicopter accidents involving Regular Army flight operations during fiscal year 1969. Separate data groupings are provided for those accidents that occurred in Vietnam, those accidents that occurred elsewhere, and their combined total. Since the vast majority of the accidents that do not occur in Vietnam (VN) take place within the continental limits of the United States, the abbreviation US is arbitrarily used to denote all accidents that do not occur in Vietnam. It should be realized then that the US data grouping will include a small number of accidents that may have occurred, for example, in Europe, Africa, or elsewhere. A second point to be stressed is that the VN data pertain strictly to accidents, not losses due to enemy action.

In the interpretation of the accident statistics to follow, it becomes possible to compare VN and US accident incidence only when some common measures of aircraft utilization are selected as weighting factors. A similar requirement exists for comparison of accident incidence in one given fiscal year with incidence in other fiscal years. To establish such reference, percent aircraft inventory, total flying hours, and total aircraft landings are used as basic weighting data in this report. These data, as well as the incidence and cost statistics discussed in this section, are summarized in Table I.

The aircraft inventory data listed in Table I show that for fiscal year 1969, the average number of UH-1 aircraft operating out of VN was 54.94 percent of the total UH-1 inventory. This results in a VN/US inventory ratio of 1.22 to 1. The total flight hours and total landings data listed in Table I show an even greater weighting factor for the VN operations; i.e., a VN/US total hours ratio of 2.75 to 1 and a VN/US total landings ratio of 2.14 to 1. Thus for this fiscal year, aircraft utilization in terms of inventory, total hours, and total landings was greater in VN.

With these aircraft utilization data serving as background reference, it becomes possible to make a weighted interpretation of the raw accident data presented in Table I. Selected excerpts from these data are presented in Figures 2 and 3. The numerical incidence of all major and minor UH-1 aircraft accidents, regardless of type or causal factor, is plotted in Figure 2. The cost of these accidents, as measured by the number of fatal accidents, number of fatalities, number of nonfatal injuries, and aircraft dollar damage is outlined in Figures 3A through 3D, respectively.

In terms of the over-all UH-1 accident problem during fiscal year 1969, there were a total of 545 accidents (81 of which were fatal), resulting in 281 fatalities, 699 nonfatal injuries, and a UH-1 aircraft damage cost of \$82,379,000. The Vietnam contribution to these totals was 479 accidents (72 of which were fatal), resulting in 255 fatalities, 639

TABLE I  
FISCAL YEAR 1969 DATA

| ALL ACCIDENT TYPES                     | UH-1 AIRCRAFT ONLY |                       |                  |                   |
|----------------------------------------|--------------------|-----------------------|------------------|-------------------|
| ACCIDENT INDEX                         | U.S.<br>ACCIDENTS  | VIET NAM<br>ACCIDENTS | ALL<br>ACCIDENTS | VN to US<br>RATIO |
| Major Accidents                        | 53                 | 451                   | 504              | 8.51              |
| Minor Accidents                        | 13                 | 28                    | 41               | 2.15              |
| Total Accidents                        | 66                 | 479                   | 545              | 7.26              |
| Aircraft Inventory - Percent Total     | 45.06              | 54.94                 | 100.00           | 1.22              |
| Total Flying Hours                     | 682,762            | 1,878,250             | 2,561,012        | 2.75              |
| Total Landings                         | 2,735,105          | 5,843,997             | 8,579,102        | 2.14              |
| Major Accidents per 100,000 Hours      | 7.76               | 24.01                 | 19.68            | 3.09              |
| Minor Accidents per 100,000 Hours      | 1.90               | 1.49                  | 1.60             | 0.78              |
| Total Accidents per 100,000 Hours      | 9.67               | 25.50                 | 21.28            | 2.64              |
| Major Accidents per 100,000 Landings   | 1.94               | 7.72                  | 5.87             | 3.98              |
| Minor Accidents per 100,000 Landings   | 0.47               | 0.48                  | 0.48             | 1.01              |
| Total Accidents per 100,000 Landings   | 2.41               | 8.20                  | 6.35             | 3.40              |
| Total Dollar Cost                      | 7,920,000          | 74,459,000            | 82,379,000       | 9.40              |
| Average Dollar Cost per Accident       | 120,000            | 155,447               | 151,154          | 1.29              |
| Total Fatalities                       | 26                 | 255                   | 281              | 9.81              |
| Average Fatalities per Accident        | 0.39               | 0.53                  | 0.51             | 1.35              |
| Fatal Accidents - Number               | 9                  | 72                    | 81               | 8.00              |
| Fatal Accidents - Percent              | 13.64              | 15.03                 | 14.86            | 1.10              |
| Average Fatalities per Fatal Accident  | 2.89               | 3.54                  | 3.47             | 1.23              |
| Total Nonfatal Injuries                | 60                 | 639                   | 699              | 10.65             |
| Average Nonfatal Injuries per Accident | 0.91               | 1.33                  | 1.28             | 1.47              |

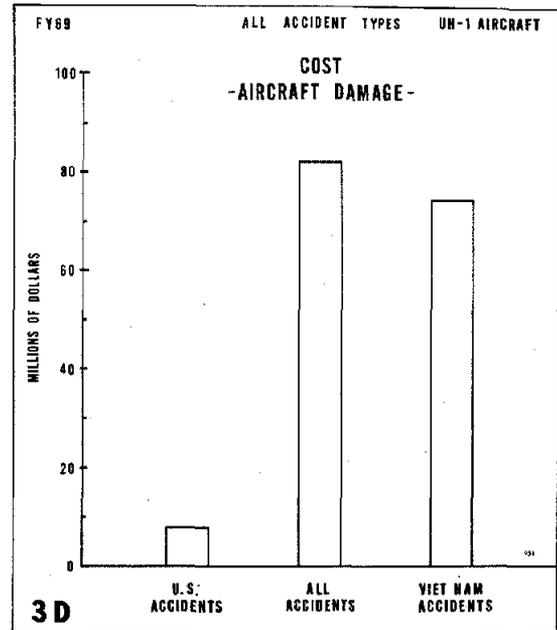
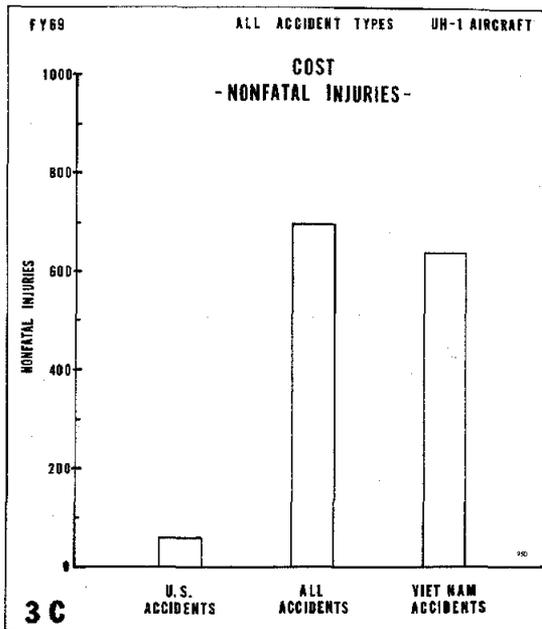
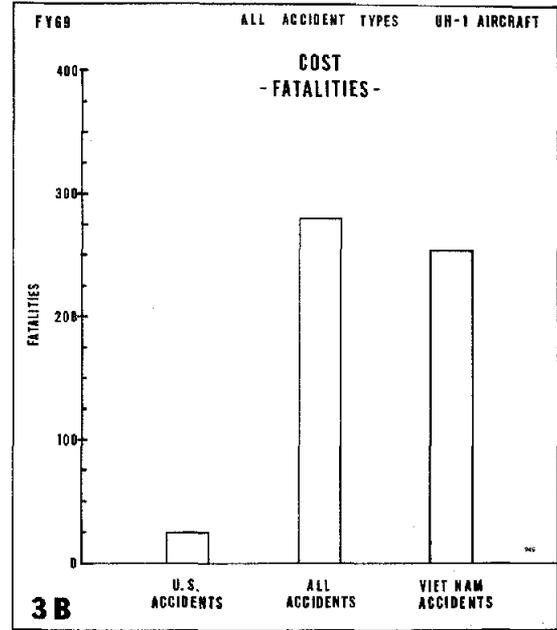
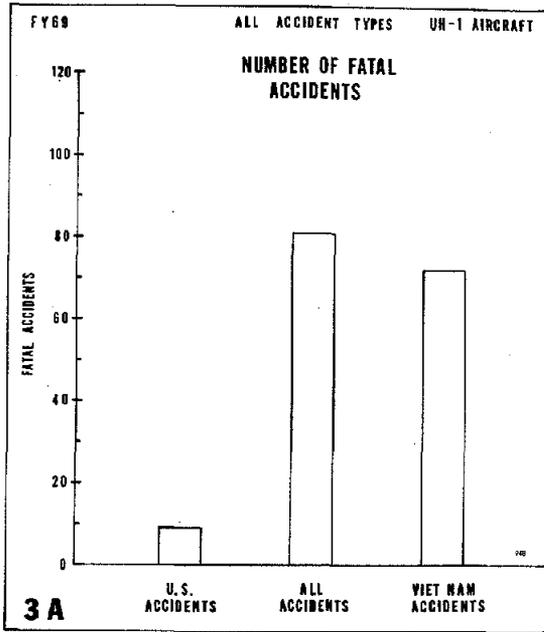


Figure 3

All UH-1 Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting UH-1 aircraft damage (D). In all cases, the VN costs were greater.

