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REPORT TO THE CONGRESS

In-Flight Escape Systems For Helicopters Should Be Developed To Prevent Fatalities B-177166

Department of Defense

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

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JUNE 12, 1973

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D C 20548

B-177166

To the President of the Senate and the
Speaker of the House of Representatives

We are reporting that in-flight escape systems for helicopters should be developed to prevent fatalities.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U S.C 53), and the Accounting and Auditing Act of 1950 (31 U S.C 67).

We are sending copies of this report to the Director, Office of Management and Budget, the Secretary of Defense, the Secretary of the Army, and the Secretary of the Navy.

Elmer B. Staats

Comptroller General
of the United States

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ABBREVIATIONS

DOD Department of Defense

GAO General Accounting Office

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

IN-FLIGHT ESCAPE SYSTEMS FOR HELICOPTERS SHOULD BE DEVELOPED TO PREVENT FATALITIES
Department of Defense B-177166

D I G E S T

WHY THE REVIEW WAS MADE

Because of increasing helicopter crash fatalities, GAO wanted to know how technological developments were being used to reduce hazards to helicopter crews and passengers

Background

From 1958 to 1968, Army and Navy helicopter flying hours increased more than 7 times, but helicopter crash fatalities increased more than 17 times Most of these fatalities occurred during noncombat operations

The conflict in Southeast Asia greatly expanded the use of helicopters The lives lost through military helicopter crashes in this area increased from about 40 in 1963 to about 1,000 a year from 1968 through 1970

Most military fixed-wing aircraft--particularly those used in combat--have some means of occupant escape during flight, such as ejection seats Escape systems have prevented over 2,800 pilot deaths since 1960 Per hours flown, accident fatality rates for helicopters are higher than for fixed-wing aircraft, but helicopters do not have such escape systems The Navy determined that equipment could be installed on helicopters to permit occupants to escape at altitudes of 100 feet or higher

FINDINGS AND CONCLUSIONS

Navy-sponsored studies show that most helicopter fatalities result from uncontrolled descents which, in turn, result in crashes causing structural failures and fires The studies show also that in-flight escape systems could prevent over 40 percent of these fatalities Other proposed survivability features could further reduce fatalities (See p 7)

The Navy has studied such escape systems since 1962 However, the Army, which uses helicopters the most, has concentrated on reducing injuries and fatalities by developing and installing energy-absorbing seats to reduce impact forces and crashworthy fuel tanks to prevent fires Although the Army system is important, it offers protection to crew members and passengers only when impact forces are low (See p 18)

From September 1967 to September 1972, 210 Army and 10 Marine Corps Cobra pilots were killed in Vietnam. In 1969 and early in 1970, U S Forces lost an average of seven Cobra helicopter pilots a month in Vietnam. A Navy analysis indicated that in-flight escape systems could have prevented 6 out of every 10 Cobra pilot deaths (See p 15)

In March 1972 the Navy obtained $500,000 to begin developing individual-type escape systems for the Cobra helicopters The Army is helping to fund this development effort (See p 18) Although the Army agrees that an in-flight escape system is desirable for its new advanced attack helicopter, its current design requirements do not provide for such a system GAO believes that the development of an in-flight escape system should be emphasized at this time to insure its availability for this helicopter (See pp 19 and 20)

The Navy has deemphasized developing and testing a capsule-type in-flight escape system for larger troop transport helicopters primarily because of the additional weight involved (See p 14)

GAO recognizes that the development of in-flight escape systems for cargo-passenger helicopters may pose severe problems and constraints regarding weight and complexity However, available technology for capsule-type in-flight escape systems has been demonstrated Therefore GAO believes effort to develop a feasible system for the troop-carrying helicopters should be continued

RECOMMENDATIONS OR SUGGESTIONS

Available technology for individual in-flight escape systems should be applied to the design of new attack, observation, and training helicopters which have fixed crews Specifically, GAO recommends that the Army·

--Emphasize and give priority to developing an in-flight escape system for the advanced attack helicopter.

--Monitor the current development of the escape system for the Cobra helicopter to determine whether the concept could be applied to the design of the advanced attack helicopter

--Reevaluate the design requirements for the advanced attack helicopter to insure that it will be capable of accepting an in-flight escape system when it becomes available (See p 20)

GAO further recommends that effort to develop a feasible solution to provide an in-flight escape capability for the larger cargo-passenger helicopters be continued

AGENCY ACTIONS AND UNRESOLVED ISSUES

In commenting on GAO's draft report, the Department of Defense (DOD) said it would continue efforts to increase the effectiveness of escape systems but disagreed that emergency in-flight escape systems should be included in helicopters now being developed or planned for development

DOD contended that an in-flight escape system had not been "demonstrated to be the most effective method of improving flight safety, considering both human life values and dollar costs " (See app I.)

