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ARMY AUTOROTATION ACCIDENTS

FISCAL YEARS 70-72

By

Kent A. Kimball
Donald F. Harden
Mark A. Hofmann

August 1973

U. S. ARMY AEROMEDICAL RESEARCH LABORATORY

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13. ABSTRACT

This report is a review of autorotation accidents occurring during the fiscal years 1970 through 1972. This work presents information on these accidents and their relation to total rotary wing accidents, accident rates, geographical areas, specific aircraft, costs, fatalities, and injuries. Data delineating the causative factors of these accidents are also presented and discussed.

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SUMMARY

A study reviewing autorotation accidents was initiated to ascertain the relative contributions that certain factors had in such accidents. The active Army, for fiscal years 1970 through 1972, was reviewed and a total of 790 accidents, or 42.3% of all accidents, were of the autorotational type. They accounted for over 89 million dollars in aircraft damage, 92 aircrew fatalities, and 652 aircrew injuries. Of these 790 accidents, it was determined that personnel error alone accounted for 32.7% of the accidents, while materiel failure alone accounted for 31.4%. Of the remaining accidents (35.9%), 20.9% were attributed to a combination of personnel error and materiel failure, while the remaining 15% were attributed to other causative factors. Though the total number and rate of rotary wing accidents was found to be declining over the time frame considered, the number of autorotation accidents attributed solely to personnel error was found to be on the increase, with fiscal year 1972 approximately 10% higher than 1970.

The study also reviews autorotation accidents in light of total accidents, rates, geographical areas, aircraft, cost, fatalities, and injuries. It also provides impact data with regard to the reduction of certain parameters, given human error were reduced.

APPROVED: ROBERT W. BAILEY
COL, MSC
Commanding

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INTRODUCTION

The autorotation maneuver is currently the only inflight escape system available to the rotary wing aviator. This maneuver requires that a number of accurate perceptual judgments and precise control movements be made over a short period of time. The ability to satisfy all of the requirements of this maneuver, and thus execute a safe power-off landing, places a considerable mental and motor workload on the human component of the flight system. Error in judgment or control can result in an accident of major consequence.

Because of the complexity of this maneuver and its critical value to the safety of aircraft flight, the autorotation maneuver has received considerable attention from the aviation community. Some have expressed that a maneuver which is taught and practiced to prevent the loss of lives and aircraft is claiming far more than its fair percentage of both these resources. Similarly, it has been proposed that the human factor in these accidents may contribute a great deal to their cause and that increased emphasis on the maneuver in training has not increased proficiency enough to warrant this heavy exposure of aircraft and men during training. Interest in these and similar ideas has provided the impetus for this research.

This report presents summary data on non-combat rotary wing accidents in Army aviation. More specifically, data is presented and discussed which references autorotation accidents and their contribution to total accidents in Army rotary wing aircraft, accident information directly related to the execution of this maneuver, the severity of accidents caused by its unsuccessful execution, and causal factors relating to its performance.

METHOD

Data contained in this report were computed and compiled from rotary wing mishap data provided by the U. S. Army Agency for Aviation Safety (USAAAVS). All figures presented are representative of rotary wing and autorotation accidents which occurred in Army aviation on a worldwide basis for fiscal years (FY) 1970 through 1972.

RESULTS AND DISCUSSION

In order to describe the relationship of autorotation accidents to Army aviation, it is necessary to first provide background on the overall scope of the problem of accidents in rotary wing aircraft.

TABLE 1

Accidents and Accident Rates
Worldwide Active Army

FISCAL YEAR	TOTAL ACCIDENTS	TOTAL COST	FATALITIES	INJURIES	ACC. RATE PER 100,000 HRS
70	944	145,968,943	496	1069	17.92
71	632	101,470,490	282	600	15.35
72	293	42,195,577	265	326	12.33
TOTALS	1869	289,635,010	1043	1995	15.89

It can be seen from Table I that a total of 1869 accidents were reported during the period of fiscal year 1970 through 1972. These accidents claimed the lives of 1043 aircrew personnel, resulted in injuries to 1955 aircrew personnel, and cost $289,635,010 in materiel damage to aircraft. On a year by year basis, a decrease in the number of accidents per year is evident. This trend is also reflected in a decreasing accident rate per 100,000 hours flown. This decrease in accidents is likely to have been facilitated by a parallel decrease in operational activity in Southeast Asia during this time. (See Appendix.) However, these totals still point out the magnitude of accidents. It also must be remembered that these frequencies, costs, fatalities, and injuries figures do not include those persons or aircraft attributed to combat losses. Further, it is worthy of note that although a decrease in accident totals across years has been recorded, that the average number fatalities per accident is higher for FY 72 than the other years considered. Also, the average number of injuries per accident for FY 72 is nearly equal or exceeds the rates for FY 70-71.

