CHAPTER 4

FUTURE DEVELOPMENTS IN ESCAPE SYSTEMS

CONTENTS

Introduction

1. Although it is doubtful if military aircraft will be required in the future to operate frequently at altitudes in excess of 60 000 ft, the trend of aircraft design is towards higher performance. Present day escape systems are satisfactory up to about 500 kt. Open ejection seats have now been developed for use up to 650 kt with improved leg and arm restraint. Head restraint becomes necessary above 600 kt. Above such speeds alternative forms of escape would be necessary. For all aircraft, including helicopters, the main development in escape systems may be to improve their capability at very low level, with a high sink rate, and attitudes other than straight and level.

Escape Path Clearance

2. The term escape path clearance means the removal of any object which may be a hazard to a successful escape. It normally means the jettisoning or disintegration of a cockpit canopy, and in this context such items as jacks, springs, explosive charges and miniature detonating cord (MDC) are currently in use. Any reduction in the time taken to clear the escape path will assist in improving the capability of a given escape system, since the time delay between operation and initiation can be reduced.

3. MDC, as used in the Harrier, Buccaneer, Jet Provost Mk 5/5A and Hawk to shatter the canopy, provides an attractive solution for fixed-wing aircraft with frangible canopies, since it permits no delay between operation and initiation of the ejection seat. In aircraft with non-frangible canopies MDC can be used to cut the canopy—*ie* a secondary means of escape path clearance—should normal jettisoning fail, or for escape on the ground. Rocket assistance is used in the Tornado, and this enables the delay between canopy jettison and the first ejection to be as low as 0.3 s.

4. The problems of escape path clearance for helicopters are even greater than for fixed-wing aircraft, mainly due to the presence of the rotor(s). Until a satisfactory means is discovered of safely removing the rotor(s), the only feasible direction of escape is sideways. Helicopters are already fitted with jettisonable doors or hatches, but these are neither automatic in operation nor do they clear rapidly after release. At the moment, there is no form of assisted escape for helicopter aircrew, but the provision of an immediately clear path would increase the chance of a successful escape by parachute.

5. As helicopter escape systems are developed, there may be a requirement to move other items from the escape path of front crew members *eg* cyclic sticks and collective levers. The situation is less difficult for the rear crewmen, as they should have more free space about them.

Ejection Seat Development

6. **High Speed.** If ejection seats are to be used at speeds in excess of 600 kt, restraint of the head as well as the limbs is necessary. Head restraint is possible by attaching a cord to the rear of the helmet that would be reeled in at the same time as the shoulder harness, immediately prior to ejection. Limb restraint devices, currently under development, may prove to be inadequate and the provision of a whole-body cover would then become necessary.

7. **Low Level/Low Speed/High Sink Rate.** The most severe situation that an ejection seat can cope with (ignoring human factors) is operation at low level, low speed and with a high sink rate. It is this situation that is critical in determining time delays and leads to the requirement to make these delays as short as possible. The one notable exception is the delay provided to give adequate deceleration to the seat before separation and main parachute deployment. The fact that MDC, when used to shatter a canopy, permits no delay was mentioned in para 3. Other means of reducing the delay are as follows:

a. The use of 5.2 m (17 ft) aeroconical main parachute, which permits opening at a higher speed without increase of opening shock. This type of parachute, although smaller, has a lower terminal velocity than the I 24 and is less prone to oscillation.

b. The introduction of command ejection coupled with lateral divergence of seat trajectories. In the Tornado, the ejection sequence is canopy–navigator–pilot, with delays of 0.3 s and 0.45 s respectively, whichever man initiates the ejection. (In addition the navigator has the ability to abandon the aircraft and leave the pilot to make his own decision). The divergent trajectories ensure a minimum of 5.2 m (17 ft) lateral separation of canopy deployment in the worst case, contributing greatly to the very small delay of 0.45 s between the firing of the two seats.

Helicopter Escape

8. The most immediate solution to the problem of helicopter escape is to provide a parachute for each crew member. Although parachutes are carried in some helicopters when operating above 3000 ft, the current parachute packs are not compatible with helicopter seats. If this situation were rectified so that all helicopters could carry parachutes (at no discomfort to the crew) and there were no impediments to manual bail out, then the chance of survival from a catastrophe occurring above about 1000 ft would be greatly increased. However, as helicopters frequently operate below 1000 ft, the number of aircrew who could be saved by a simple parachute may not be great.

9. As the normal operational height for helicopters is below 1000 ft, other forms of escape, *ie* assisted escape, are necessary. The most promising concept for the medium term is sideward extraction, since this could be applied to existing helicopters. Longer term concepts are sideward/upward ejection (L-shaped trajectory) and, for multi-crew or passenger helicopters, a recovery capsule.

10. **Sideward Extraction.** An upward rocket-assisted extraction system is currently being used by the USAF for low-speed fixed-wing aircraft. Sideward extraction is a development of that system. On escape initiation, the extraction rocket is shot out in a similar manner to a drogue gun bullet. As its 3 m (10 ft) line becomes taut, the rocket ignites and pulls the crewman clear of the helicopter. The acceleration due to the rocket (about 9*g*) is applied through the normal parachute harness, so either the seat is tilted or the man is pulled head first out of the helicopter. This is illustrated in Fig 1.