GAO believes that DOD is not adequately considering the costs of not having emergency in-flight escape systems

--Trained and experienced aviators and other trained military personnel are killed Army and Navy estimates of the initial cost of training each helicopter pilot range from $20,000 to $100,000

--Death benefits must be paid

--New pilots must be trained

--Helicopter pilot and crew morale--as well as military readiness--is adversely affected

GAO recognizes that it may be expensive to develop, install, and maintain an in-flight escape system but believes that the potential decrease in the number of fatalities and severe injuries warrants further consideration For a detailed discussion of DOD's reasons for objecting to the recommendations, see page 21

MATTERS FOR CONSIDERATION BY THE CONGRESS

GAO is bringing this matter to the attention of the Congress because of its continuing interest in military developments affecting the safety of military personnel and because congressional monitoring may be needed to stimulate action

CHAPTER 1

INTRODUCTION

Parachutes and ejection seats have provided reasonably effective means of escape from fixed-wing aircraft for over 20 years A Navy investigation showed that in-flight escape systems in these aircraft had saved 2,800 lives from 1960 to 1970

However, helicopter crews and passengers have no means of safe escape when in-flight emergencies cause the pilot to lose control of the craft Because of the helicopter's spinning rotor blades and inherent instability, it is not practicable for the crew and passengers to use parachutes and bail out Successful parachute escapes from helicopters are rare

If a pilot can control the helicopter after an in-flight emergency occurs, such as when engine power is lost, he can attempt to land the craft using "autorotation" (controlling descent by using the upward flow of air through the rotor blades to make them rotate) Just before landing, the angle of the rotor blades is changed to produce a lifting effect which cushions the impact Autorotation, however, does not provide full survival capability, as shown by helicopter casualty statistics--about 5,000 fatalities in Vietnam alone since January 1961.

We wanted to know whether the military was giving enough consideration to technological developments which could prevent such fatalities

We reviewed Army and Navy efforts to develop helicopter personnel survival systems--mainly in-flight escape systems--and their plans to install them in planned, developmental, and operational helicopters We also reviewed reports on Navy-sponsored studies, including feasibility studies, of the helicopter escape and survival problem We interviewed officials of the Office of the Director of Defense Research and Engineering, the Army, and the Navy in the Washington, D C., area and of the Naval Weapons Laboratory in Dahlgren, Virginia.

CHAPTER 2

URGENT NEED FOR

HELICOPTER IN-FLIGHT ESCAPE SYSTEMS

The military needs to do more to protect the lives of helicopter crews and passengers by developing in-flight escape systems Navy-sponsored studies since 1962 have repeatedly shown that most helicopter personnel fatalities resulted from crashes of uncontrolled helicopters and that in-flight escape systems could have prevented from 40 to 60 percent of these fatalities

The first Navy-sponsored study, completed in October 1962, concluded that about 60 percent of the Navy and Marine Corps helicopter fatalities from 1952 to 1960 could have been prevented if in-flight escape systems had been available Later, an updated analysis which included Navy and Marine Corps fatalities from 1961 to 1965 and Army fatalities from 1958 to 1965 showed that 45 percent of them could have been prevented Similar percentages were noted in a later study which included Army, Navy, and Marine Corps helicopter accidents through 1968

In these analyses, available reports on helicopter accidents were studied individually to determine circumstances surrounding in-flight emergencies and the causes of death of personnel involved Each fatal accident was then judged to determine whether occupants could have survived and what safety provision would have been necessary for survival Some accidents were excluded from the studies because of insufficient data

The following table summarizes the consolidated results of the three studies The statistics show that all missions and operations were vulnerable to fatal accidents In fact, more helicopter occupants were killed during noncombat operations than during combat operations

Combined Army-Navy-Marine Corps
Helicopter Occupant Fatalities (note a)

	Noncombat		Combat		Combined total	
	Number	Percent	Number	Percent	Number	Percent
Safety provision needed						
In-flight escape	780	44 1	155	29 6	935	40 8
Emergency flotation	146	8 3	3	0 6	149	6 5
Fire protection	124	7 0	96	18 3	220	9 6
Impact protection	167	9 4	25	4 8	192	8 4
Fire and impact protection	192	10 9	97	18 5	289	12 6
Flotation and impact protection	46	2 6	9	1 7	55	2 4
Total preventable	1,455	82 2	385	73 5	1,840	80 2
Not preventable	314	17 8	139	26 5	453	20 8
Total fatalities	1,769	100 0	524	100 0	2,293	100 0

[a]1958-68 for the Army and 1952-68 for the Navy and Marine Corps

In each analysis, an accident qualified as an in-flight escape situation if

--The pilot had clear warning of an impending loss of lift and/or control.

--The pilot could react after the emergency began

--The helicopter cleared the terrain at 100 feet or more when the pilot was warned

--Descent was uncontrolled and resulted in severe impact forces causing fatal or critical injuries to the occupants (It was assumed that in a controlled descent the pilot would autorotate rather than use the escape system)

Other survivable accidents from which there was no escape were those which did not meet the above criteria but in which fatal or critical injuries could have been prevented only by incorporating safety features for impact protection, emergency flotation, or crash fire protection or a combination of these features

A sharp escalation in Vietnam helicopter crash casualties--from 12 deaths in 1961 and 1962 to about 1,000 in 1968--further underscored the need for in-flight escape systems In total there were about 5,000 helicopter occupant deaths in Vietnam from January 1961 to January 1971 and about 4,700 helicopter losses On the basis of the above studies, one-third of these deaths might have been prevented with in-flight escape systems

Two types of in-flight escape systems have been proposed the capsule type for troop transport helicopters and the individual type for helicopters not carrying troops (i e , when only a crew is involved)

CHAPTER 3

EFFORTS TO DEVELOP A

CAPSULE IN-FLIGHT ESCAPE SYSTEM

The Navy began a program in 1964 to develop a practical means of in-flight escape from helicopters.