TABLE 2

Autorotation Accidents and Accident Rates
Worldwide Active Army

FISCAL YEAR	TOTAL ACCIDENTS	TOTAL COST	FATALITIES	INJURIES	ACC. RATE PER 100,000 HRS
70	395	44,364,000	43	360	7.50
71	289	35,614,000	31	222	7.02
72	106	9,312,000	18	70	4.46
TOTALS	790	89,290,000	92	652	6.72

Table 2 presents similar data from autorotation accidents. For the three-year period, a total of 790 autorotation accidents were recorded, accounting for 92 aircrew personnel deaths, 652 aircrew personnel injuries, and $89,290,000 in materiel cost. A decrease in autorotation accidents over this period is in evidence. This finding might be expected in that the frequency for all rotary wing accidents had decreased over this time frame.

TABLE 3

Percentage of Total Rotary Wing Accidents Attributed to the Autorotation Maneuver

FISCAL YEAR	TOTAL ACCIDENTS	AUTOROTATION ACCIDENTS	PERCENT
70	944	395	41.8
71	632	289	45.7
72	293	106	36.2
	1869	790	42.3

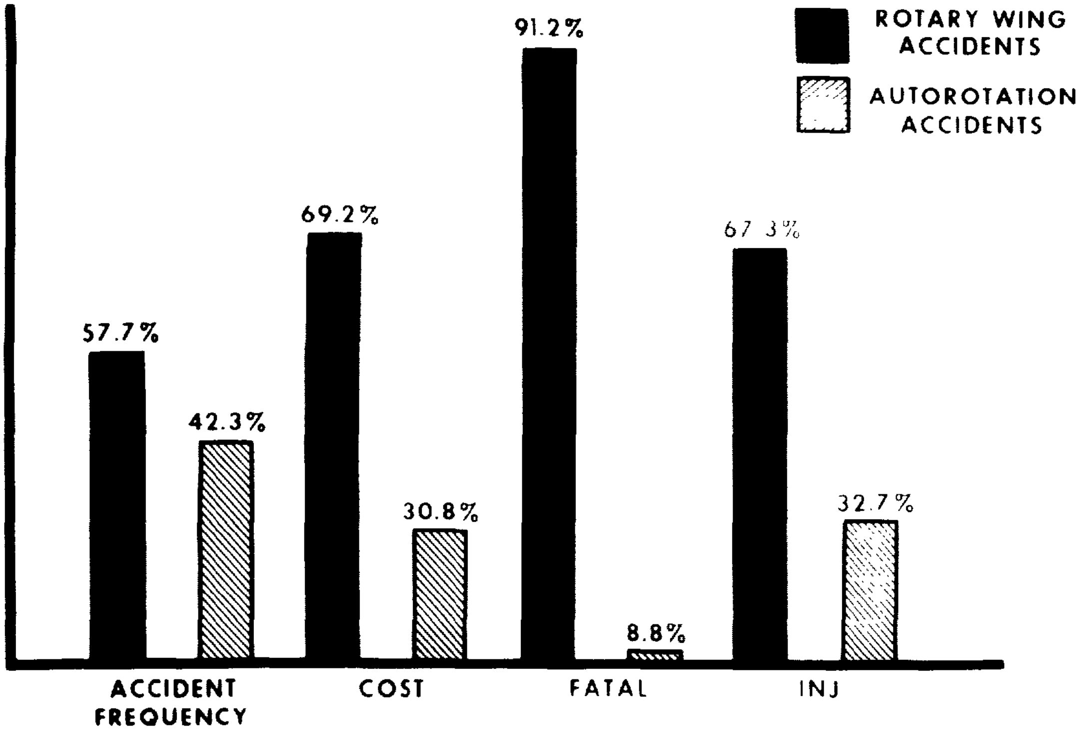
Relating the totals per year for both autorotation and total rotary wing accidents, a percentage of accidents attributed to the unsuccessful completion of autorotations was obtained. It can be seen from Table 3 that autorotation accidents comprise 42.3% of all accidents reported during the fiscal year 1970 to 1972 time frame. This percentage appears large to be caused solely by one maneuver accident type. However, it must be remembered that with the exception of practice autorotations this maneuver is used only after some emergency has occurred or is thought to have occurred.

TABLE 4

Relationship between Autorotation Accidents and Severity

FISCAL YEAR	ACCIDENT PERCENT	COST PERCENT	FATALITY PERCENT	INJURY PERCENT
70	41.8	30.4	8.7	33.7
71	45.7	35.1	11.0	37.0
72	36.2	22.1	6.8	21.5
AVERAGE %	42.3	30.8	8.8	32.7

Table 4 presents data on the percentages of the frequency of autorotation accidents as compared with total percentages of cost, fatalities, and injuries. These figures reflect a nonlinear relationship between the frequency of occurrence for these type accidents and their severity. The assumption that reducing the number of accidents of this type would bring a like reduction in the loss of men and materiel is not substantiated by these figures. In contrast, they support the idea that these autorotation maneuver associated accidents may not be as serious in terms of manpower and materiel losses as accident frequency figures might lead one to suspect. Notwithstanding, however, the fatality and injury contributions associated with accidents yielded by this maneuver raise some questions as to its overall efficacy, for it must be remembered that the maneuver's sole purpose is to provide personnel a means of emergency escape. A histogram representing the figures for total rotary wing accidents and autorotation accidents is presented in Figure 1. This figure serves to illustrate the relatively large difference in severity between these two accident categories.



