

Safety Regulation Group



**CAP 641**

**Report of the Review of Helicopter Offshore  
Safety and Survival**

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# Contents

	<i>Page</i>
Glossary	v
Executive Summary	vii
1 Background	1
2 The Regulatory Framework	2
3 Analysis of Accident Data	4
4 Basic Principles	6
5 The Safety and Survival System	8
6 Pre-Flight (Phase 1)	9
Passenger Acceptance	9
Passenger Briefing	10
Personal Safety Equipment	11
Passenger Boarding	13
Departure Criteria	13
7 Post-Flight (Phase 2)	14
Passenger Disembarkation	14
Safety Equipment – Continued Airworthiness	14
8 Before Ditching or Crash (Phase 3)	15
Communications	15
Pre-Ditch/Crash Actions – Crew	16
Pre-Ditch/Crash Actions – Passengers	17
9 Ditching (Phase 4)	18
Flotation	18
Crew Actions	19
Evacuation	20
General Comment	20
10 Crash (Phase 5)	20
Survivability	20
Flotation/Stability	21
Escape	22
FAA Study	24
11 Sea Survival (Phase 6)	25
Liferaft	25
LSJ	25
Immersion Suit	26
LSJ/Immersion Suit Relationship	27

	<i>Page</i>	
12	Rescue (Phase 7)	28
	Rescue Time v Survival Time	28
	Detection and Location of Survivors	29
	Retrieval of Survivors	29
	Post Survival Debriefing	30
13	Assessment of the Overall System	31
14	Recommendations	34
 <b>ANNEXES</b>		
A	Terms of Reference	37
B	Composition of Steering and Working Groups	39
C	Respondents, Contributors and Organisations Visited	41
D	Evidence from Cormorant Alpha Survivors	43
E	Other Committees and Groups	47
F	Fatal Offshore Accidents	49
G	Group 'A' Multi Engine Helicopter Event Rates	51
H	Review of Relevant Accident Data	53
J	Event Tree	59
K	Safety and Survival System Table	61
L	Breathing Aids for Underwater Escape from Helicopters	73
M	Weather Criteria	75

## Glossary

AAIB	Air Accidents Investigation Branch
ADELT	Automatically Deployed Emergency Location Transponder
AFDS	Automatic Flotation Deployment System
AIL	Airworthiness Information Leaflet
ANO	Air Navigation Order
AOC	Air Operators' Certificate
AOGBO	Application Outside Great Britain Order
BCAR	British Civil Airworthiness Requirement
BHAB	British Helicopter Advisory Board
BROA	British Rig Owners Association
BMT	British Maritime Technology
CAA	Civil Aviation Authority
CAP	Civil Aviation Publication
DOT	Department of Transport
DRA	Defence Research Agency
FAA	Federal Aviation Administration
FRC	Fast Rescue Craft
HARP	Helicopter Airworthiness Review Panel
HMLC	Helicopter Management Liaison Committee (See Note *)
HSC	Health and Safety Commission
HSE	Health and Safety Executive
HSMRC	Helicopter Safety Research Management Committee (See Note *)
HSSG	Helicopter Safety Steering Group (See Note *)
HSW	Health and Safety at Work
HUZUP	Hood Up – Zip Up
IADC	International Association of Drilling Contractors
IAL	International Aeradio Ltd
ICAO	International Civil Aviation Organisation
IFE	In Flight Entertainment
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements
LSJ	Life Saving Jacket
NATS	National Air Traffic Services
OHOSG	Offshore Helideck Operations Steering Group (See Note *)
OPITO	Offshore Petroleum Industry Training Organisation
PA	Public Address
RAF IAM	Royal Air Force Institute of Aviation Medicine
RGIT	Robert Gordon Institute of Technology
RHOSS	Review of Helicopter Offshore Safety and Survival
RNAS	Royal Naval Air Station
SAR	Search and Rescue
SARBE	Search and Rescue Beacon Equipment
SBAC	Society of British Aerospace Companies
SBV	Standby Vessel
UKOOA	United Kingdom Offshore Operators Association
UTR	Upper Torso Restraint

Note \* Further details of these committees/groups are at Annex E



## **Executive Summary**

This Review was commissioned by the Civil Aviation Authority following recommendations made after the helicopter crash at the Cormorant Alpha platform in 1992. It addresses all aspects of offshore helicopter safety and survival in the context of an integrated system, with the intention of maximising the prospects of occupants surviving a helicopter accident at sea. It does not address the causes or prevention of helicopter accidents.