TECHNICAL FEASIBILITY DEMONSTRATED

Using obsolete drone UH-25B helicopters as test vehicles, the Navy conducted five full-scale tests of a capsule-type escape system from March to June 1966.[1] The Navy used the helicopter's fuselage or capsule as a vehicle to lower the occupants to the ground. Before the helicopter began descending, certain unoccupied parts--including the rotor blades--were ballistically separated from the capsule so that parachutes could be used to slow the descent

The successful tests were conducted at 74, 143, and 187 feet. In each case, the escape system functioned perfectly. Thus technical feasibility of the concept had been proven The fact that it worked at these altitudes is important because the earlier Navy-sponsored analysis revealed that 90 percent of the in-flight emergencies occurred at altitudes between 100 and 600 feet

APPLICATION TO OPERATIONAL HELICOPTERS

On the basis of these successful tests, in June 1967 the Navy began investigating the adaptability of survival systems to the helicopters then being produced Besides in-flight escape systems, the study included an evaluation and selection of systems for surface impact protection, fuel protection, passive defense (i e., armor plating), and emergency flotation. These other survival features were included for those emergencies when in-flight escape was not feasible, such as when emergencies occurred at low altitudes or when autorotation could be used

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[1]Three tests were completely successful, one was aborted due to drone malfunction, and one was not successfully initiated.

The Navy evaluated 14 different types of helicopters to see if it was feasible to modify them so that personnel survival systems could be installed The principal determining factor was the percentage of payload required by the survival system. The capsule system was considered feasible for four of the helicopters [1] The Navy selected the CH-46D and the UH-1E helicopters for detailed study because a great many of them were being used, the recovery system weight was less than one-third of the available payloads, and the ratio of probable survivals to relative costs was high

The CH-46D helicopter

The CH-46D helicopter, a tandem-rotor type, carries a crew of 3 and 17 to 25 fully equipped troops (or about 5,000 pounds of cargo) Its weight when empty is about 15,000 pounds and its normal gross weight is about 24,000 pounds.

The emergency in-flight escape system resulting from the study included a ballistic subsystem to sever the rotors and unoccupied parts of the helicopter and a recovery subsystem to lower the occupied part to the ground Other survival features included a crash impact subsystem to protect against impact forces, an emergency flotation subsystem, and a passive defense subsystem

The personnel survival system was designed to meet or surpass the requirement for a maximum of 40 feet per second impact velocity when the recovery system was initiated at or above 100 feet and when the aircraft velocity was within

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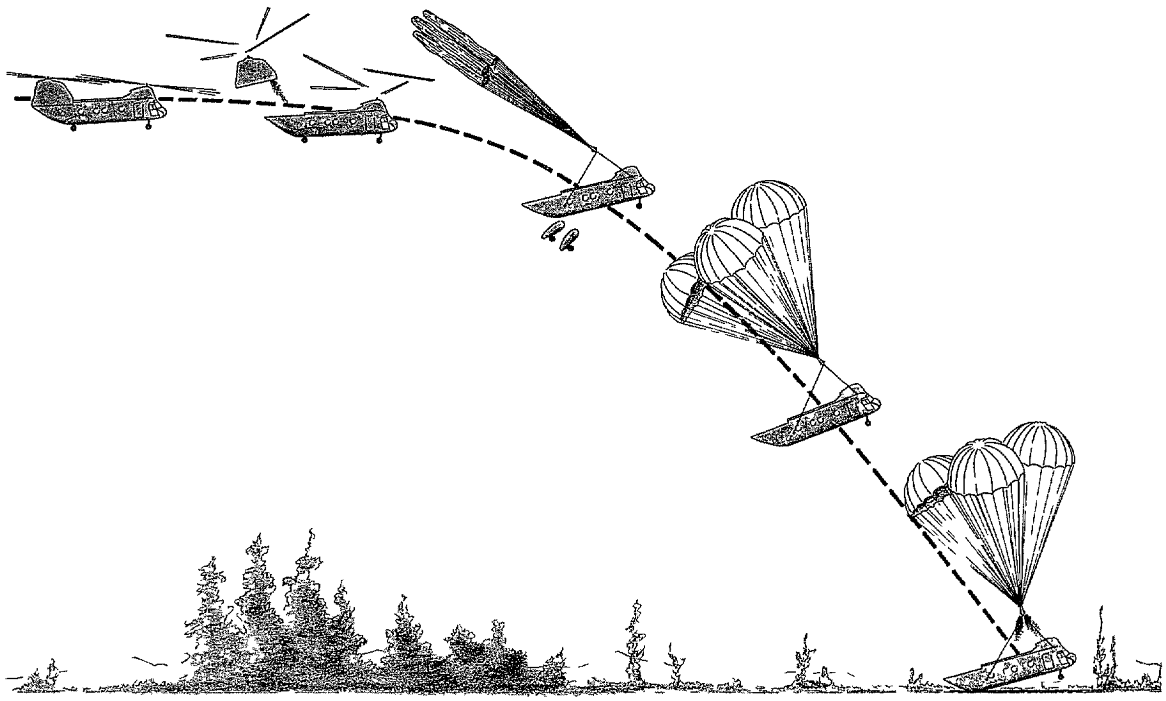
[1] Ejection seats (i e., individual in-flight escape systems) were recommended for two more helicopters This type of system is discussed in chapter 4

normal limits. The sequence of events for the CH-46D in-flight capsule escape system is shown below.