ROTARY WING AND AUTOROTATION ACCIDENTS COMPARATIVE SEVERITY

FIGURE 1

Nonetheless, because of the frequency of these accidents and the crucial importance of this maneuver to flight crew personnel, it remains a maneuver which merits both scientific and operational consideration.

Considerable emphasis has been placed on the human component in this type accident. Because this maneuver places a high workload on the aviator, it has been assumed that many accidents of this type have been caused by incorrect decisions or actions on the part of aircrew personnel.

In order to more fully illustrate the contribution of human error to these accidents, attention must be given to all factors which have been determined to be related to their cause. Since it is difficult to completely encompass all possible factors in accident research, an attempt has been made to consider all relevant factors and include them under four groupings. The four categories utilized here are: Personnel only - those accidents attributed to solely personnel error, which includes only accidents in which investigators determined that aircrew members, ground crews, or air traffic controllers committed an unsafe or incorrect action; materiel only - those accidents which on investigation proved to be caused by component failure in the aircraft; a combination category - which represents accidents in which both materiel failure and human error were cited as present and contributing to the accident; and finally, other - a category which encompasses either materiel failure or human error, plus other variables such as weather, operating environment or any other possible contributing factor.

TABLE 5

Autorotation Accidents by Causal Factors
Worldwide Active Army

FISCAL YEAR	ACC	PERS ONLY	PERCENT	MAT ONLY	PERCENT	COMB	PERCENT	OTHER	PERCENT
70	395	122	30.9	126	31.9	89	22.5	58	14.7
71	289	93	32.2	99	34.2	56	19.4	41	14.2
72	106	43	40.5	23	21.7	20	18.9	20	18.9
	790	258	32.7	248	31.4	165	20.9	119	15.0

Table 5 breaks all autorotation accidents into these factors. Considering the decrease in total autorotation accidents from fiscal year 1970 to 1972, it is of interest to note that while a decrease in accidents caused by materiel failure is evident across years, the average breakdown between human error and materiel failure is not widespread. The largest difference (18.8%) between categories appears for 1972. This difference may be attributable to increased maintenance efficiency and a more selective flight environment made possible by decreased tactical mission requirements.

Based on the average percentages reported in Table 5, it would seem that materiel failure and human error are relatively equal contributors to these types of accidents. Even though the average percentage for human error is slightly higher than materiel failure, it must be remembered that this category includes all personnel, to include pilot error. The percentage of accidents attributed directly to pilot error only would perhaps be somewhat reduced.

As has been previously shown, autorotation accidents do not seem, in general, to be as serious as other types. Similarly, autorotation accidents caused by human error do not seem to be as severe as those involving materiel failure. Figures are presented in Tables 6 and 7 which serve to illustrate this point.

TABLE 6

Relationship between Human Error and Accident Severity - Autorotation

FISCAL YEAR	HUMAN ERROR PERCENT	COST PERCENT	FATALITY PERCENT	INJURY PERCENT
70	30.9	23.3	19.3	23.2
71	32.2	22.9	19.8	21.3
72	40.6	32.5	25.0	33.3
AVERAGE	32.7	24.2	19.9	23.9

TABLE 7

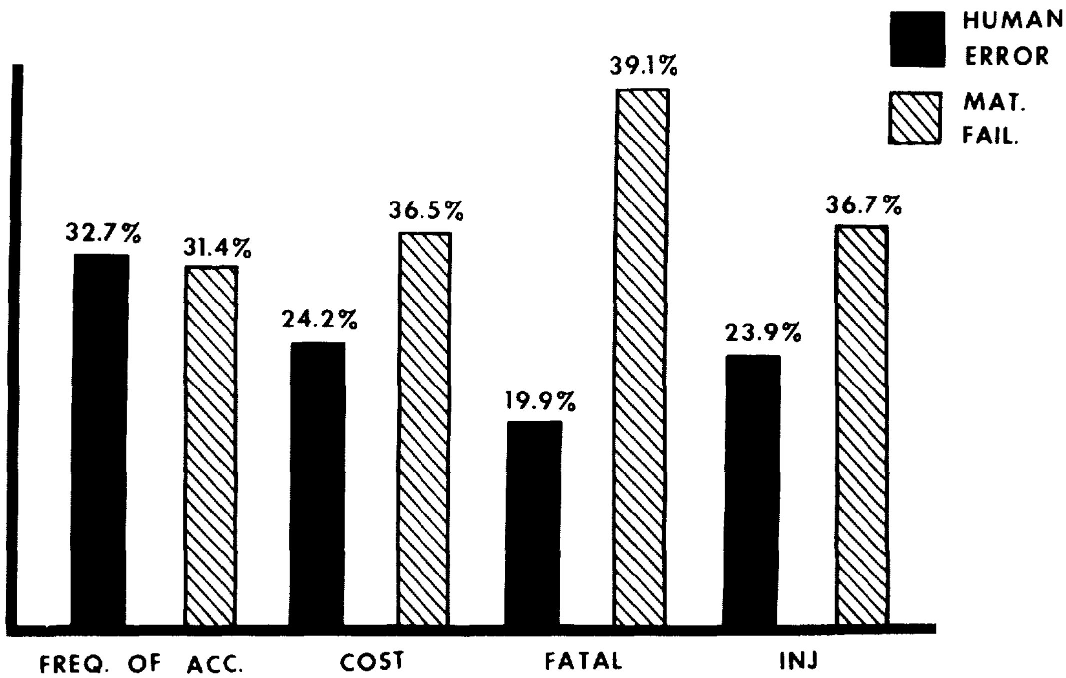
Relationship between Materiel Failure and Accident Severity