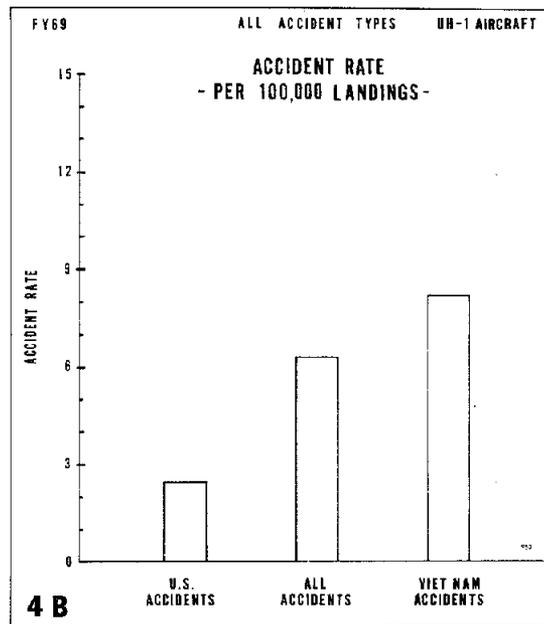
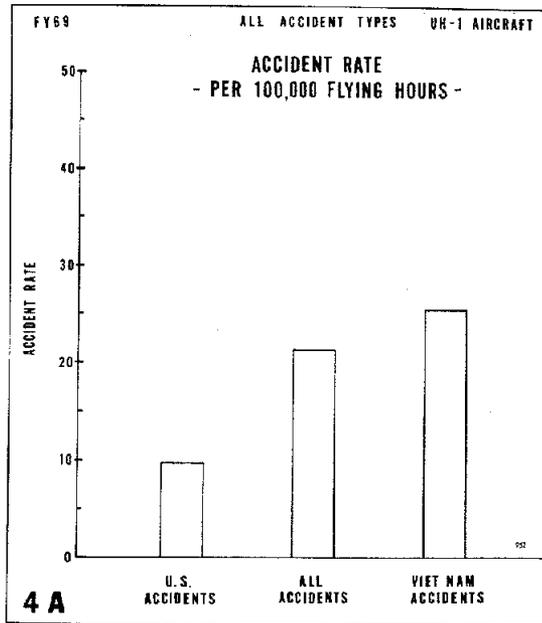


Figure 4

All UH-1 Accident Types: Normalized incidence data showing the average number of UH-1 accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). The over-all rates were 21.28 accidents per 100,000 hours and 6.35 accidents per 100,000 landings. The VN rate was 2.64 times the US rate using hours as reference, and 3.40 times the US rate using landings as reference.

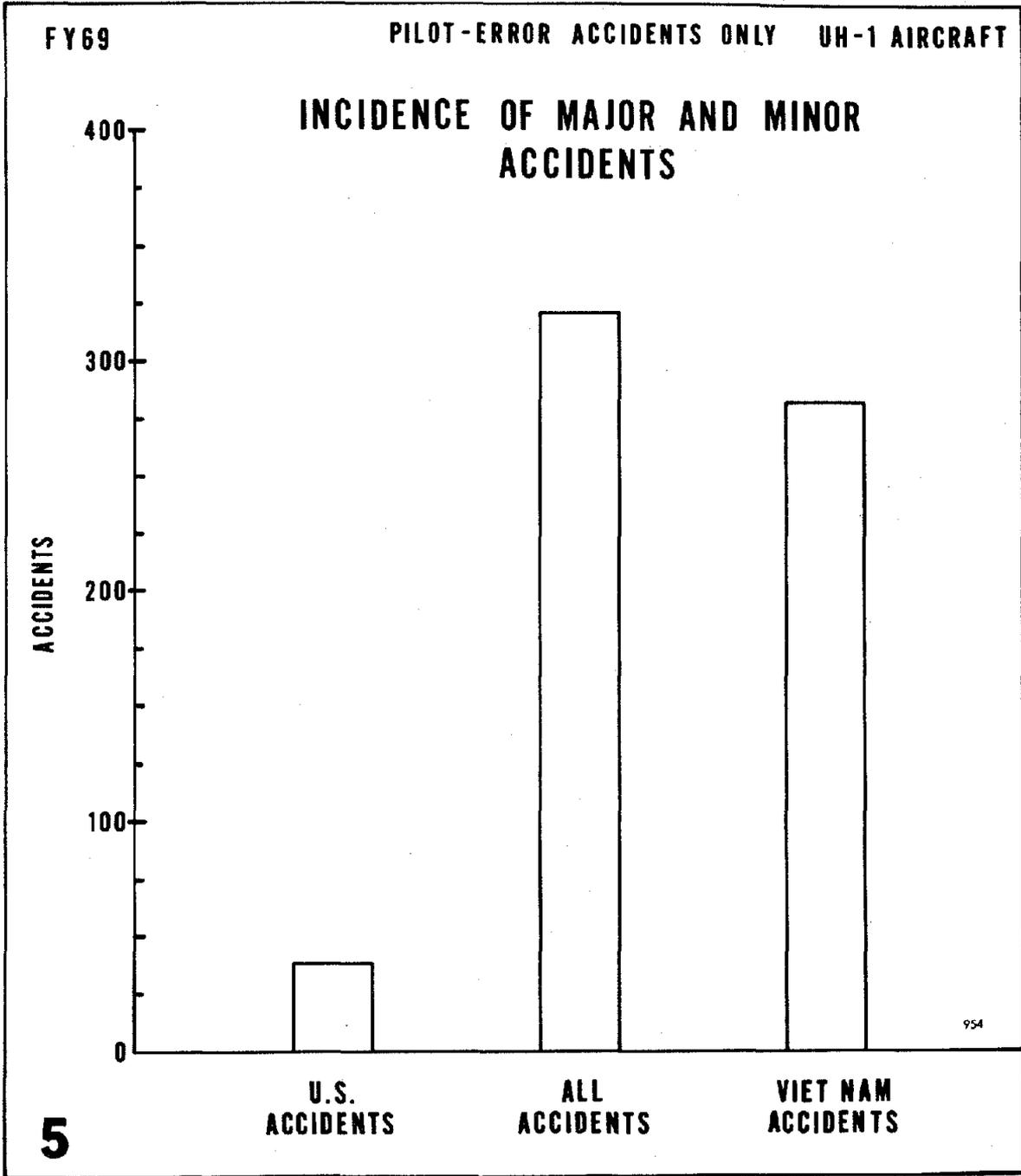


Figure 5

UH-1 Pilot-Error Accident Types: Total number of major and minor UH-1 aircraft accidents involving the presence of one or more pilot-error factors as classified by USABAAR. The number of pilot-error accidents that occurred in VN was 7.23 times the number of accidents that occurred elsewhere.