CH-46 RECOVERY SEQUENCE



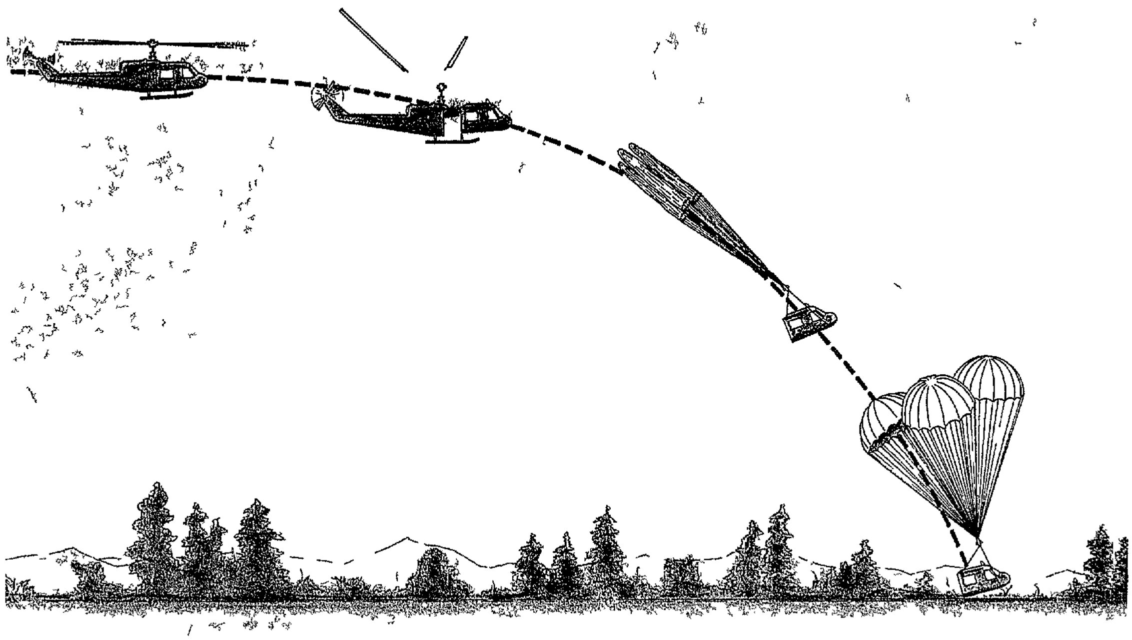
The total survival system weight for this craft was 1,247 pounds (8 percent of the empty weight), including an in-flight escape system weighing 662 pounds (4 3 percent of the empty weight)

The UH-1E helicopter

The UH-1E helicopter is a light, single-rotor helicopter with a fuselage about 40 feet long and a payload capacity of about 1,400 pounds Its weight when empty is 4,700 pounds.

A recovery subsystem was designed for this helicopter. It consisted of four 36-foot, ballistically deployed and spread parachutes to be used at altitudes above 100 feet and at airspeeds from zero to 200 feet per second Surface impact protection was provided by crash-energy-absorbing troop and crew seats, crash-resistant fuel cells, and breakaway, self-sealing fuel lines. The sequence of events for the UH-1E in-flight capsule escape system is shown below.

UH-1E RECOVERY SEQUENCE



The survival system weighed 769 pounds (16.4 percent of the empty weight), which included an in-flight escape system weighing 303 pounds (6 5 percent of the empty weight)

In May 1968 the Navy issued its final report on the above study of helicopter personnel survival systems and concluded that

> "An in-flight personnel recovery system for helicopters is feasible and practical Previous tests have demonstrated the feasibility of the concept, and subsequent advancement in the state of the art of ballistically deployed and opened parachutes combined with retro-rockets has made the concept efficient and practical "

DEVELOPMENT EFFORTS

In September 1968 the Naval Air Systems Command proposed a development program to pursue the capsule system. The proposed development work was estimated to cost $5.3 million over a 4-year period. In its proposal, the command stated that

> "Current rotary-wing aircraft do not provide an acceptable probability of occupant survival in emergency situations. Currently operational helicopters were not designed for personnel survival and safety in crashes, in fact, personnel surviving a helicopter emergency do so only when the crash impact is light, post-crash fires are small, or the helicopter floats for a sufficient time to permit the occupants to escape an at-sea crash
>
> "The proposed helicopter capsule escape system will respond to this operational deficiency by providing a substantial capability for personnel survival."

The proposal included the development of a survival system applicable to rotary-wing aircraft to be used between 1975 and 1980 and retrofitting the CH-46D aircraft with the escape system. The Navy estimated that the proposed personnel survival system would "ensure the survival of over 80 percent of helicopter occupants involved in emergency situations of the type that now result in fatalities."