The Review is based upon an Event Tree, which is a diagrammatic representation of an offshore helicopter flight, depicting a number of significant points (or 'nodes') where something might go wrong. The Event Tree thus illustrates all the major possibilities including a safe flight, a ditching, a crash (with or without warning), the subsequent flotation or sinking of the aircraft, the availability or otherwise of liferafts, the functioning of personal safety equipment and the rescue process. The Event Tree is depicted at Annex J.

The Event Tree is then developed into a System Table, which is a tabular listing of all the significant events in the history of a helicopter accident, grouped into seven phases commencing with departure from base and ending with rescue from the sea. A number of elements are identified within each event, and each is analysed in turn in Sections 6 to 12 of the report, where specific deficiencies and possible remedies are discussed. The System Table appears in full at Annex K.

The penultimate section of the report contains an overall assessment of the present safety and survival system. It points to the 100% success record of survival after ditchings and the inevitably less favourable record of crash survival; it suggests the need for greater emphasis on safety measures related to heavy impacts as opposed to ditchings, but cautions against prejudicing ditching survival in an unrealistic attempt to help the victims of non-survivable crashes.

The report concludes with 17 recommendations. There are few, if any, radical proposals. For the most part, the report endorses work which is already in hand or nearing completion; however, it identifies a number of areas where further studies need to be initiated or where existing work needs to be coordinated or given more urgency. Conversely, it considers and dismisses as impracticable two proposals which have gained currency – the provision of underwater breathing apparatus and the prohibition of offshore flights in weather unsuitable for ditching. The report does, however, make a positive proposal for a more methodical way of ensuring that offshore managers appreciate the relationship between the time it would take to rescue survivors of a crash and the time they could be expected to survive in the water in the prevailing conditions.



## **1 BACKGROUND**

- 1.1 The Review of Helicopter Offshore Safety and Survival (RHOSS) arose from recommendations made by the Air Accidents Investigation Branch (AAIB) and the Sheriff of Grampian, Highlands and Islands following the crash of an AS 332L Super Puma helicopter at the Cormorant Alpha platform in the East Shetland Basin of the North Sea on 14 March 1992.
- 1.2 In both the AAIB report (No.2/93) and the Sheriff's Fatal Accident Inquiry determination, it was suggested that the Civil Aviation Authority (CAA) should carry out a review of the safety and survival aspects of offshore helicopter flights. Specifically, in paragraph 38.9 of his report, the Sheriff referred to an integrated review of all safety features, while in paragraph 4.9 of its report the AAIB recommended a re-assessment of passenger safety and survivability using the concept of an integrated escape and survival system. In its response to the AAIB report, the CAA accepted this recommendation and undertook to set up a review body which would include representatives of government agencies, medical institutions, research organisations and offshore operators.
- 1.3 In accordance with this undertaking, RHOSS was established in October 1993 with a remit to complete its work by the end of 1994. Its Terms of Reference, which have been interpreted as applying only to UK-registered aircraft operating over the sea areas around the United Kingdom, are at Annex A. Throughout this report, the expressions 'offshore operations' and 'offshore passengers' are used in the context of flights in support of or in connection with the offshore exploitation or exploration of mineral resources (including gas). For simplicity, the expression 'oil company' has been used to describe any organisation which engages the services of a helicopter operator for the purposes described above.
- 1.4 The work of RHOSS hinged upon a Steering Group of nine members (three from the CAA and six from other organisations) with an independent chairman and with a secretary provided by the CAA. The Steering Group met at least once each month, and delegated detailed studies to a number of Working Groups, each of which was chaired by a Steering Group member and included both CAA and non-CAA representation. The composition of the Steering and Working Groups is listed at Annex B.
- 1.5 The formation of RHOSS was promulgated in the Official Record and advertised in the aviation press and the Scottish local media. Participation was invited from interested parties and a number of written submissions were received; these are listed at Annex C. In addition to considering these written responses, the Steering Group arranged to have presentations from and/or discussions with certain individuals and organisations, including a Principal Inspector from the AAIB, a team from the Aviation Study Group based at Linacre College, and two survivors from the Cormorant Alpha accident; the first-hand experience of these two survivors was especially valuable to RHOSS, and is summarised at Annex D. The Steering Group spent two days at Aberdeen viewing various aspects of offshore operations, including survival training and the development, production and maintenance of safety equipment. Those members of the Steering Group who had not previously done so flew as passengers to an offshore platform.
- 1.6 Our Terms of Reference required us to take account of the activities of other committees and working groups engaged in similar or parallel studies in order to