FISCAL YEAR	MAT FAILURE PERCENT	COST PERCENT	FATALITY PERCENT	INJURY PERCENT
70	31.9	36.7	39.3	36.7
71	34.3	39.9	41.9	41.0
72	21.7	25.6	29.2	25.2
AVERAGE	31.4	36.5	39.1	36.7

It can be seen that autorotation accidents which were caused by human error produced 24.2% of the materiel cost, 19.9% of the fatalities, and 23.9% of the injuries. Theoretically, if the human error component (32.7%) in autorotation accident causation was eliminated, a lesser percentage reduction in materiel cost, fatalities, and injuries would be realized than might be expected. If these percentages are contrasted with Table 7, it is evident that accidents caused by materiel failure produced 36.5% of the materiel cost, 39.1% of the total fatalities, and 36.7% of all injuries. Elimination of the causative factor of materiel failure (31.4%) in these types of accidents would yield larger savings in lives and materiel than a similar theoretical elimination of human error. Figure 2 is a graphic comparison of these percentages.

In reference to Figure 2, in terms of the medical significance of these data, it is interesting to note the large differences (19.2%) between the fatality figures produced by these two causative factors. Undoubtedly, human error reduction would lead to a decrease in fatalities, but a similar reduction in materiel failures in aircraft would decrease deaths in these accidents almost twice the human error figure.

It seems appropriate to entertain two possible conclusions from these data. First, human error does cause a significant number of autorotation accidents. Their reported frequency lends weight to the proposal that a concentrated effort should be undertaken to systematically investigate the complexity of this maneuver, delineate the psychological and perceptual motor factors involved, and to investigate training procedures. However, the cost figures presented here would seem to indicate the need for effort in a second area, that of improving maintenance and aircraft component reliability.



AUTOROTATION ACCIDENTS, MATERIEL FAILURE AND HUMAN ERROR, COMPARATIVE SEVERITY

FIGURE 2

TABLE 8

R/W Accidents, Flight Hours, Accident Rates, and Percent Contribution of Each Aircraft to Total Accidents - Worldwide Active Army

AIRCRAFT	ACCIDENTS	FLIGHT HOURS	ACCIDENT RATE	PERCENT
UH-1	919	6,076,073	15.12	49.2
OH-6	347	872,698	39.76	18.6
AH-1	222	882,252	25.16	11.9
TH-55	120	1,218,743	9.85	6.4
OH-58	90	618,162	14.56	4.8
CH-47	63	571,147	11.03	3.4
TH-13	48	912,597	5.26	2.6
OH-23	38	495,250	7.67	2.0
CH-54	7	46,198	15.15	.4
CH-34	5	39,370	12.70	.2
Other	10	28,889	- - -	.5

As might be expected, aircraft types within the Army differ in the number of accidents they sustain. Table 8 presents data on all rotary wing accidents separated by aircraft type. If attention is directed to the five aircraft with the highest accident totals for the three-year period under study, it can be observed that the UH-1 was involved in almost three times as many accidents as any other aircraft in the Army inventory. However, it is important to realize that this aircraft has an exposure rate approximately five times that of any other aircraft listed, and therefore, it yields an accident rate of 15.12/100,000 hours. The TH-55 and TH-13 aircraft have the lowest accident rates. This would seem reasonable inasmuch as these helicopters have been primarily used for training purposes. It is likely that these aircraft were exposed to mostly good operating conditions and received good maintenance, factors which may have contributed to their low accident rate.