Approved technical development plan

In December 1969 the Naval Air Systems Command issued an approved technical development plan The plan--called the Helicopter Escape, Protection and Survival System--included a 9-year advanced development program costing $14.4 million

The approved plan differed from the September 1968 proposal in that the CH-46D retrofit part of the program was deleted and developing a survival system for future helicopters was primarily emphasized. The plan included the development of a capsule system for troop transports and an individual system for aircrews To make sure that the survival system would not weigh too much, the Navy established a weight limit of no more than 5 percent of the helicopter's gross weight.

According to the Navy's plan, the 5-percent weight limit for all survival features should be attainable

Carrying this additional weight without adversely affecting the helicopter's mission is an important consideration. We therefore asked DOD whether existing helicopters could assume this added weight. DOD told us that retrofitting an operational craft with an escape system would require the maximum payload to be reduced in proportion to the helicopter's power margin. We were informed however, that the additional weight could be taken care of in the development of new helicopters by establishing power requirements based on the helicopter's total weight including escape mechanisms.

We noted that the Navy had not requested funds for the capsule-type in-flight escape system during fiscal year 1973. On March 6, 1972, the Navy told a subcommittee of the House Committee on Appropriations that the program was of low priority primarily because of the system's weight Also, the capsule system (1) substantially increased cost, (2) reduced the payload, although most helicopters were already fully loaded, (3) reduced time on station, and (4) could prove extremely difficult to maintain

We believe many of these problems might be minimized if the military continued development work and provided for in-flight escape systems during the initial design of new helicopters. The military position seems to be to wait until technological advances have minimized the problems, our position is that technology should be exploited and advanced where appropriate to insure that these life-saving systems are developed and available as soon as possible

The Navy recently shifted its emphasis to the individual escape system. This relatively new program is discussed in detail in chapter 4

CHAPTER 4

EFFORTS TO DEVELOP AN INDIVIDUAL IN-FLIGHT ESCAPE SYSTEM

The AH-1 Cobra helicopter is an operational high-performance, single-rotor helicopter capable of weapons fire, low-altitude, high-speed flight, search and target acquisition reconnaissance by fire, multiple weapons fire support, and troop helicopter support There are two Cobra models the single-engine or G model presently being used by the Army and Marine Corps and the twin-engine or J model planned for procurement for the Marine Corps Both models carry a pilot and front-seat gunner who is also a pilot.

Between September 1967 and September 1972, the Army and Marine Corps lost 220 Cobra pilots--210 Army and 10 Marine Corps--in Vietnam In 1969 and early 1970, U S forces were losing an average of seven Cobra pilots each month.

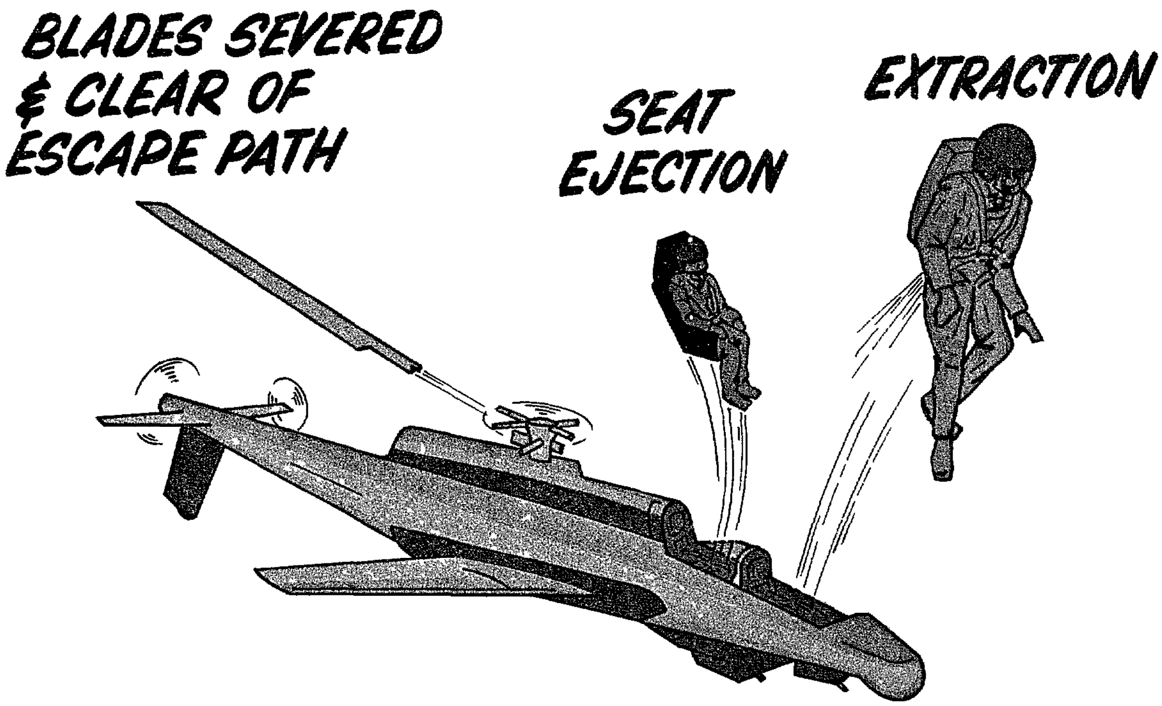
The Navy analyzed data on the Cobra helicopter fatalities to determine whether an in-flight escape system could have prevented the deaths The Navy studied individual records and based its conclusions on the information and circumstances involved in each specific case The analysis disclosed that 6 out of every 10 Cobra crew fatalities might have been prevented by an in-flight escape system