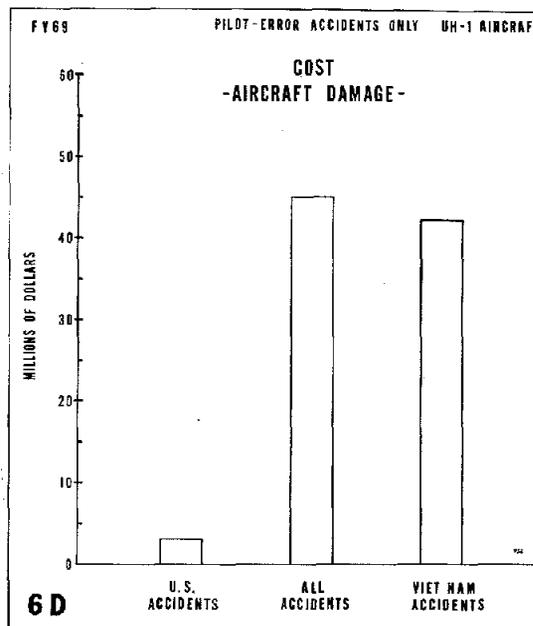
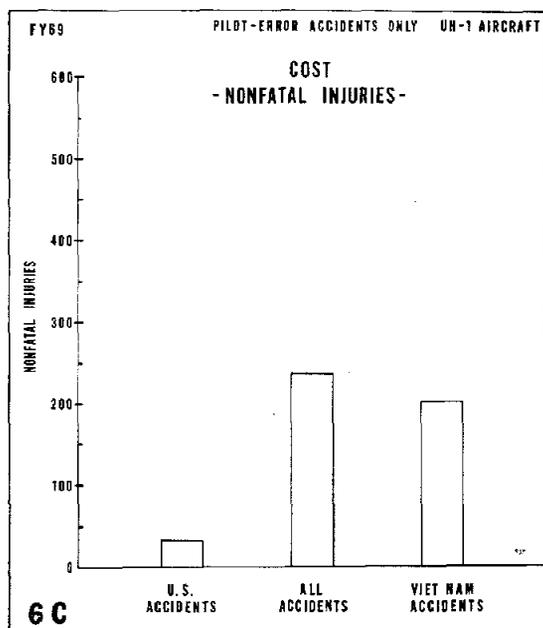
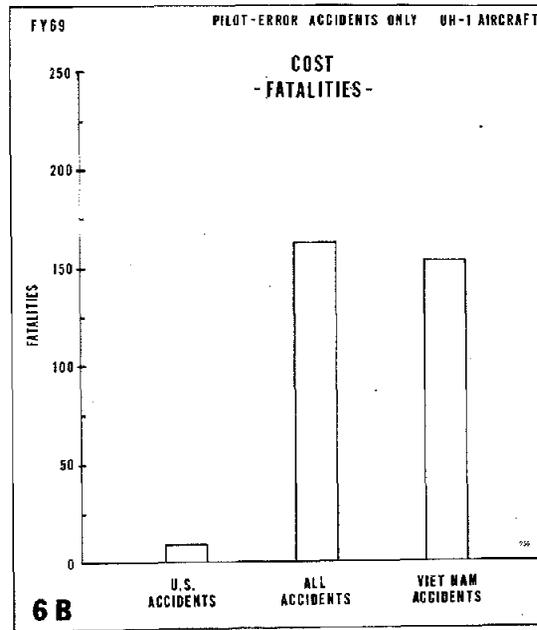
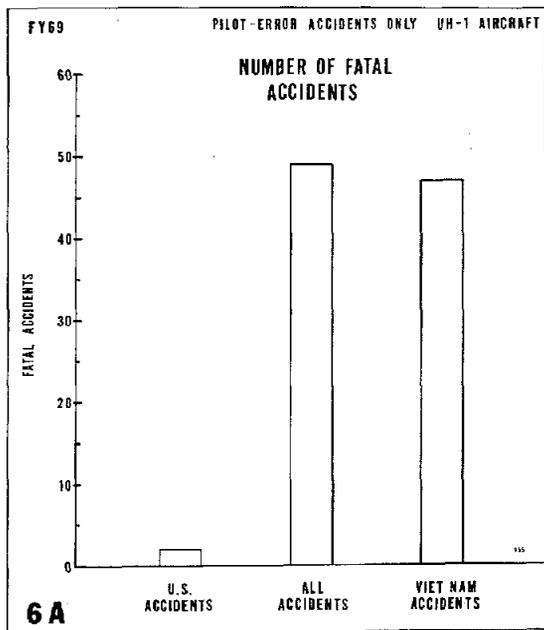


Figure 6

UH-1 Pilot-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting UH-1 aircraft damage (D). As with the all accident data, the loss was greatest in VN.

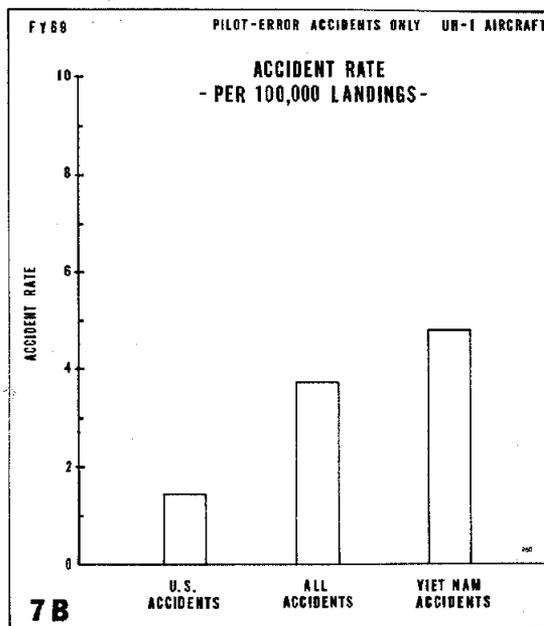
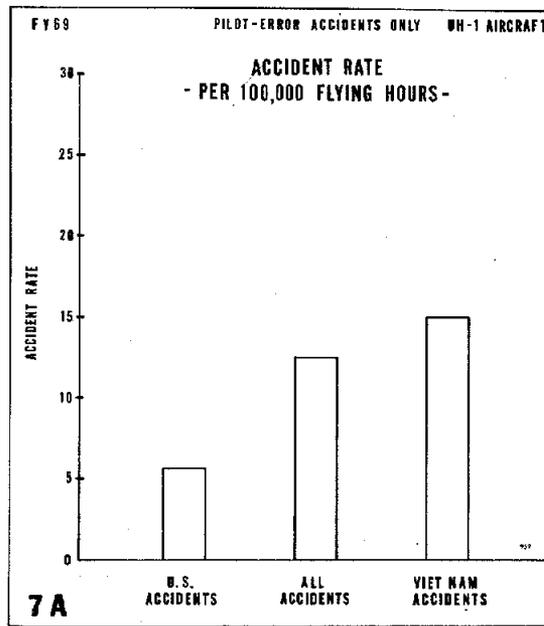


Figure 7

UH-1 Pilot-Error Accident Types: Normalized incidence data showing the average number of UH-1 pilot-error accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). The total hours and total landings data of Figure 1 served as normalization reference. These rate data are intended only as a fiscal year 1969 baseline reference for comparison with similar data for other fiscal years of the longitudinal study. The over-all rates were 12.53 pilot-error accidents per 100,000 hours and 3.74 accidents per 100,000 landings. The VN rate was 2.63 times the US rate using hours as reference, and 3.38 times the US rate using landings as reference.

| ACCIDENT INDEX                         | ORIENTATION-ERROR ACCIDENTS ONLY |                    | UH-1 AIRCRAFT ONLY |                |
|----------------------------------------|----------------------------------|--------------------|--------------------|----------------|
|                                        | U.S. ACCIDENTS                   | VIET NAM ACCIDENTS | ALL ACCIDENTS      | VN to US RATIO |
| Major Accidents                        | 6                                | 38                 | 44                 | 6.33           |
| Minor Accidents                        | 1                                | 1                  | 2                  | 1.00           |
| Total Accidents                        | 7                                | 39                 | 46                 | 5.57           |
| Total Dollar Cost                      | 1,062,712                        | 7,067,585          | 8,130,297          | 6.65           |
| Average Dollar Cost per Accident       | 151,816                          | 181,220            | 176,745            | 1.19           |
| Total Fatalities                       | 8                                | 31                 | 39                 | 3.87           |
| Average Fatalities per Accident        | 1.14                             | 0.79               | 0.85               | 0.69           |
| Fatal Accidents - Number               | 2                                | 14                 | 16                 | 7.00           |
| Fatal Accidents - Percent              | 28.57                            | 35.90              | 34.78              | 1.26           |
| Average Fatalities per Fatal Accident  | 4.00                             | 2.21               | 2.44               | 0.55           |
| Total Nonfatal Injuries                | 3                                | 64                 | 67                 | 21.33          |
| Average Nonfatal Injuries per Accident | 0.43                             | 1.64               | 1.46               | 3.83           |

there were only two minor accidents. As with the all-accident and pilot-error accident data, the orientation-error data show a much higher accident incidence and personnel cost in VN; i.e., the VN/US accident incidence ratio was 5.57 to 1, the VN/US fatal accident ratio was 7.00 to 1, and the VN/US nonfatal injury ratio was 21.33 to 1. In the case of the VN/US average dollar damage per accident ratio, the 1.19 to 1 value indicates approximately equal cost in each location. With regards to total dollar damage, the cost of orientation-error accidents in VN was 6.65 times greater than the cost in US.