avoid duplication or omission. An initial investigation revealed a large number of formal bodies with an interest in offshore safety but, on closer scrutiny, it became evident that many of them were peripheral to the topics which we needed to address or were channels of communication rather than active participants in safety research. Five committees and groups, briefly described at Annex E, were considered to be directly concerned with topics central to our work. In certain instances, their involvement and expertise were found to be far deeper than we could expect to achieve within the time and resources available, and as a consequence this report will be found, in places, to do no more than comment upon, and where appropriate endorse, work that has already been done or is under way.

## **2 THE REGULATORY FRAMEWORK**

### **Civil Aviation Legislation**

- 2.1 Civil aviation safety in the United Kingdom is governed by the Civil Aviation Act and related subordinate legislation, the principal instrument of which is the Air Navigation Order (ANO). The ANO provides the legal basis for airworthiness requirements (the design and technical standards that must be met by aircraft registered and certificated in the United Kingdom) and requirements for the issue of an Air Operators' Certificate (AOC) (which must be held by any person conducting public transport operations).
- 2.2 Airworthiness requirements have hitherto been expressed in the form of British Civil Airworthiness Requirements (BCARs), while operational requirements have been set out in the ANO itself and in associated Regulations and publications. Following the establishment of the European Joint Aviation Authorities (JAA), of which the United Kingdom was a founder member, national requirements for both airworthiness and operational matters are in the process of replacement by Joint Aviation Requirements (JARs), the adoption of which should be substantially completed in 1995. JARs will be binding upon all members of the JAA and any new safety regulations that the United Kingdom wishes to introduce (including any proposed changes to requirements stemming from this report) will need to be considered by the JAA and accepted or rejected on a Europe-wide basis. There is thus little scope for unilateral action by the CAA.
- 2.3 Civil aviation is divided into various categories – private flights, aerial work and public transport – the last of which covers all flights involving the carriage of passengers for hire or reward. Public transport, in turn, can take various forms, principal among which are scheduled services (in which passengers book their passage individually with the airline or its agent), charter flights (in which airlines are contracted to carry groups of passengers who have booked their flight with an air tour operator), and air taxi operations (in which individual passengers or groups of passengers retain the exclusive use of an aircraft for a particular journey).
- 2.4 Offshore helicopter operations in support of the oil and gas industry do not fit precisely into any of these categories. In so far as many of the flights are carried on throughout the year in a regular and predictable pattern, they resemble scheduled services; but, as they are in the main performed by relatively small aircraft carrying fewer than 20 passengers and providing none of the creature comforts of present-day airliners, the environment is more that of an air taxi operation. However, because helicopter operators work under contract to oil companies which decide

where and when their employees and sub-contractors are to fly, and present them in a group at the point of departure, the closest parallel is that of charter flights.

- 2.5 The common factor in all public transport operations is the requirement for an AOC, for which the CAA prescribes a common set of standards; variations in the standard are related only to differences in the type, size or capacity of the aircraft involved rather than to the type of public transport it is engaged upon. Thus offshore helicopter operations, falling as they do under the common mantle of public transport regulations, are subject to the same safety standards as all other public transport flights in similar types of aircraft – for example, scheduled services to the Scilly Islands and sightseeing charters and air taxi operations elsewhere around the British coast.
- 2.6 Nevertheless, the working pattern of offshore helicopter operations involves individual passengers in a larger than average number of flights, with the need to land on and take off from small platforms in mid-ocean; a large proportion of each flight is carried out over water at relatively low level, while the hostile offshore environment, particularly in winter, adversely affects the prospects of survival and rescue after an accident. In recognition of this, the CAA has raised a number of special requirements – specifically in Airworthiness Notice 27 – for helicopters involved in offshore operations.