INDIVIDUAL IN-FLIGHT ESCAPE SYSTEMS

As we said in chapter 3, the Navy began to develop in-flight escape systems for helicopters in 1964 In 1966, the Navy proved the technical feasibility of a capsule escape system. However, the Navy did not consider a capsule-type in-flight escape system feasible for the Cobra because the system was heavy (about 420 pounds) and complex and because installation would require major aircraft modifications

The military services have had over 20 years of experience with individual in-flight escape systems in their fixed-wing aircraft Two types of individual escape systems are used in these aircraft the ejection-seat system and the extraction system Both types were considered for the Cobra

EXTRACTION/EJECTION SEAT SYSTEM



Ejection-seat system

The ejection-seat system was considered for the Cobra The system uses cartridges and rocket catapults to eject the crewman and his seat from the cockpit After clearing the cockpit, the crewman is separated from his seat, and his parachute is deployed to control his descent

The Navy considered all existing and proposed ejection-seat systems, however, the physical dimensions of the seats would require major modifications to the Cobra to make the ejection seats compatible The modified ejection-seat system would also add 219 pounds to the aircraft (about 11 percent of the available payload) and would cost about $24,000

Extraction system

The Air Force now uses the extraction system in two types of fixed-wing aircraft and the Navy is retrofitting it into a fixed-wing aircraft This system uses a rocket which physically pulls the crewman clear of the aircraft through the opened canopy The rocket then automatically releases the crewman and his parachute is deployed Each extraction system would add 150 pounds to the helicopter, cost about $15,000, and require fewer modifications than the ejection-seat system

The Navy selected the extraction system as the best candidate for the Cobra and conducted two demonstration tests to establish the feasibility of the system The Navy also demonstrated that the main rotor blades could be severed and the canopy opened to provide a clear exit path for the occupants

In its October 1971 report on an in-flight escape system for the Cobra helicopter, the Navy stated that an extraction system was technically feasible and operationally practical at that time The Navy concluded that an extraction system would be a low technical risk because proven concepts and off-the-shelf components would be used On the basis of its findings, the Navy recommended that a development program be established and that the Cobra helicopter be retrofitted with an extraction in-flight escape system. The system for each Cobra helicopter was estimated to cost about $15,000(1) and total development cost was estimated at about $3 5 million

The Marine Corps established an operational requirement in 1971 for an emergency in-flight escape system for its Cobra helicopters. Because the Army was also using Cobra helicopters, the Navy asked the Army in May 1971 whether it had a similar operational requirement for an in-flight escape system Although no formal requirement existed at that time, the Army subsequently validated the Navy's analysis of fatal mishaps in the Cobra, advised the Navy that the Army's attack helicopters needed escape systems, and proposed that the development work be a joint Army-Navy effort

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[1]In March 1973, a Navy official told us the latest cost estimate is $25,000

On December 14, 1971, a contractor conducted a test which demonstrated that the helicopter's rotor blades could be severed so that the blades would leave the aircraft in a predetermined direction--thereby minimizing the risk of striking other aircraft According to the Navy, this feasibility demonstration added impetus for going ahead with the Cobra in-flight escape system

DOD EMERGENCY FUNDS REQUESTED FOR THE COBRA

In March 1972 the Navy obtained $500,000 from DOD's fiscal year 1972 emergency fund to begin work on the development of this system The Army and Navy are funding the project with about $1 8 million each The Navy plans to include an escape system in the AH-1J Cobra helicopters to be procured for the Marine Corps in fiscal year 1975

Before the development work on the Cobra began, the Army had not funded the development of any helicopter personnel in-flight escape systems The Army has, however, spent an average of $5 million annually to develop crash survivability features for helicopters to reduce the impact and resultant damage to the craft and occupants For example, the Army has concentrated on improvements such as energy-absorbing seats to reduce impact and crashworthy fuel tanks to prevent postcrash fires The Navy's analyses of helicopter fatalities, however, have revealed that such crash survivability features would have had no effect in preventing many of the fatalities For example, most of the fatal accidents in Cobras involved in-flight emergencies occurring at 300 feet or more The Navy study showed that in 93 percent of the gunship crashes, all crewmen aboard the helicopters were killed because of the crash impact resulting from the height Only an in-flight escape system might have prevented many of these fatalities

Crash survivability features being developed by the Army are important in reducing fatalities when crash impact is minimal When the pilot cannot maintain control of the craft from higher altitudes, however, an in-flight escape system is needed Although the Army has concentrated only on crash survivability systems, the Army Materiel Command has proposed for fiscal years 1974 and 1975 to investigate available in-flight escape system concepts for possible application to future Army aircraft