The accident rate data of Figure 10, derived from the total hours (A) and total landings (B) data of Figure 1, indicate that there was an over-all average of 1.80 and 0.54 orientation-error accidents per 100,000 hours and per 100,000 landings, respectively, for fiscal year 1969. These rates are lower than the corresponding rates for both fiscal year 1967 (ref. 2) and fiscal year 1968 (ref. 5). As with the all-accident and pilot-error accident data, the orientation-error accident rate was greatest in VN. Based on equal flying hours, the VN rate was 2.03 times the US rate; with equal landings as reference, the VN rate was 2.61 times the US rate.

#### COMPARATIVE INCIDENCE AND COST OF UH-1 ORIENTATION-ERROR ACCIDENTS

The arrangement of the data presented in the preceding sections was selected to differentiate between the actual incidence and cost of all UH-1 accidents, pilot-error



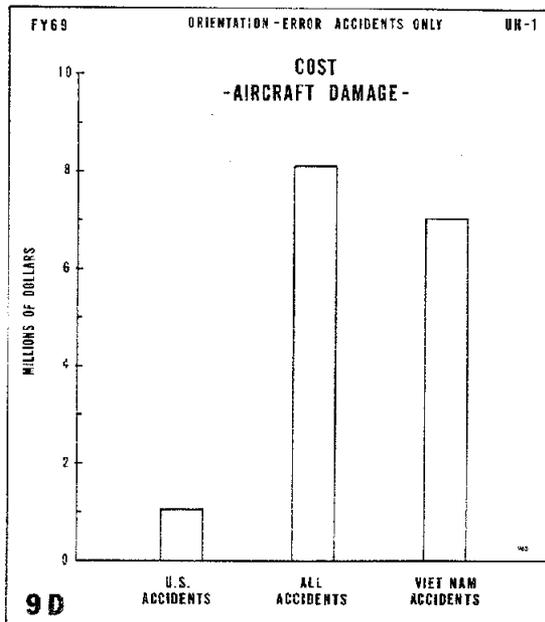
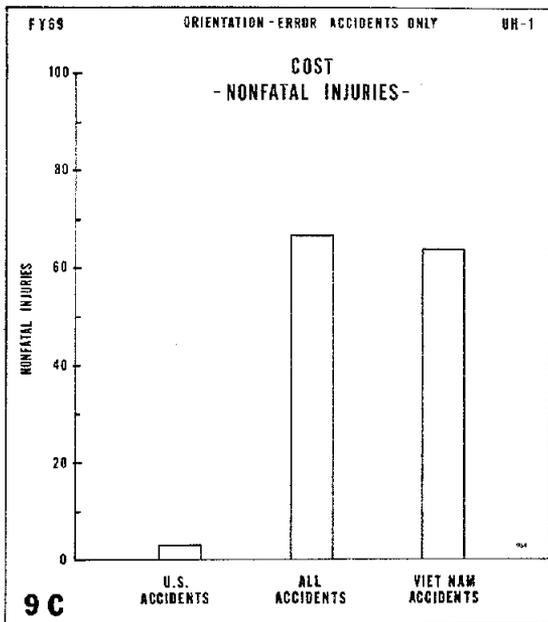
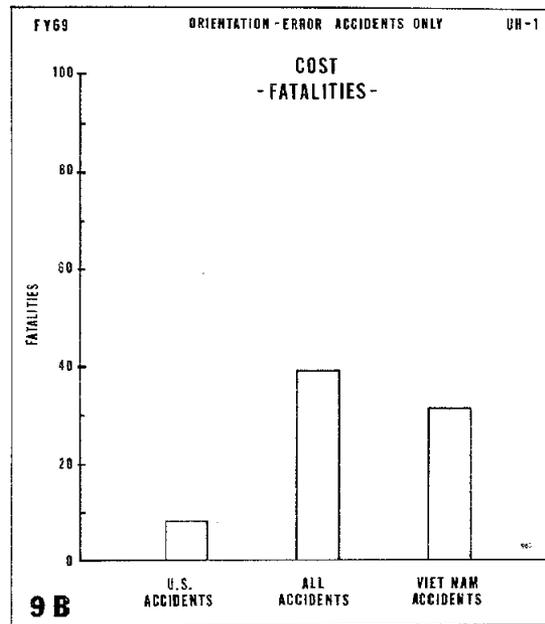
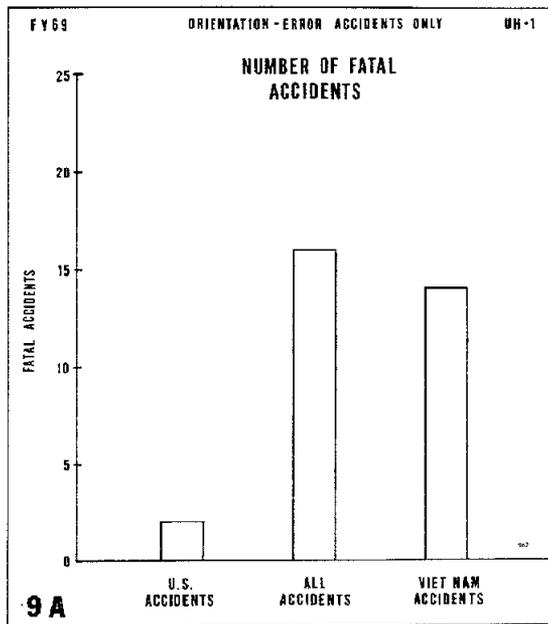


Figure 9

UH-1 Orientation-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting UH-1 aircraft damage (D). The higher cost of VN operations is obvious.

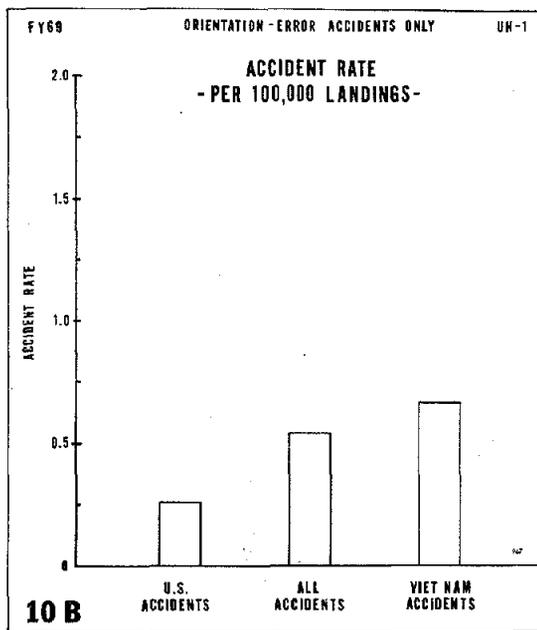
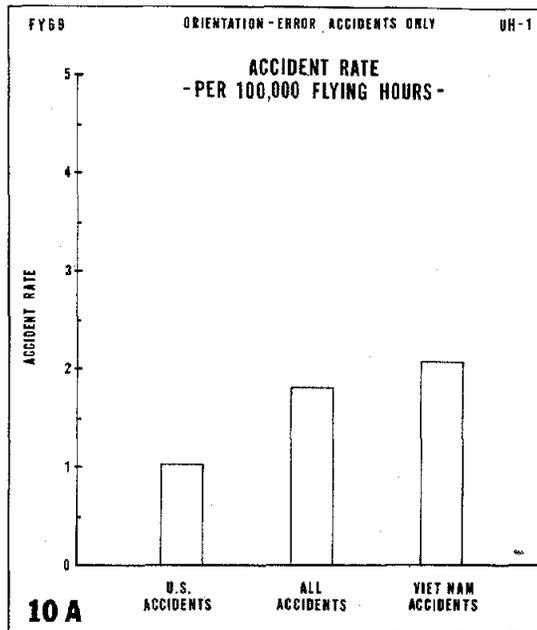


Figure 10

UH-1 Orientation-Error Accident Types: Normalized incidence data showing the average number of UH-1 orientation-error accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). The total hours and total landings data of Figure 1 served as reference. These rate data are intended only as a fiscal year 1969 baseline reference for comparison with similar data for other fiscal years of the longitudinal study. The over-all rates were 1.80 orientation-error accidents per 100,000 hours and 0.54 accidents per 100,000 landings. The VN rate was 2.03 times the US rate using hours as reference, and 2.61 times the US rate using landings as reference.

type UH-1 accidents, and orientation-error type UH-1 accidents. In this section, selected incidence and cost data are expressed in percentage figures with the objective of gaining some insight into the relative contribution of orientation-error accidents to the over-all accident problem.