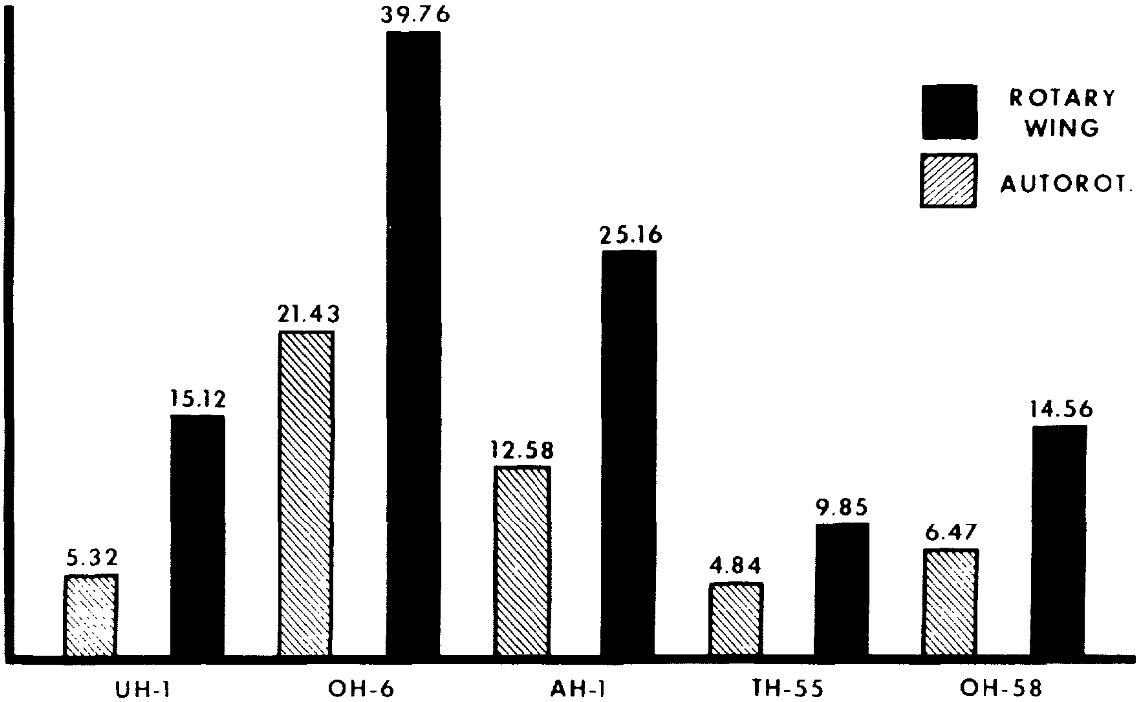
In contrast, it is evident that the OH-6 and AH-1 aircraft rank much higher in the number of accidents per hours flown. The OH-6 and AH-1 rank one and two in the category of accidents per flight hours of all aircraft used in the Army. It is likely that these high rates are due in part to the particular mission profiles flown by these aircraft, both in combat and in tactics training. The OH-58 is also high for probably the same reasons. It can be seen that the cargo helicopters also have higher rates than strictly training aircraft.

TABLE 9

Percentage of Total R/W Accidents Contributed to by Autorotation by Individual Aircraft

AIRCRAFT	ACCIDENTS	AUTOROTATION ACCIDENTS	AUTOROTATION ACC RATE	AUTOROTATION PERCENT
UH-1	919	323	5.32	35.1
OH-6	347	187	21.13	53.9
AH-1	222	111	12.58	50.0
TH-55	120	59	4.84	49.2
OH-58	90	40	6.47	44.4
TH-13	48	36	3.94	75.0
OH-23	38	21	4.24	55.3
CH-47	63	12	2.10	19.0
CH-54	7	1	2.16	14.3
CH-34	5	0	- -	0.0

Table 9 presents data relating the contribution of accidents involving the autorotation maneuver to total accidents by aircraft. Those aircraft referred to in Table 8 as having the largest number of accidents similarly are involved in the largest number of autorotation accidents. Of particular interest in this table are the high percentages of accidents which occur during autorotations. For example, the OH-6 and AH-1, which were cited as having the highest accident rates, also have a large percentage of these accidents during autorotation. It might also be added that they have the highest autorotational accident rates. The TH-55 and OH-58 also have relatively large percentages in this category, with the UH-1 maintaining the lowest percentage of the five. These aircraft, relative to the OH-6 and AH-1, also have lower autorotation accident rates. Comparing the data presented in Tables 8 and 9, it can be seen that generally, aircraft possessing the most total accidents are sustaining nearly half of them as a result of an unsatisfactory completion of an autorotation maneuver.



ROTARY WING AND AUTOROTATION ACCIDENT RATES BY AIRCRAFT (ACC./100,000 HRS.)

FIGURE 3

Perhaps a more meaningful way to represent this relationship between total accidents and autorotation accidents for particular aircraft is presented in Figure 3. Again, it seems evident that the AH-1 and OH-6 are problem aircraft. Considering total accidents and those connected with autorotation, their accident rates for the autorotation category are approximately half as large as their total accident rate.

TABLE 10

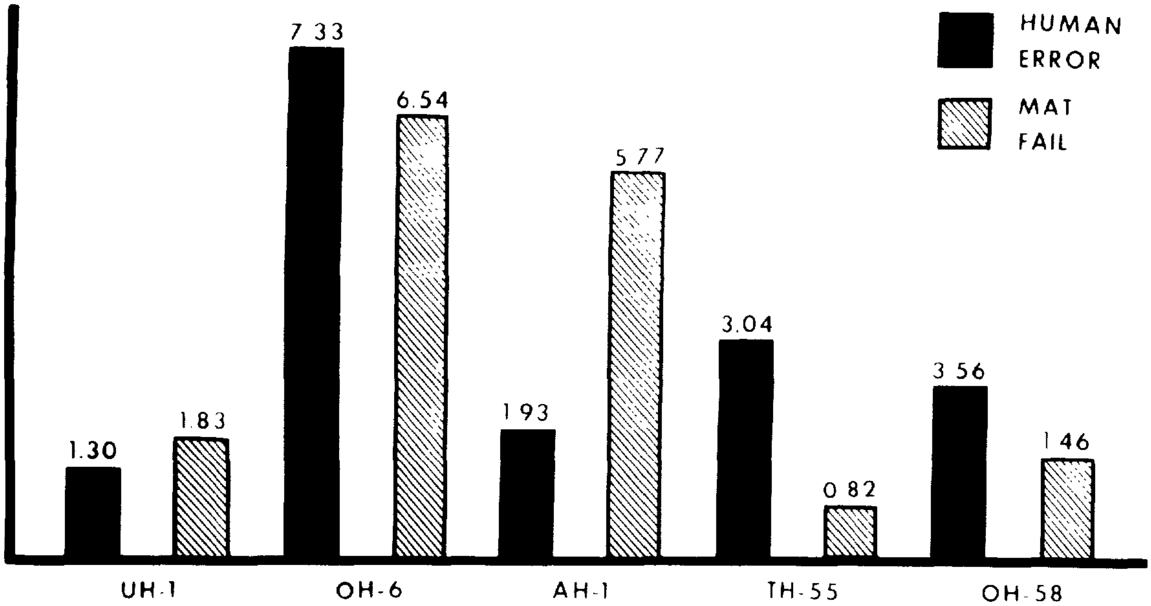
Autorotation Accidents by Craft with Causal Factors
Worldwide Active Army