Except for the Cobra, the military services are not developing in-flight escape systems for other helicopters that are either in operation or presently being developed. Yet the Navy analyses showed that these life-saving devices are needed to significantly reduce helicopter fatalities

NO PROVISION FOR AN IN-FLIGHT ESCAPE SYSTEM IN THE ADVANCED ATTACK HELICOPTER

Design requirements for the Army's new advanced attack helicopter, which is being developed as a manned aerial weapons system to be used primarily in the antiarmor role, do not provide for an in-flight escape system Although the Army agrees it is desirable to have such a system, its November 1972 requirement document and request for proposal for the advanced attack helicopter state that the original design should not include space, weight, and power provisions for an in-flight escape system nor be considered in design tradeoffs. However, the documents note that there may be a future requirement for an escape system.

In commenting on our draft report, DOD stated that in-flight escape systems had not been demonstrated to be the most effective method of improving flight safety, considering both human life values and dollar costs However, Army officials informed us that a cost-effectiveness or cost-benefit analysis for an in-flight escape system had not been made to support this position. Therefore, we question the decision to exclude this feature from the helicopter's design requirements without such an analysis.

Experience with the Cobra in Vietnam shows the need for an in-flight escape system Although self-sealing fuel tanks and other crashworthy features--some of which are also in the Cobras--are included in the advanced attack helicopter's design, an uncontrollable helicopter descent from 100 feet or higher without an in-flight escape system is likely to result in the occupants' death. We therefore believe further consideration is warranted

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

The military services are developing new helicopters which do not include provisions for in-flight escape systems The technology for developing these systems is available and the feasibility of the concept--particularly of the individual extraction escape system, which could be used in attack and observation-type helicopters where only one or two crew members are involved--has been proven An in-flight escape system is currently being developed for the Cobra helicopter and is scheduled to be qualified for operational use by October 1974

In view of the critical need for such life-saving devices and to avoid costly modifications in the future, we believe that the development of an in-flight escape system should be emphasized at this time to insure its availability for the proposed advanced attack helicopter

We recognize that developing in-flight escape systems for cargo-passenger helicopters poses more severe problems and constraints regarding weight and complexity However, we believe that effort to develop technology which could solve these problems should be continued

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

We recommend that, in addition to other safety features, available technology for individual in-flight escape systems be applied to the design of new attack, observation, and training helicopters with fixed crews Specifically, we recommend that the Army

--Emphasize and give priority to developing an in-flight escape system for the advanced attack helicopter

--Monitor the current development of the escape system for the Cobra helicopter to determine whether the concept could be applied to the design of the advanced attack helicopter

--Reevaluate the design requirements for the advanced attack helicopter to insure that it will be capable of accepting an in-flight escape system when it becomes available

We further recommend that effort to develop a feasible solution to provide an in-flight escape capability for the larger cargo-passenger helicopters be continued.

AGENCY COMMENTS AND OUR EVALUATION

The Director of Defense Research and Engineering commented on our draft report on behalf of the Secretary of Defense (see app I) DOD stated that our draft report did not present a "balanced perspective" of a solution to a problem well known and receiving continuing attention within the Department and that use of in-flight escape systems, except perhaps for selected attack helicopters, was not consistent with DOD's objective of reducing the cost and complexity of weapon systems.

Although DOD stated that it would continue efforts to increase the effectiveness of escape systems, it disagreed with our recommendation that, in addition to other survival features, provisions be made for emergency in-flight escape systems in helicopters now under development or planned for development DOD's main reason for disagreeing was that an in-flight escape system had not been "demonstrated to be the most effective method of improving flight safety, considering both human life values and dollar costs " Specifically, DOD commented that we

--did not adequately consider the costs of the proposed escape system,

--did not fully recognize improved survivability features of helicopters now in development, and

--did not adequately consider the hazards of the system, which include (1) use of multiple explosive charges which may be subject to inadvertent or incomplete actuation and (2) severance of rotor blades which become high velocity missiles

We believe DOD has not adequately considered the benefits of having emergency in-flight escape systems, such as saving trained and experienced aviators and possibly other trained military personnel Our position on each of the objections is presented below.

Did not adequately consider the costs of the proposed escape system

Army and Navy estimates of the initial cost of training each helicopter pilot range from $20,000 to $100,000. If experienced pilots die in crashes, death benefits must be paid, new pilots must be trained, and helicopter pilot and crew morale--as well as military readiness--is adversely affected We recognize that it may be costly to develop, install, and maintain an in-flight escape system, but we believe the potential decrease in fatalities and severe injuries warrants further consideration.

During our review, several agency officials stated that the cost of helicopter escape systems was a major constraint However, except for the Cobra's system, which the Navy estimated would cost $15,000,(1) none of the officials knew how much a system would cost

Did not fully recognize improved survivability features of helicopters

The features referred to are energy-absorbing seats to reduce impact forces, crashworthy fuel systems to prevent postcrash fires, and aircraft designs to provide maximum protection for occupants when they experience crash forces within human tolerance

Evidence that these features cannot take the place of an in-flight escape system is contained in the Army's "Crash Survival Design Guide," revised October 1971 The Army studied impact conditions occurring in accidents of various types of Army aircraft The Army excluded accidents "resulting in catastrophic uncontrolled free falls from altitudes of a hundred feet or more" because

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[1]The latest estimate is $25,000.