In Figure 11, the total number of fatal accidents occurring within each of the three accident classifications is expressed as the percentage of the total number of accidents occurring within the given classification. For the combined total of VN and US accidents, 14.86 percent of all accidents were fatal, 15.26 percent of all pilot-error accidents were fatal, and 34.78 percent of all orientation-error accidents were fatal. The probability of a fatal accident was highest when orientation error was present. However, as indicated in Figure 12, when a fatal accident did occur, the average number of fatalities that resulted was about the same for all-accidents and pilot-error accidents, and slightly lower for orientation-error accidents. In terms of the average number of nonfatal injuries resulting from an accident, as indicated in Figure 13, the cost was highest for orientation-error accidents and lowest for pilot-error accidents. The average dollar damage of an accident, as shown in Figure 14, was also higher for the orientation-error class of accidents. The relative magnitude of this damage can be assessed on the basis of the replacement cost of a UH-1 which then was slightly greater than \$250,000.

In Figures 15 through 18, orientation-error accident statistics are expressed as their percent contribution to both the all-accident and pilot-error accident statistics. Thus in Figure 15, the total number of orientation-error accidents is expressed as the percent incidence of the total number of all accidents and percent incidence of the total number of pilot-error accidents. For fiscal year 1969, orientation-error accidents accounted for 8.44 percent of all accidents and 14.33 percent of all pilot-error accidents.

As shown in Figure 16, the contribution of orientation-error fatal accidents to the over-all fatal accident problem was considerable. Of the total number of fatal accidents of all types, orientation-error accidents accounted for 19.75 percent. For fatal pilot-error accidents, 32.65 percent were due to orientation error. The same trend follows for total fatalities, as indicated in Figure 17. Fatalities due to orientation-error accidents accounted for 13.88 percent of all fatalities, and 23.93 percent of all pilot-error fatalities. In terms of the total cost of orientation-error accidents, they contributed 9.87 percent of the total cost of all-accidents, and 17.89 percent of all pilot-error accidents (Figure 18).

As with the previous UH-1 incidence and cost reports (refs. 2 and 5), a related report will be prepared to describe the various accident factors found to be present in each of the fiscal year 1969 major UH-1 orientation-error accidents. The format of this report will be identical to that of the previous factor reports (refs. 3 and 6).

At this point, no attempt will be made to draw any further conclusions as to the over-all significance of the results since corresponding UH-1 data are under preparation for subsequent fiscal years. The long-term value of these data will depend upon whether

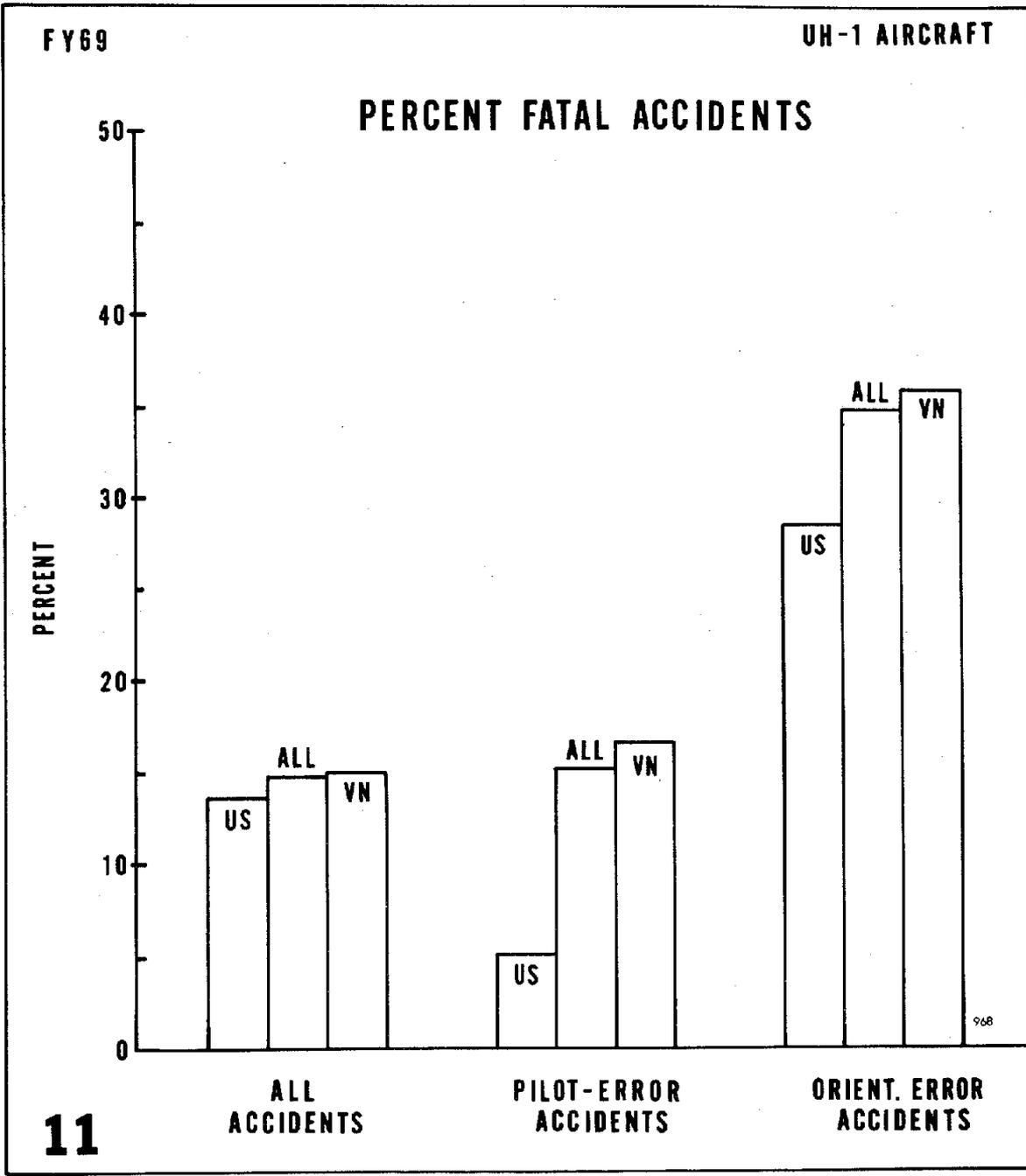


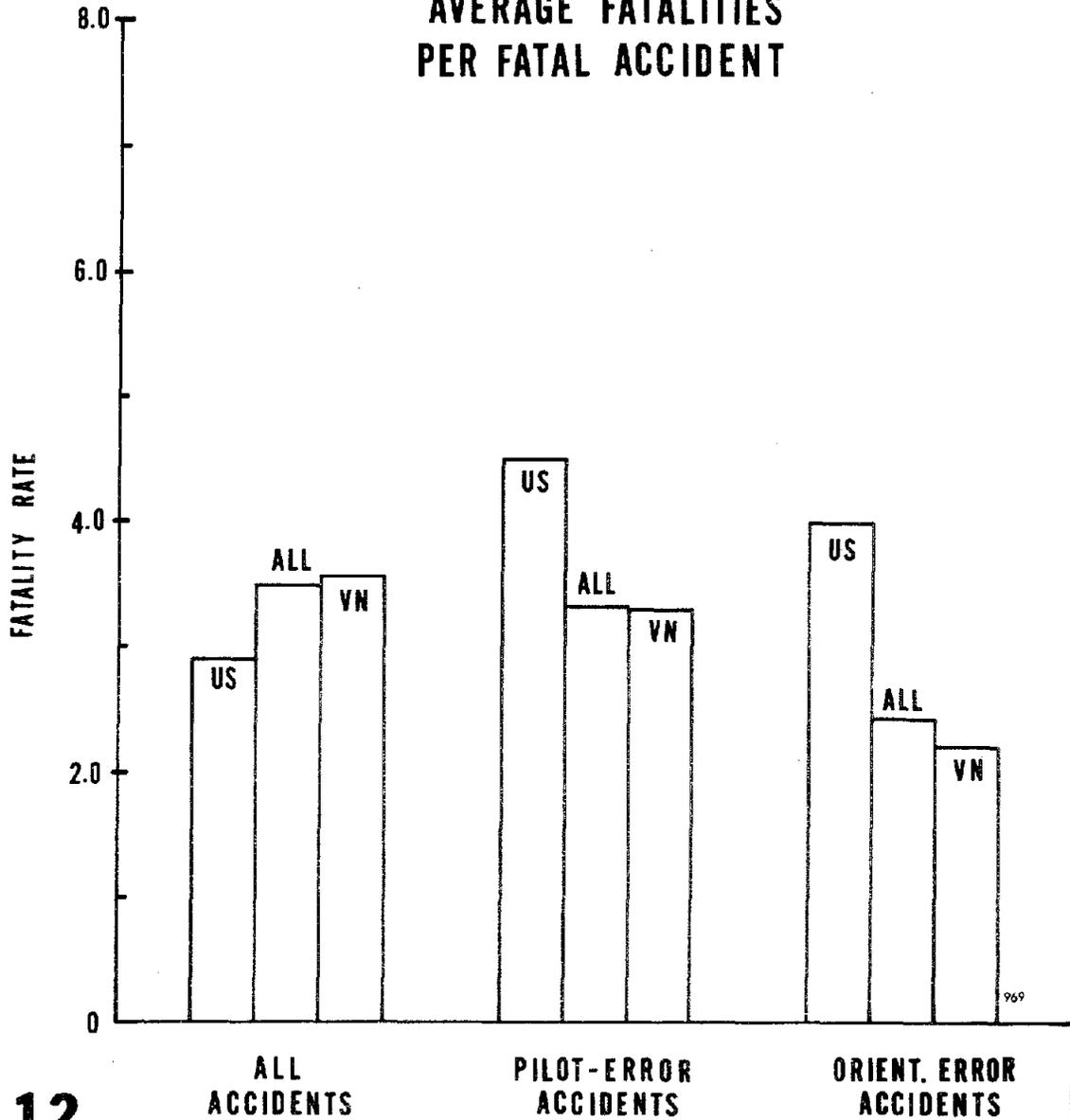
Figure 11

Comparative incidence of fatal accidents expressed as the percent of the total number of accidents within the "All Accident Type," "Pilot-Error Accident Type," and "Orientation-Error Accident Type" classifications that resulted in one or more fatalities. Orientation-error accidents had the greatest percent incidence of fatal accidents.