### **International Obligations**

- 2.7 As a signatory to the Chicago Convention, the United Kingdom is bound by the standards of the International Civil Aviation Organisation (ICAO), among which is a requirement for each national administration to provide search and rescue facilities within the airspace for which it is responsible.
- 2.8 In the United Kingdom, this responsibility is carried by the Department of Transport (DOT), which makes use of facilities provided by the armed forces and by HM Coastguard.

### **Health and Safety Legislation**

- 2.9 Responsibility for offshore safety regulation was transferred from the then Department of Energy to the Health and Safety Commission and Executive (HSC and HSE respectively) on 1 April 1991. This was a result of one of the recommendations in Lord Cullen's report on the Piper Alpha disaster, all of which were accepted by the Government.
- 2.10 The principal legislation is the Health and Safety at Work etc. Act (HSW Act). The HSW Act and its associated legislation is applied to offshore installations and certain specified activities in connection with such installations, or any activity which is immediately preparatory to the specified activities, by the Application Outside Great Britain Order 1989 (AOGBO). The Regulations developed by the then Department of Energy under the Mineral Workings (Offshore Installations) Act 1971 are now relevant statutory provisions under the new HSW Act.
- 2.11 Whilst the AOGBO specifically excludes application of the HSW Act, and its associated legislation, to aircraft which are in flight in the offshore sector, there are currently a number of Regulations made under the Mineral Workings Act 1971 which have specific requirements applying to helidecks on offshore installations and to associated helicopter operations. These are:

- The Offshore Installations (Construction & Survey) Regulations 1974 – SI 1974/289. These contain detailed requirements on the design and construction of the helideck.
- The Offshore Installations (Operational Safety, Health and Welfare) Regulations 1976 – SI 1976/1019. These contain three individual regulations dealing with the management of helideck operations on offshore installations.
- The Offshore Installations (Emergency Procedures) Regulations 1976 – SI 1976/1542. These contain a requirement that the emergency procedures manual should specify the action to be taken in the event of accidents involving helicopters on or near the installation.
- The Offshore Installations (Fire Fighting Equipment) Regulations 1978 – SI 1978/611. These contain a requirement setting out the fire-fighting equipment to be available on the helideck.

2.12 However, Lord Cullen also recommended in his report that there should be wide ranging reform of offshore health and safety legislation, comprising two complementary elements:

- The introduction of a new requirement for submission by installation operators/owners, and acceptance by HSE of a safety case for each installation (now implemented through the Offshore Installations (Safety Case) Regulations 1992).
- A programme to progressively reform existing offshore legislation.

The legislation referred to in paragraph 2.11 is now the subject of reform as part of this wider programme. The objective is to replace the existing legislation, which is couched mainly in prescriptive terms, with regulations in a more modern form, expressed mainly in terms of objectives (or ‘goals’) to be achieved.

2.13 It is planned that the new goal-setting requirements on the safety of helidecks and helideck operations will replace the existing legislation during the course of 1995 in the context of the following reform packages:

- The proposed Offshore Installations (Prevention of Fire & Explosion, and Emergency Response) Regulations.
- The proposed Offshore Installations and Pipe-line Works (Management and Administration) Regulations.
- The proposed Offshore Installations (Design and Construction etc) Regulations.

### **3 ANALYSIS OF ACCIDENT DATA**

3.1 In order to provide a statistical background to its work, RHOSS commissioned three working papers which drew information from the CAA's Safety Data Analysis Unit. These should be viewed in the context of an industry which at present operates some 215 offshore installations equipped with helidecks and employs about

30,000 regular offshore workers. In the 18 years from 1976 to 1993 the offshore industry has generated 2.2 million helicopter operating hours in the carriage of some 38 million passengers, for the loss of 85 lives in 8 fatal accidents, representing a fatality rate of 3.86 per 100,000 flying hours.