"Such accidents almost invariably result in * * * nonsurvivable impact forces, and are of little value in establishing realistic crash survival envelopes that would be useful to the aircraft designer "

These are precisely the conditions when an in-flight escape system is needed

Did not adequately consider the hazards of using explosive charges and the danger of severed rotor blades

Ballistic techniques have advanced considerably in recent years to the point that some explosives are relatively safe and reliable to use and easily installed and maintained Shaped charges have been used successfully in the F-111 aircraft to separate the cockpit for crew survival and in space capsules They will also be used in the Navy's new F-14 and S-3 aircraft

Rotor blades are severed by placing linear-shaped explosive charges on the rotor shaft and rotor yoke The blades and hub assembly are jettisoned in a predetermined direction--forward and aft--by their own momentum after the charges go off Officials we interviewed did not estimate the mathematical risk of the jettisoned components' striking other aircraft

MATTERS FOR CONSIDERATION BY THE CONGRESS

We are bringing this matter to the attention of the Congress because of its continuing interest in military developments affecting the safety of military personnel and because congressional monitoring may be needed to stimulate action in this area

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON D C 20301

29 NOV 1972

Mr Harold H Rubin, Deputy Director
Technology Advancement, Procurement
and Systems Division
U S General Accounting Office
Washington, D C 20548

Dear Mr. Rubin

This letter provides comments on the GAO Draft Report dated September 8, 1972, "Needed In-Flight Escape Systems to Reduce Helicopter Fatalities" forwarded separately to me and the Secretary of Defense for comment This response is for the Secretary of Defense and was prepared after considering the results of reviews by the Military Departments. Both general and specific comments are appropriate

In general, the conclusions and recommendations by the GAO study are based on a particular approach, in-flight escape systems, to reduce fatalities in helicopter crashes This approach is but one of the many systems which have been proposed for all new aircraft, each with merits of its own, but which add to the cost and complexity of these aircraft Even though we are always interested in ways to increase safety in flight, this particular recommendation has not, at this time, been demonstrated to be the most effective method of improving flight safety, considering both human life values and dollar costs

Specifically, the draft report does not adequately consider the costs of the proposed escape system, does not fully recognize improved survivability features of helicopters now in development, and presents an inconsistent treatment of utility/transport helicopters and utility/transport airplanes. System costs of the proposed escape system involve not only the initial acquisition costs but the additional costs of life-time maintenance and the cost of increasing the helicopter's over-all size in order to perform any given mission plus carry the weight and cube of the escape system for the life of the aircraft. Additionally, the escape systems provide an inherent hazard in that the aircraft must be equipped with multiple explosive charges subject to inadvertent or incomplete actuation The concept involves severance of rotor blades which become high velocity missiles presenting another hazard New helicopters now in development will contain many features which will greatly reduce the number of catastrophic crashes as well as the likelihood of serious injuries when crashes occur. Fail safe structural design, redundant control systems and other features will reduce crashes from combat damage and other factors significantly without the additional hazards of the proposed ejection system Some of these advanced features, such as crash resistant fuel systems, are being incorporated in operational systems now

The draft report cites the success of escape systems in fighter airplanes as evidence of the potential benefits It repeats the well advertised and partly demonstrated potential for attack type helicopters (such as Cobra) and then extends the need also to utility/transport helicopters without similar airplane analogy In practice, all aircraft experience catastrophic crashes when control systems are lost, not just helicopters Unlike airplanes, utility and transport helicopters can and do make frequent safe emergency landings (including auto-rotation) after experiencing emergencies which would result in fatal crashes for airplanes

In summary, we do not believe that the draft report presents a balanced perspective of a solution to a problem well known and receiving continuing attention within the Department of Defense The proposed solution is not consistent with our objective of reducing cost and complexity of weapon systems except perhaps for selected attack helicopters We do intend to continue our technology efforts at an appropriate level to increase the effectiveness of escape systems

In view of the foregoing, it does not appear that any useful conclusions can be reached by the data presented in the report Therefore, we recommend that the report not be finalized for submittal to the appropriate Committees of Congress

Sincerely,

for John S Foster, Jr.

PRINCIPAL OFFICIALS OF THE DEPARTMENT OF DEFENSE AND THE DEPARTMENTS OF THE ARMY AND NAVY RESPONSIBLE FOR ADMINISTRATION OF THE ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office From	To
DEPARTMENT OF DEFENSE		
SECRETARY OF DEFENSE		
Elliot L Richardson	Jan 1973	Present
Melvin R Laird	Jan 1969	Jan 1973
Clark M. Clifford	Mar 1968	Jan 1969
DEPARTMENT OF THE ARMY		
SECRETARY OF THE ARMY		
Robert F. Froehlke	July 1971	Present
Stanley R. Resor	July 1965	June 1971
DEPARTMENT OF THE NAVY		
SECRETARY OF THE NAVY		
John W Warner	May 1972	Present
John H Chafee	Jan 1969	May 1972
Paul R. Ignatius	Aug 1967	Jan 1969

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