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### AVERAGE FATALITIES PER FATAL ACCIDENT



12

Figure 12

Average number of fatalities per fatal accident for each of the three basic accident type classifications.

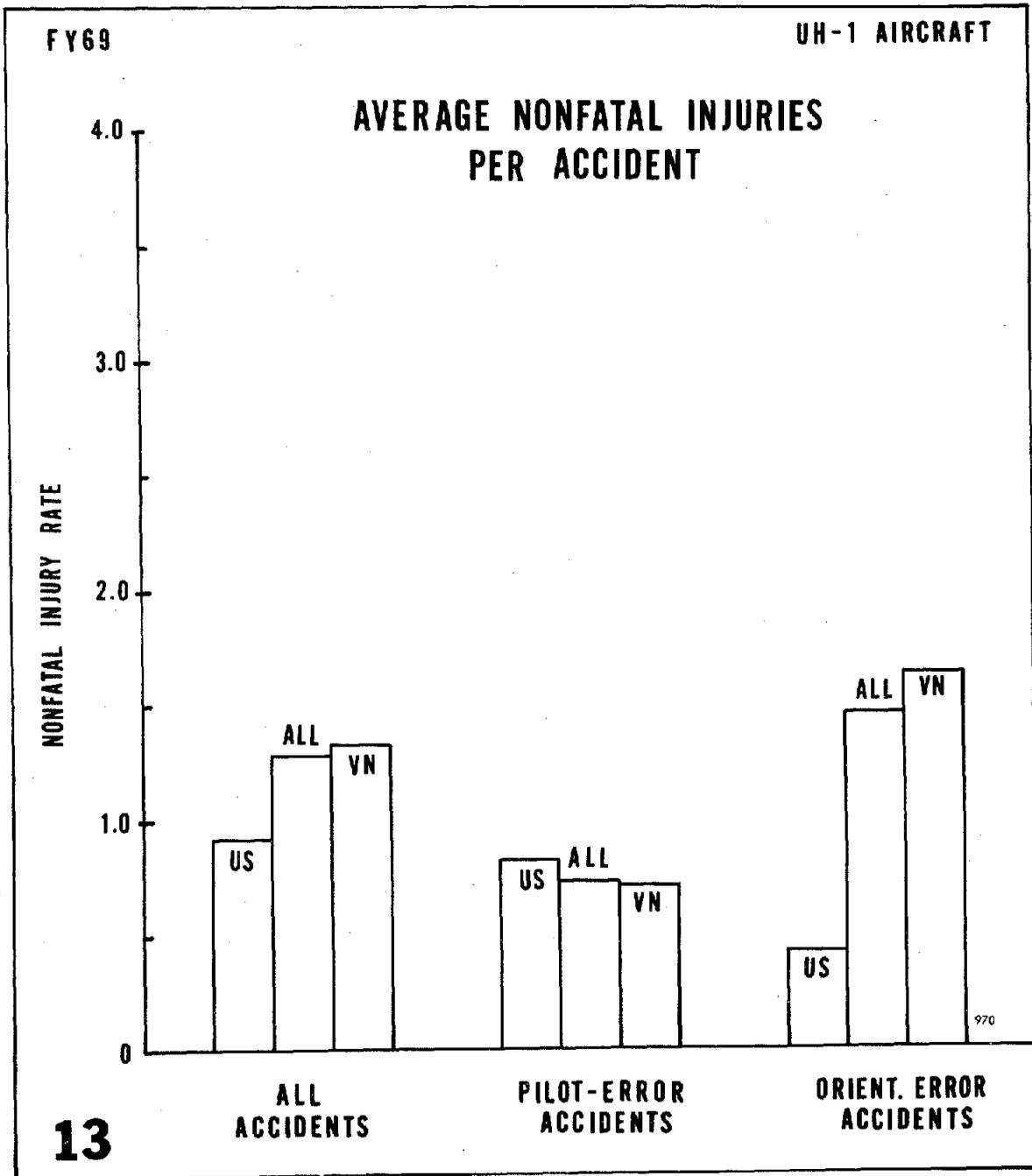


Figure 13

Average number of nonfatal injuries per accident for each of the three basic accident type classifications.

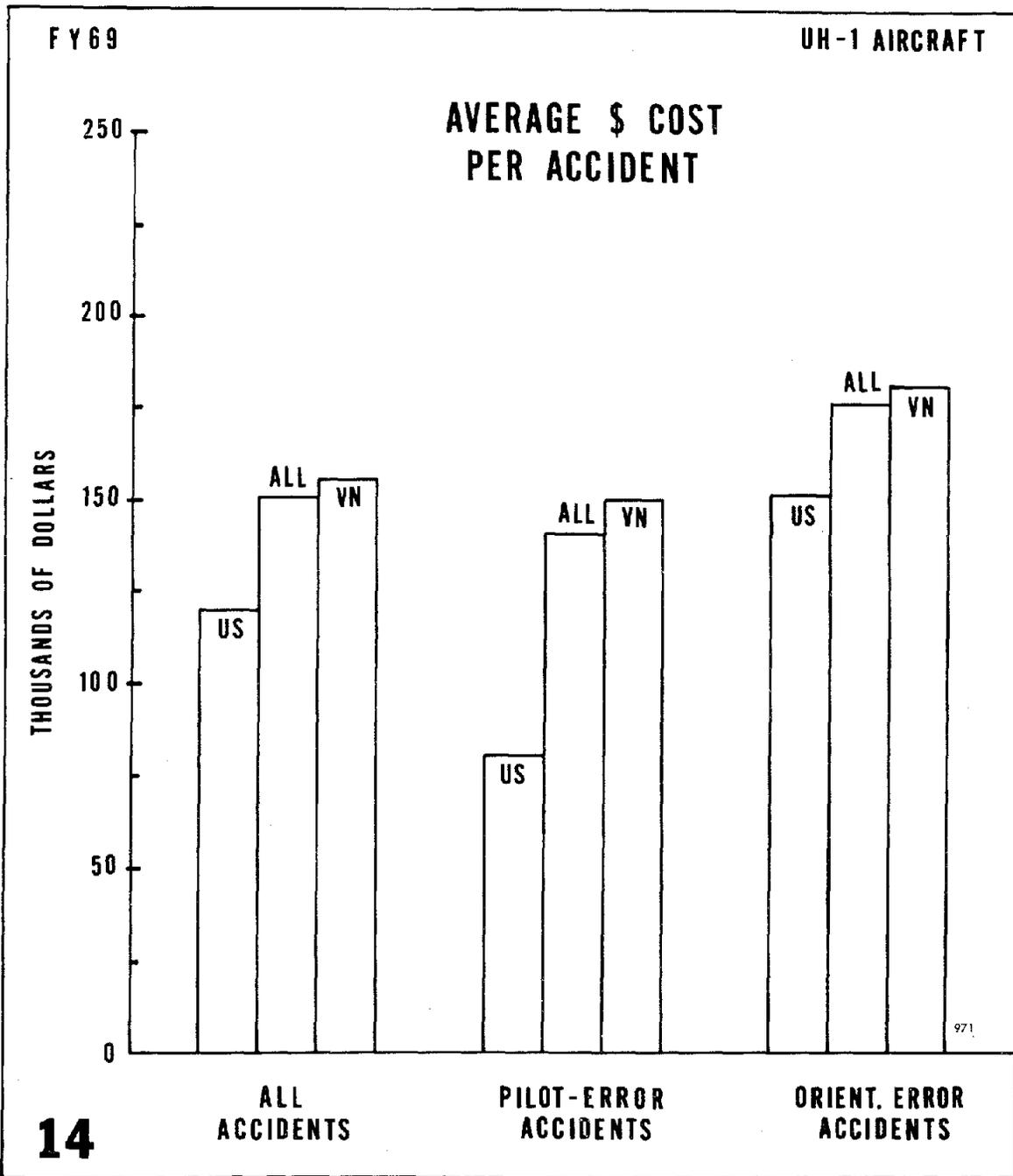


Figure 14

Average dollar cost of aircraft damage per accident for each of the three basic accident classifications. (Strike damage to a UH-1 aircraft approximates \$250,000.) The average cost of orientation-error accidents only slightly exceeds the cost of the other two accident classifications.