- 3.2 The first working paper, reproduced at Annex F, provides brief details of these 8 fatal accidents, 4 of which were considered non-survivable and one of which accounted for more than half of the total fatalities. The total of 19 deaths in the 4 survivable accidents represents a theoretical maximum number of lives that might possibly have been saved through the perfect functioning of the safety and survival system (which will be described in Section 5 of this report); this would equate to an average of about one life per year. However, this figure includes a number of deaths on impact, which could probably not have been prevented, and deaths which may have been attributable to deficiencies in the system that have subsequently been remedied. Past experience can, of course, do no more than offer a very broad indication of likely future benefits; in so far as it has validity, it would seem that the potential for saving additional lives through further improvements to the safety and survival system is something less than one per year.
- 3.3 The second working paper, reproduced at Annex G, is a statistical analysis of 151 events (not necessarily resulting in an accident) occurring to UK-registered Group A (multi-engined) helicopters between 1976 and 1993. The ringed figures represent the event rate per 100,000 flying hours and, in brackets, the actual number of events. During this period approximately 2.4 million hours were flown (excluding training flights), most but not all of which was in connection with the offshore oil and gas industry. This represents an overall event rate of about 6.29 per 100,000 hours.
- 3.4 Annex G shows the distribution of incident causes between operational error, mechanical/system failure and flight-deck indication of a malfunction. This is interesting, and may be of use in other studies, but is not of direct concern to RHOSS. What is of significance, however, is the information which the chart provides concerning the eventual outcome. Of the 151 events, 20 were dealt with by a diversion to an alternate helicopter landing site and 88 more ended in a successful forced landing. There were 9 non-survivable crashes (5 on land and 4 at sea) and 23 survivable crashes (16 on land and 7 at sea), some of which resulted in fatalities, and there were 11 ditchings, all without loss of life.
- 3.5 Survivable impacts on water exceeded non-survivable impacts by a factor of 1.75 and the combined total of ditchings and survivable impacts on water exceeded non-survivable impacts on water by a factor of 4.5.
- 3.6 The high proportion of forced landings on land compared to ditchings at first sight seems remarkable in view of the fact that about 85% of Group A flying takes place over water. It is, however, readily explained by the natural tendency of captains to opt for dry land or the nearest offshore platform if the emergency is such that they have a choice, and to abort a flight while still within reach of a suitable landing site if they have any doubts about the aircraft's reliability.
- 3.7 Another significant aspect of Annex G is that of the 16 survivable crashes on land only one resulted in fatalities, whereas of the 7 survivable crashes on water 4 resulted in deaths. Clearly this higher proportion of fatalities at sea stems from the fact that if one survives a crash on land and can escape from the cabin before fire

occurs, survival is more or less assured in an area so well-provided with rescue services as the United Kingdom; at sea, escape from the cabin is only the beginning of the survival process, as was well illustrated by the Cormorant Alpha accident.

- 3.8 Of greatest interest to RHOSS are the 7 survivable impacts with water and the 11 ditchings, representing, respectively, event rates of 0.29 and 0.46 per 100,000 flying hours. One conclusion that can be drawn from this is that, since there is no vast difference in the likelihood of either eventuality, it would not be reasonable to optimise safety measures entirely in favour of one at the expense of the other, for example in the cases of helicopter flotation and liferaft deployment.
- 3.9 The third working paper, reproduced at Annex H, provided a more detailed review of data from 17 survivable or potentially survivable accidents since 1970. A total of 16 survival features were identified, and each accident was assessed against these, the results being presented in a tabular form at Appendices 2 and 3 of the Annex. These depict the relative importance of the 16 survival features, in terms of the total number of adverse mentions which each received in the 17 accident reports. Some caution is required in interpreting these figures, since they include failings which were noted many years ago and which may well have already been rectified. Nevertheless, Annex H permitted the six RHOSS specialist Working Groups readily to extract details of past accidents which were relevant to their own area of interest, and provided a basis for their assessment of problems still unresolved.
- 3.10 One further item of statistical information which RHOSS found of interest was provided by Dr Anton, of the Aviation Study Group, who presented a tabular breakdown of the warning time available before an impending crash or ditching. Of the 15 survivable accidents included in his analysis, in 5 cases there was more than 5 minutes warning, in 3 cases there was between 1 and 5 minutes warning, and in 7 cases there was less than 1 minute of warning. This, clearly, has a bearing upon the preparatory actions that can be performed by crew and passengers between the first indication of trouble and the moment of impact.