ACFT	ACC	PERS ONLY	PERCENT	MAT ONLY	PERCENT	COMB	PERCENT	OTHER	PERCENT
UH-1	323	79	24.5	111	34.4	78	24.1	55	17.0
OH-6	187	64	34.2	57	30.5	35	18.7	31	16.6
AH-1	111	17	15.3	51	46.0	23	20.7	20	18.0
TH-55	59	37	62.7	10	17.0	11	18.6	1	1.7
OH-58	40	22	55.0	9	22.5	7	17.5	2	5.0
TH-13	36	20	55.5	4	11.1	6	16.7	6	16.7
OH-23	21	15	71.4	2	9.5	3	14.3	1	4.8
CH-47	12	4	33.3	4	33.3	2	16.7	2	16.7
CH-54	1	0	0	0	0	0	0	1	100.0

Figures separating autorotation accidents into causative factors by aircraft are presented in Table 10. Previously in this writing the causative factors of autorotation accidents were discussed and the data indicated that accidents caused by materiel failure were more severe in terms of cost, lives, and injuries than may have been previously assumed. If attention is again directed at the five aircraft with the highest accident frequency, it is evident that a large percentage of accidents are being caused by component failures. The most graphic example would be figures for the AH-1 helicopter, where 46% of the autorotation accidents occurring in this craft were the result of materiel failure.

Figure 4 provides further aid in comparing the extent of materiel failure and human error as causative factors in autorotation accidents. Accident rates were computed for the categories of personnel error and materiel failure. Of the five aircraft, the UH-1 and AH-1 have more materiel failure than personnel error caused accidents per hour flown. However, the highest materiel rate failures are associated with the AH-1 and OH-6. The OH-6, interestingly enough, also possesses the highest rate of accidents attributed to personnel error. Nonetheless, the materiel failure rates for those two aircraft would seem to be out of proportion relative to the rest of the aircraft utilized in Army aviation.

A review of the previous data across all the aircraft with regard to materiel failure would seem to indicate there should be concern about the possibility of inherent engineering and/or materiel shortcomings. Further, there may be a need to examine mission profiles flown and the level of maintenance they receive. As shown, accidents involving materiel failure seem to be most serious, so partial success in attacking this aspect of the accident problem would yield a sizable return in terms of decreased destruction of both man and materiel resources. With regard to the contribution of the human operators to these accident statistics, it again is evident from Figure 4 and Table 10, that in almost all aircraft considered, human error contributes a significant amount and warrants the attention previously mentioned.



MATERIEL FAILURE AND HUMAN ERROR AUTOROTATION ACCIDENT RATES BY AIRCRAFT (ACC./100,000 hrs.)

FIGURE 4

Some members of the aviation community have expressed concern about the worth of the amount of training and practice of autorotation maneuvers presently being conducted. Although the data presented in this report are not sufficient nor detailed to the extent that they can be utilized to determine the worth of such training, it is of interest to view the figures compiled on autorotation practice accidents and relate them to the ultimate concern of success of the autorotation in an emergency situation.