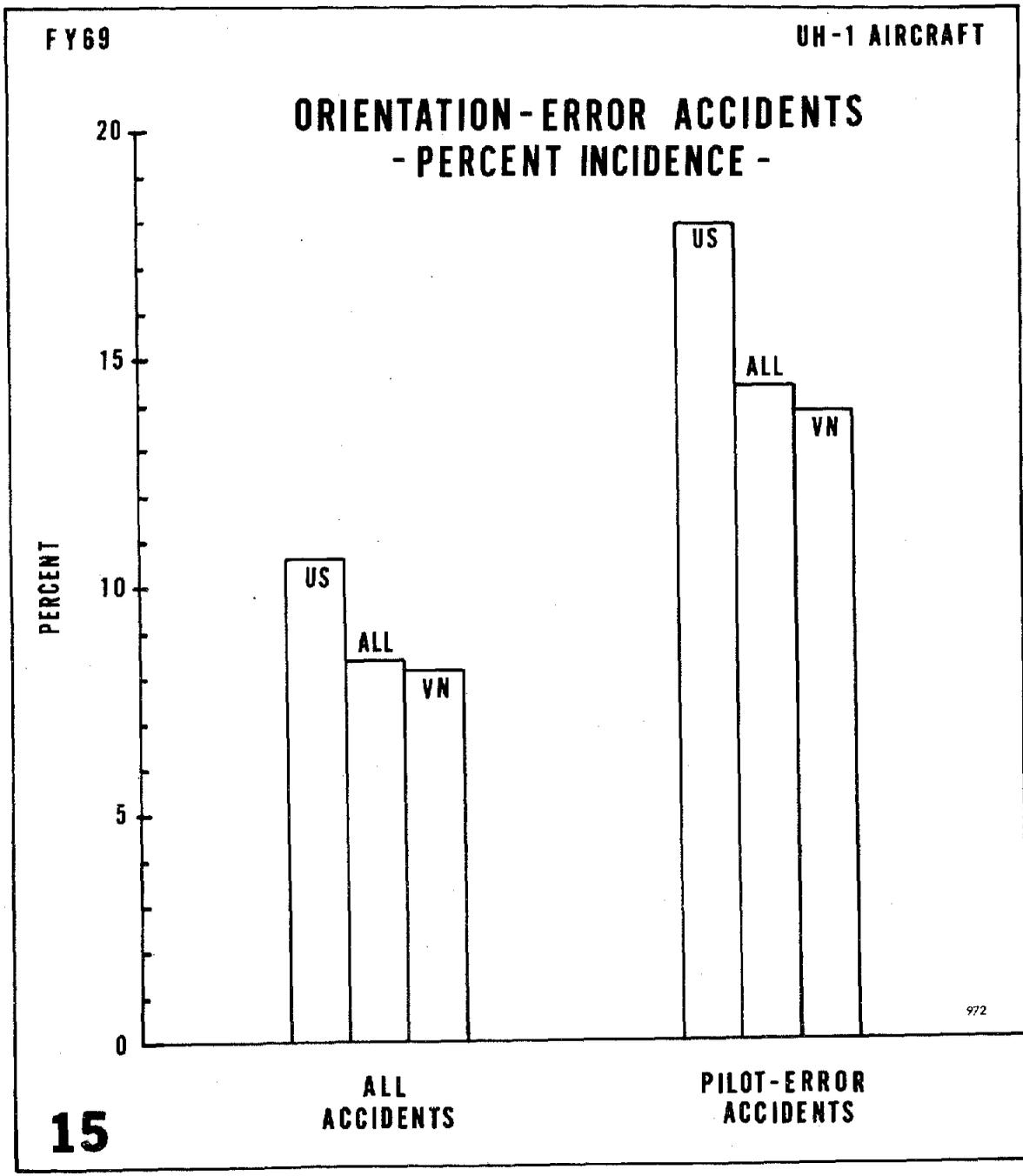


Figure 15

Percent contribution of all UH-1 orientation-error accidents to the total number of UH-1 accidents occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 8.44 percent of all accidents and 14.33 percent of all pilot-error accidents.

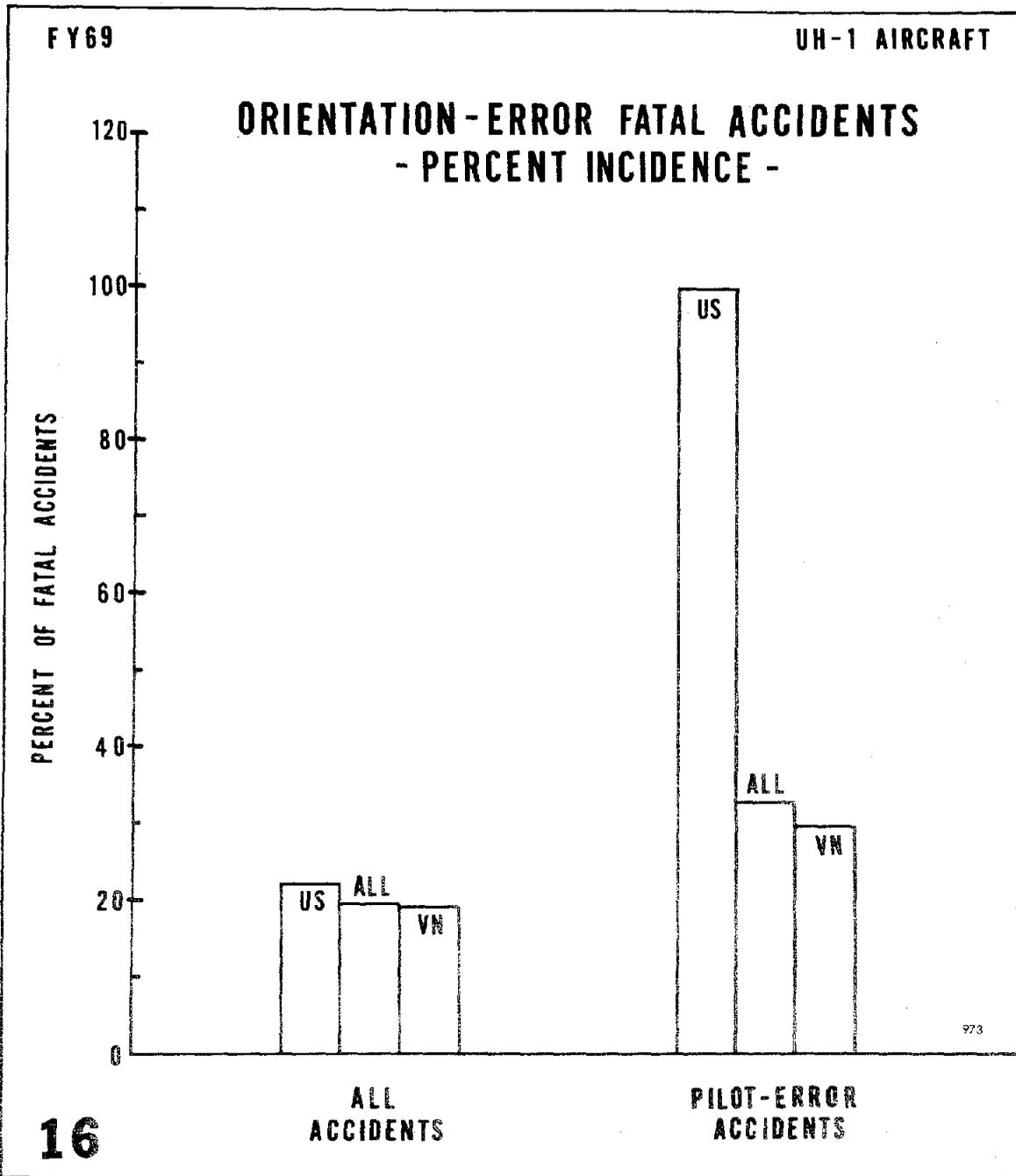


Figure 16

Percent contribution of fatal UH-1 orientation-error accidents to the total number of fatal accidents occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications. Fatal orientation-error accidents accounted for 19.75 percent of all fatal accidents and 32.65 percent of all fatal pilot-error accidents.