## **4 BASIC PRINCIPLES**

### **The Total System**

- 4.1 RHOSS is concerned with an integrated system for safety and survival in the event of an offshore helicopter accident or incident. However, such a system is itself part of a wider system designed to provide a safe and efficient means of transporting passengers to, from and between offshore platforms. This overall system includes all the measures intended to minimise the probability of an accident or incident occurring.
- 4.2 Aviation authorities adopt a 'top down' approach to this overall system, on the principle that prevention is better than cure. For example, the hierarchy of airworthiness objectives is first to minimise the probability of anything going wrong; second, to try to ensure that if something does go wrong the aircraft will still be able to continue safely to a suitable landing site; and third, to maximise the chances that if the flight cannot be continued, the aircraft can alight in a controlled fashion rather than crashing. The essence of this philosophy is that every advance in achieving a higher objective reduces the significance of every objective lower down the scale.

- 4.3 The long-term aim of this policy is to achieve a situation in which the operational and engineering reliability of offshore helicopter activities equates to that of multi-engined fixed-wing public transport, so that passengers might travel in a 'shirt-sleeve' environment without the need for special safety and survival equipment. The work resulting from the report of the Helicopter Airworthiness Review Panel (HARP) of 1984 is an example of the efforts that have been made towards this objective.

### **The 'Top Down' Principle**

- 4.4 These wider considerations are beyond our remit, and it is self-evident that unless and until such a desirable situation is achieved, a special offshore safety and survival system will be required. Nevertheless, even within this safety and survival system the same 'top down' principle can be applied.
- 4.5 For example, if a helicopter is destined to crash into the sea, it is clearly better for it to remain upright than inverted; but if it inverts, it is better for it to float than to sink; but if it is going to sink, it is better that the occupants should be able to vacate the hull immediately than that they should have to escape later from under the water. As in the airworthiness example cited above, improvements in provision for stability, buoyancy and means of rapid egress would tend to reduce the significance of problems associated with underwater escape.
- 4.6 In considering the various possibilities for improving the safety and survival system, we believe firmly that this 'top down' principle should be applied. In essence, our reasons are as follows:
- (a) As one follows the path of possible failures in a system, the scope for further failures multiplies. Thus a preventive measure early in the system has the cumulative benefit of reducing the probabilities of all subsequent failures.
  - (b) Failures in the earlier parts of a safety and survival system tend to be related to the design and construction of equipment, or to operational management, rather than human performance on the day. An improvement in this area is thus likely to offer a finite and possibly measurable reduction in the probability of failure. In the later stages of the system, however, one is in the realm of 'last resort' devices, almost exclusively personal survival equipment, which depend largely upon the ability of individuals to make the most of them. The wide range of situations in which the equipment may need to be used, and the great variety in the presence of mind, stamina and competence of individuals, make it very difficult to assess the likely benefits of any proposed measure in these later parts of the system.
  - (c) Improvements in the earlier part of the system, being related to aircraft design and equipment or the management of operations, can be introduced through the existing mechanism of airworthiness requirements and Operations Manuals. New legislation would generally not be required, and the improvements could be applied consistently across the entire offshore industry via the relatively small number of AOC holders. On the other hand, extensions to the mandatory provision of items of personal safety equipment might well require fresh legislation and would involve a considerable task of co-ordination among the many offshore customer agencies.