TABLE 11

Emergency Situation Autorotation Accidents
Active Army

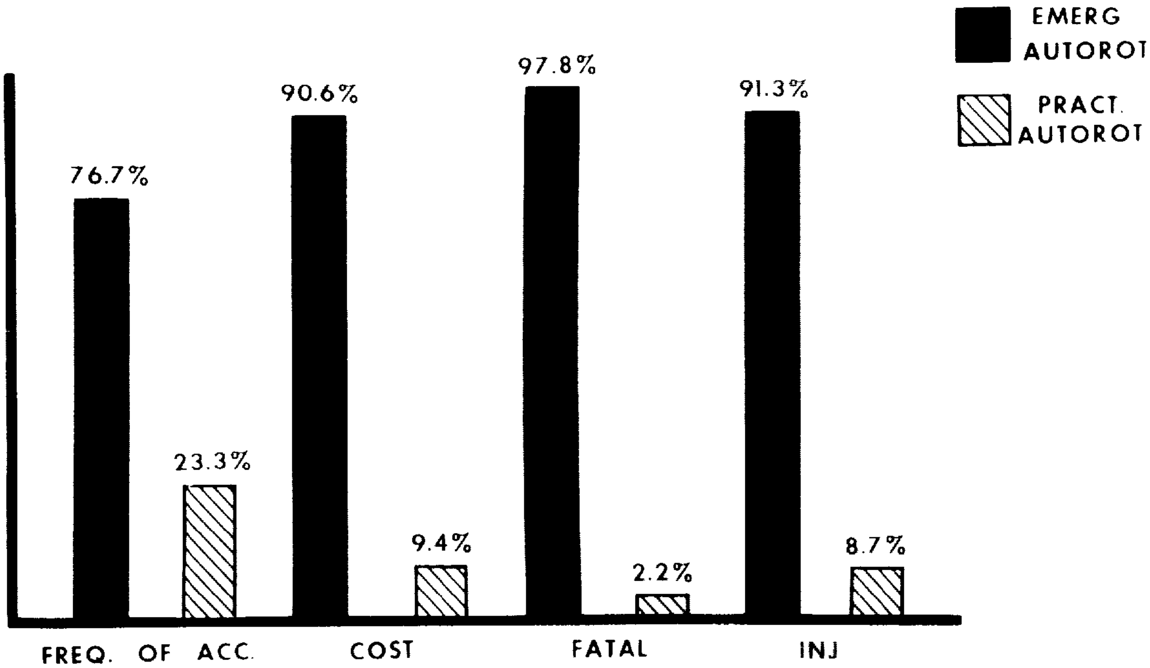
FISCAL YEAR	ACCIDENTS	PERCENT ACCIDENTS	COST	FATALITIES	INJURIES
70	307	77.7	40,248,000	42	327
71	227	78.5	32,813,000	30	210
72	72	67.9	7,872,000	18	58
	606	76.7	80,933,000	90	595

TABLE 12

Practice Situation Autorotation Accidents
Active Army

FISCAL YEAR	ACCIDENTS	PERCENT ACCIDENTS	COST	FATALITIES	INJURIES
70	88	22.3	4,115,000	1	33
71	62	21.5	2,801,000	1	12
72	34	32.1	1,440,000	0	12
	184	23.3	8,356,000	2	57

Table 11 presents a breakdown by year of the number, percentage, cost, fatality, and injury figures attributed to autorotation accidents occurring under emergency conditions. If reference is given to Table 2 in this report, it is evident that cost, fatality, and injury figures for these unsuccessful emergency autorotations command a large proportion of the total population of these accidents. In contrast, figures for practice situation autorotation accidents are considerably smaller.



FREQUENCY OF EMERGENCY AND PRACTICE AUTOROTATION ACCIDENTS AND THEIR SEVERITY

FIGURE 5

Comparing these practice and emergency autorotation accidents in terms of relative severity, it is obvious that accidents taking place during practice are not claiming a large portion of the total resources lost as a result of unsuccessful autorotations. Figure 5 serves to illustrate the large differences between these accident categories. Emergency autorotation accidents are not only more numerous, but are also much more severe. For example, 76.7% of total autorotation accidents occurring under emergency conditions account for 97.8% of the fatalities, 91.3% of the injuries, and 90.6% of the cost of all autorotation accidents. Conversely, as can be seen from Figure 5, the 23.3% of these accidents occurring during practice accounts for small percentages in these categories.

It is not possible to estimate what effect autorotation practice has had on these emergency figures. It seems appropriate to point out however, that practice costs measured here may be reasonable, if they can be positively related to a decrease in accidents or their severity under emergency conditions.

Any possible method of decreasing the accidents involved in practicing this maneuver while maintaining proficiency would, of course, be worthwhile. A potential way of reducing accidents has been considered by those involved in training. This approach would utilize only power recovery autorotations in practice and discontinue touchdown autorotations as a part of the training curriculum.

TABLE 13

Touchdown Maneuver - Autorotation Accidents
Active Army

FISCAL YEAR	ACCIDENTS	PERCENT OF TOTAL AUTOROTATION ACCIDENTS	COST	FATALITIES	INJURIES
70	83	21.0	3,128,000	1	23
71	59	20.4	2,648,000	1	12
72	29	27.4	1,021,000	0	6
	171	21.6	6,797,000	2	41

TABLE 14

Power Recovery Maneuver - Autorotation Accidents
Active Army

FISCAL YEAR	ACCIDENTS	PERCENT OF TOTAL AUTOROTATION ACCIDENTS	COST	FATALITIES	INJURIES
70	5	1.3	987,000	0	10
71	3	1.1	153,000	0	0
72	5	4.7	419,000	0	6
	13	1.7	1,559,000	0	16

Table 13 presents data on touchdown autorotation accidents during the three-year period under study. The touchdown maneuver comprised 21.6% of all autorotation accidents in the Army for these three years. Although the cost of these accidents does not seem to be unreasonable at first glance, this figure does represent 7.6% of the total cost of all autorotation accidents. On the other hand, in Table 14, it is shown that power recovery accidents contributed only 1.7% to total autorotation accidents. The relative cost contribution of these type accidents was only 1.7% of total cost for autorotation accidents for the period.