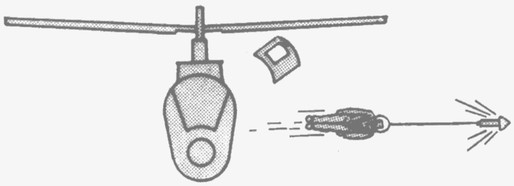

Fig 1 Sideward Extraction

The rocket is released automatically before burnout and the parachute is then deployed, full inflation occurring within 2 s of initiation. In the worst case (*ie* with 90° bank) this system would cater for a sink rate of 4000 ft/min from a height of 400 ft; in the best case (zero bank and no sink), escape would be available above about 60 ft. The concept could also cater for a semi-portable system for rear crewmen.

11. **Sideward/Upward Ejection.** The concept of sideward/upward ejection (also known as as sideward ejection with an L-shaped trajectory) is superior to all other methods of escape that do not require the removal of the rotor. On initiation, the seat would be ejected sidewards either ballistically or by means of a rocket. After sufficient time has elapsed for rotor clearance, the seat would be propelled vertically, probably by a separate rocket, as shown in Fig 2. The seat would require a stabilization and orientation control system to enable it to achieve a true vertical. At present, little is known of human tolerance to high accelerations in two successive directions. This concept is only suitable for cockpit crew and, because of the extensive development that would be required, it would not be practical for retrofit.

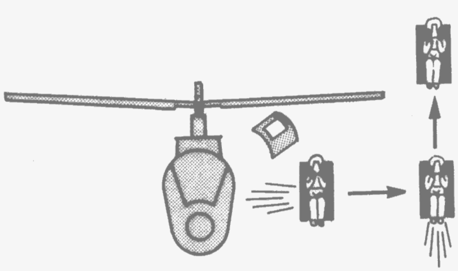

Fig 2 Sideward/Upward Ejection

12. **Escape Capsule.** If a helicopter has more than two crew members, it becomes increasingly difficult to provide an individual escape system for each crew member. For such helicopters, and those that carry passengers, a modular recovery concept in which the entire occupied section of the helicopter is recovered, appears to be the only practical possibility for escape. In the capsule escape concept, the occupied part is separated from the remainder of the helicopter by removing the rotor and as much of the airframe as possible by explosive severance systems. A cluster of ballistically deployed and spread parachutes are used for recovery. The two stages of this concept are shown in Fig 3. This system could only be incorporated in the design stage of a helicopter, and its weight penalty would be about 20% of the payload.

Escape Modules

13. Escape from aircraft at speeds much higher than 600 kt would require not only conventional restraint but also positive blast protection. This could only be provided by some form of escape module, such as an encapsulated seat or a jettisonable pressure cabin. An encapsulated seat was designed for the USAF B–58 Hustler. On either ejection or loss of pressurization, the shell surrounding the seat would close to form a personal pressure cabin with a clear window and simplified flying controls. The capsule contained all the personal survival equipment including a parachute and flotation devices.

14. The USAF F–111 aircraft is equipped with a jettisonable pressure cabin. On ejection, the whole cockpit separates under rocket power and is stabilized by small fins which deploy on separation. The cabin contains its own parachutes and flotation gear in a similar manner to the capsule. It is possible for the crew to survive for some time without leaving the cabin. The Rockwell

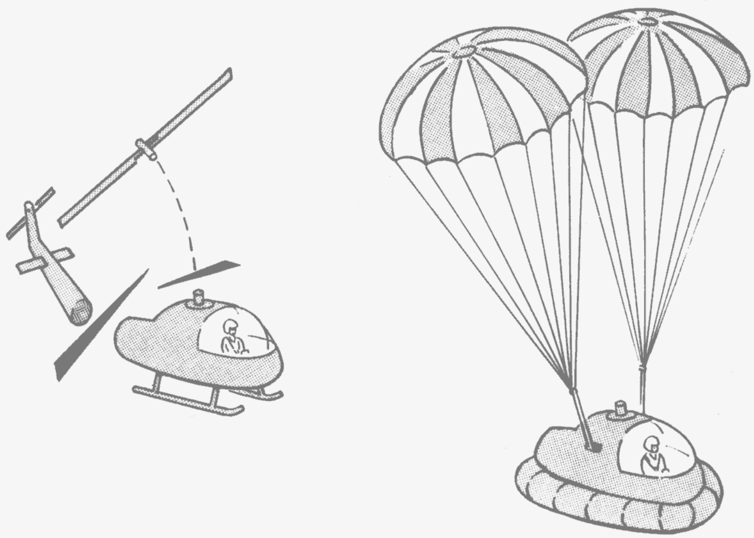

Fig 3 Escape Capsule Concept

International B–1 was designed to have a similar system, but it has been fitted to the three prototypes only, due to its high cost and weight. At the moment there is no research or development on escape modules being undertaken in the UK.


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