## **RHOSS Philosophy**

- 4.7 We are conscious of the fallacy in the argument that runs: ‘Something must be done. This is something. Therefore it must be done.’ It is very easy, in the aftermath of a tragic accident, to propose a wide range of additional safety measures on the grounds that they might have been of benefit in the specific instance of what may well have been a unique accident. It is far less easy to be sure that such measures would produce any significant improvement in safety throughout the generality of all possible future accidents, and if so whether or not a similar improvement might be achieved by other, simpler means. We believe that, as a regulatory body, the CAA is only justified in requiring additional safety measures when they can be expected to produce overall benefits at a reasonable cost.
- 4.8 In principle, we favour improvements at the earlier part of the system as being more cost-effective and reliable and easier to apply. At the same time, it is recognised that unless and until such improvements reduce the probability of failure to the low level postulated in paragraph 4.3 above, there will remain a need for specialised personal safety equipment and training of the highest standard reasonably attainable. Therefore, this aspect has also been addressed.
- 4.9 Moreover, although we may conclude that it would not be appropriate for the CAA to introduce new regulatory requirements in a particular area, that need not necessarily preclude individual operators or customers from voluntarily taking such measures provided it can be established that there would be no overall safety disbenefit.

## **5 THE SAFETY AND SURVIVAL SYSTEM**

- 5.1 The early meetings of the RHOSS Steering Group concentrated on discussion of the form in which a ‘Safety and Survival System’ should be expressed; in this we were assisted by a presentation by the AAIB Principal Inspector who originated the expression in drafting his report on the Cormorant Alpha accident, and by the HSE member of the Group who was able to draw upon experience of similar systems elsewhere.
- 5.2 It was agreed that the system would be amenable to expression in the form of an ‘event tree’. This is essentially a chronological description of the significant events in an offshore flight, allowing for the possibility that there might be an incident (with or without warning) which might develop into either a ditching or a crash, from which the occupants would be required, respectively, to evacuate or to escape, after which they would need to survive in the sea (with or without a liferaft) for as long as might be necessary for the rescue services to locate and retrieve them to a place of safety.
- 5.3 The convention adopted in the Event Tree, illustrated at Annex J, is that events proceed horizontally from left to right, with each failure of the system represented by a vertical line. Because of the large number of elements in the system, a comprehensive Event Tree would assume unwieldy proportions; Annex J therefore presents only the most significant failure ‘nodes’. Six of these have been identified by the capital letters O, F, M, L, S and R, which correspond to the specialist fields allocated to six RHOSS Working Groups – Operations, Flotation, Mobility, Liferafts, Survival Equipment and Rescue.

- 5.4 Of crucial importance is the distinction between a ‘ditching’ and a ‘crash’, which are generally understood to represent, respectively, a controlled and an uncontrolled descent into the water. However, the nature of the surface into which the aircraft descends is as important as the degree of control which the pilot is able to retain until the moment of impact; a perfectly controlled descent into a rough sea can have the characteristics, in terms of escape and survival, of an uncontrolled crash. We have therefore followed the spirit of the JAR definition of a safe forced landing – ‘Unavoidable landing or ditching with a reasonable expectancy of no injuries to persons in the aircraft or on the surface’. This has been reflected in the layout of the Event Tree, where the term ‘ditching’ is limited to controlled descents (with some measure of warning) into a ‘non-hostile’ sea, while a ‘crash’ subsumes all uncontrolled or inadvertent impacts with the water, controlled descents into a hostile sea and the case of a helicopter falling off a helideck.
- 5.5 The Event Tree has also been divided into seven areas of activity – Pre-Flight, Post-Flight, Before Ditching or Crash, Ditching, Crash, Sea Survival and Rescue. These represent the phases in a more detailed tabulation which we have called the System Table and which appears in full at Annex K. This is also constructed in chronological form, each phase containing a number of events which, in turn, contain a number of elements. These last are the building-blocks of the system, each of which needed to be examined both in its own right and in terms of its compatibility with other elements.
- 5.6 The System Table offers several items of information against each element. First, it allocates the element to one of the major nodes on the Event Tree. It then describes the current requirements (ie existing responsibilities and regulations), offers a brief assessment of their adequacy or otherwise, identifies remedial work at present in progress and finally indicates any further action required. Sections 6 to 12 of this report discuss the contents of the System Table in detail; each section relates to one phase of the System Table, and each side heading in these sections relates to a specific event.