TABLE 15

Percentages for Combined Power Recovery and Touchdown Autorotation Accidents

	ACCIDENTS	PERCENT FREQUENCY	PERCENT COST	PERCENT FATALITIES	PERCENT INJURIES
Power Recovery	13	7.1	18.7	0	28.1
Touchdown	171	92.9	81.3	100	71.9

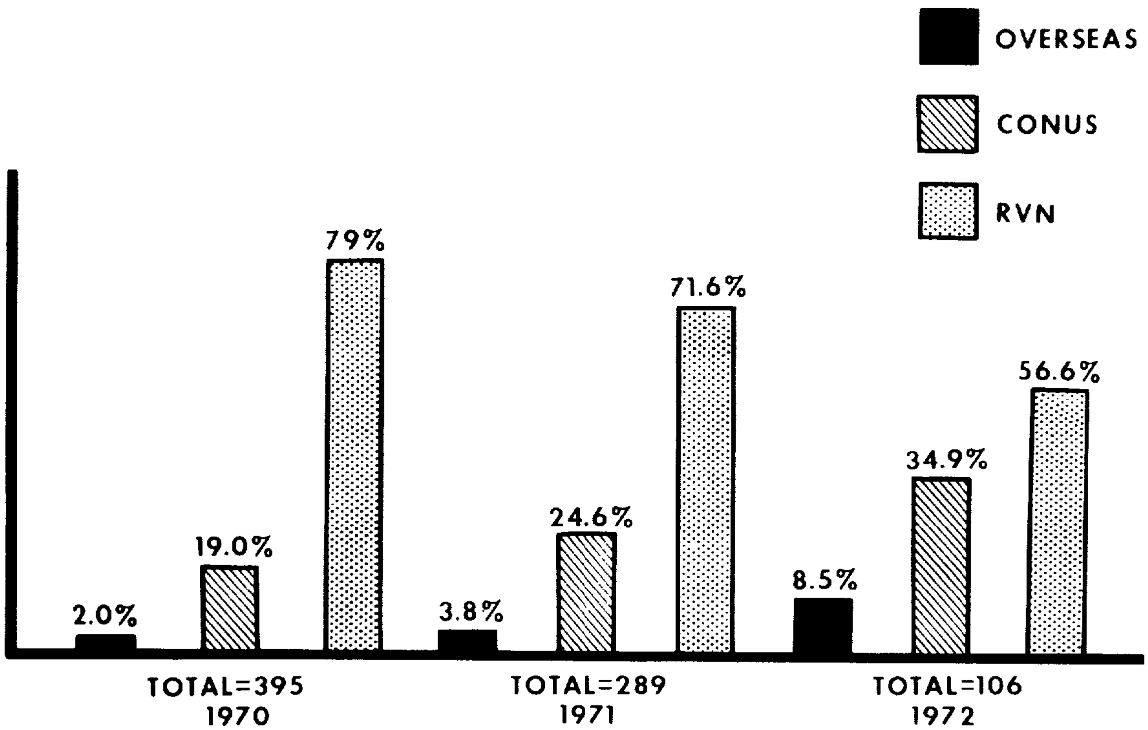
If the totals for accidents, costs, fatalities, and injuries from Tables 13 and 14 are combined and percentage derived, it can be observed that the use of only the power recovery maneuver in training might possibly be a desirable alternative. Table 15 presents these combined percentages. Before this procedure could be adopted, however, it would be necessary to gather information which would serve to aid in the determination of whether or not the discontinuance of the touchdown maneuver could be implemented with no expense to aviator proficiency when faced with an emergency autorotation. Although some work has been done which addresses this problem, more is likely to be needed before decisions on this aspect of training can be made.

In summary, it may be appropriate to reiterate several key points made in this discussion. First, the data presented within this report shows that the autorotation maneuver is associated with a large number of accidents resulting in many injuries and the loss of many lives, a situation which brings into question the matter of whether or not an additional inflight escape system might be warranted. Second, it serves to delineate two major problem areas of concern with regard to the autorotational maneuver, those involving materiel failure and those involving human error. With regard to the former, increased maintenance efficiency and/or greater hardware reliability are desirable owing to the high percentage and severity of autorotational accidents attributed to this factor. In this respect, it was suggested that it may be appropriate to give consideration to particular aircraft. Obviously, if success in this area could be achieved, there would be less need for the maneuver;

however, even partial success might aid to decrease the severity of such accidents. Thirdly, it was pointed out that accidents attributed to the human factor in the flight system, though not as severe as those attributed to materiel failure, are numerous. Efforts in research and training techniques should be continued in an attempt to decrease the frequency of this causal factor. Finally, the data presented and discussed here is strictly of an epidemiological nature and can in no way serve to determine the worth of the practice of this maneuver and its impact on accidents in rotary wing aviation. It may, however, serve to increase the awareness of interested personnel to these types of problems and thus provide impetus for further critical research efforts.

APPENDIX

In order to determine the relative contribution by geographical area for autorotation accidents within the time frame of concern, a breakdown by years for the Continental United States (CONUS), overseas, and the Republic of Vietnam (RVN) was performed. This figure illustrates the shift in such accidents in Southeast Asia during this time period. It also demonstrates an increase in these types of accidents for CONUS and overseas.



PERCENTAGE AND NUMBER OF AUTOROTATION ACCIDENTS BY GEOGRAPHICAL AREA BY YEAR