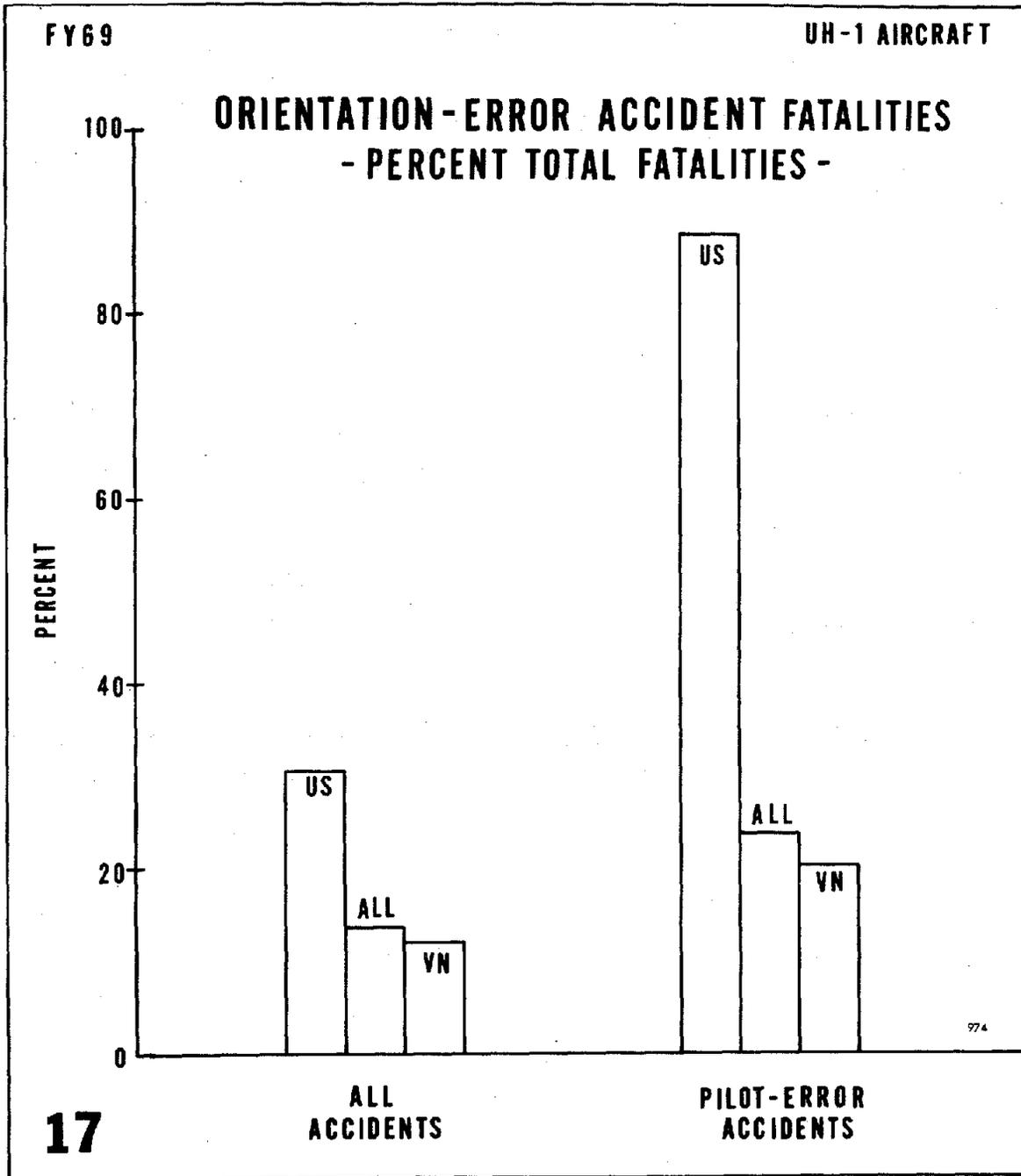


Figure 17

Percent contribution of all UH-1 orientation-error accident fatalities to the total number of fatalities occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications. Fatalities due to orientation-error accidents accounted for 13.88 percent of the total number of accident fatalities and 23.93 percent of the pilot-error accident fatalities.

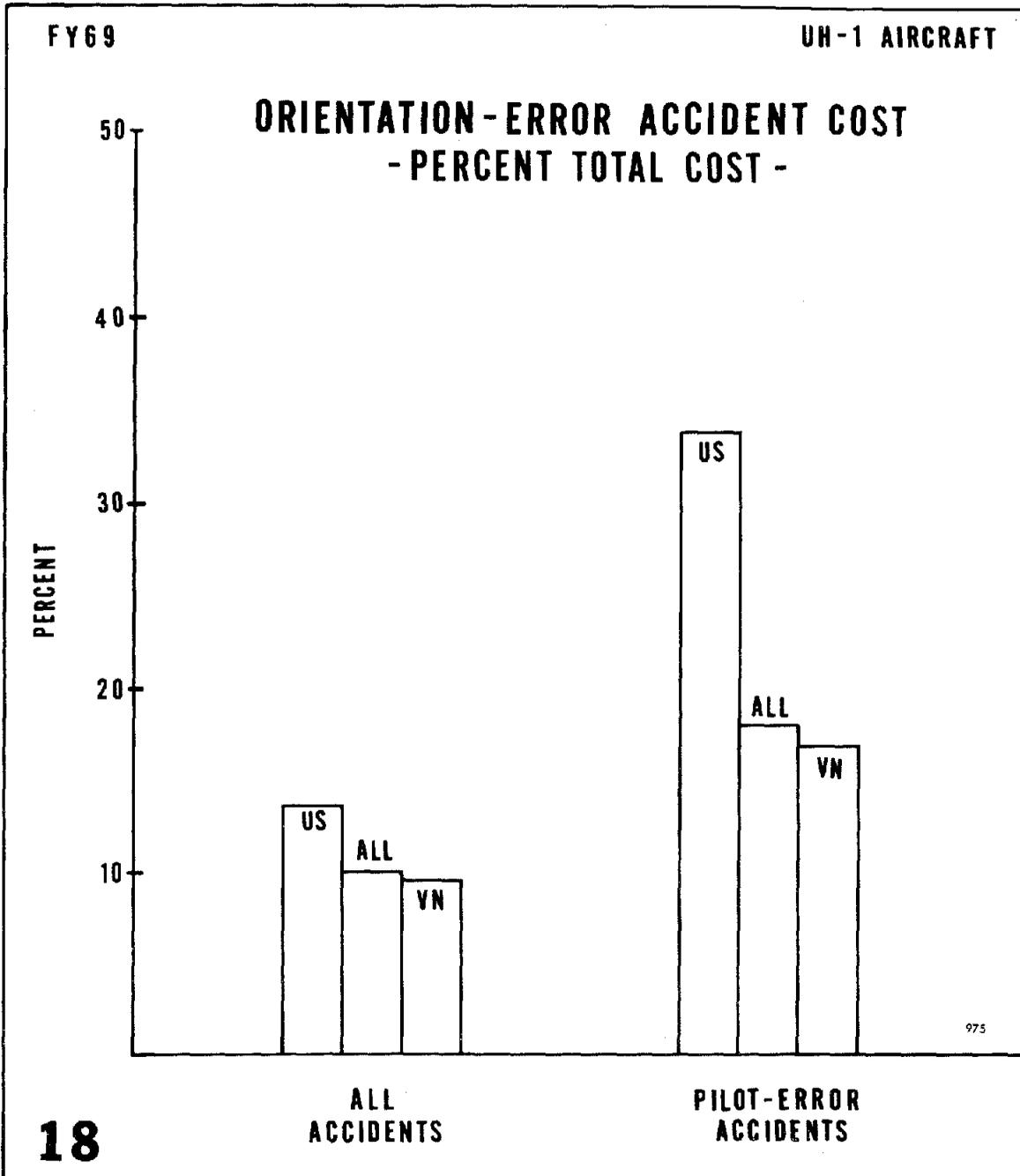


Figure 18

Percent contribution of the total dollar cost of all UH-1 orientation-error accidents to the total dollar cost of all accidents occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications. The dollar cost of orientation-error accidents accounted for 9.87 percent of the total cost of all accidents and 17.89 percent of the total cost of all pilot-error accidents.

the longitudinal analysis does or does not establish the presence of consistencies or trends in the accident experiences. Moreover, it is the function of this element of the longitudinal study only to provide quantitative UH-1 accident data; the evaluation of the data in terms of their mission implications must remain with those responsible for direction of military aviation operations.

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