## **6 PRE-FLIGHT (PHASE 1)**

### **Passenger Acceptance (Event 1.1)**

- 6.1 We considered that the Escape and Survival System should be deemed to start with the process of accepting passengers for an offshore flight. In Section 2 it was established that such flights are a form of public transport operation, similar to charter flights in that individual passengers are selected and initially processed by the sponsoring oil company, which then presents them to the helicopter operator. It follows that the oil companies, rather than the helicopter operators, are better placed to exercise control over the suitability and preparedness of the passengers they wish to have conveyed.
- 6.2 As a population, offshore passengers represent an atypical cross-section of the air-travelling public, since they do not normally include children, the elderly or the infirm. By the nature of their work, they are predominantly male and comparatively fit. However, it has been pointed out to us that as the offshore industry has matured, so the average age of the work-force has increased, and many of the regular offshore travellers are now in their late forties or early fifties and of an age when increasing girth might be expected to reduce their mobility in an emergency and when pre-

existing medical conditions might affect their chances of survival. The view was also expressed to us that the ban on alcohol consumption offshore, while laudable in its own right, encourages a culture in which some offshore workers tend to 'make up for lost time' when ashore, with adverse effects on their long-term health.

- 6.3 Apart from the minimum of 18 years, there is no specific limit to the age or physique of offshore passengers (Element 1.1.1). Employers do require them to undergo regular medical examinations at a frequency that increases with age and these would, for example, detect those who are grossly overweight or evidently suffering from cardiovascular, respiratory or alcohol-dependency problems. Since a more rigorous regime would have implications for the continued employment of the individual, we believe that this is not an area where the CAA should be expected to intervene; we consider that it is best left to the employers to decide on the fitness or otherwise of their staff to work offshore, and that must continue to include an assessment of their fitness to travel to and fro by helicopter.
- 6.4 It has been suggested to us that, in the past, some offshore passengers have arrived at the departure terminal the worse for drink. The ANO specifically prohibits anyone from entering an aircraft in such a condition and it is the operator's responsibility to enforce this rule. Whatever may have been the case previously, we believe that the supervision provided during passenger briefing and kitting-up is adequate to ensure that drunkenness among departing offshore helicopter passengers is not now a serious problem.
- 6.5 The remaining aspect of Passenger Acceptance is Training (Element 1.1.2), which again rests with the sponsoring oil company. All regular offshore travellers are required to undergo an initial escape and survival course approved by the Offshore Petroleum Industry Training Organisation (OPITO), followed by periodic refresher training. Having visited one establishment which provides such courses, we were impressed by the quality of training offered, and this was confirmed during our discussions with Cormorant Alpha survivors who agreed that their training, while inevitably not totally realistic, had made a major contribution to their survival. There was a suggestion, however, that there was no mechanism by which the experience of accident survivors could be fed back into the system. We believe that the content of the initial and refresher training is generally of a high order, but that it should be kept under review by OPITO and that lessons from real emergencies should be made available to future trainees.

### **Passenger Briefing (Event 1.2)**

- 6.6 Under the ANO, the responsibility for briefing passengers on emergency procedures and equipment rests with the aircraft commander. In practice, for flights between the mainland and the offshore fields (Element 1.2.1), this is carried out before boarding the aircraft by means of a supervised video with an additional verbal briefing on the immersion suit. The briefings are prepared in consultation between the helicopter operators and the United Kingdom Offshore Operators Association (UKOOA), and can be configured to match whatever type of aircraft is to be used; they are updated as necessary. CAA inspectors formally approve all aspects of the briefings, and we believe that a high standard is achieved.
- 6.7 It had been suggested to us, on the one hand, that the briefings are too long and tend to induce boredom and inattention, and on the other that they dwell so much on what might go wrong that some passengers might be intimidated. Having

experienced these briefings, and bearing in mind the range of safety information that needs to be imparted, we formed the view that the briefings are well-constructed and pitched at about the right level to encourage safety-awareness without provoking alarm among the generally hardy and matter-of-fact offshore population. We noted that briefings were well-controlled and appeared to be taken seriously by all concerned.

- 6.8 For shuttle flights between offshore platforms (Element 1.2.2), briefings take an abbreviated form and are repeated every 24 hours. It has been put to us that they tend to concentrate on personal survival equipment rather than aircraft layout and escape routes. The point was made to us that offshore shuttle flights are frequently flown in different types of aircraft from those used for transit flights, whereas the personal equipment generally remains the same. Recipients thus tend to be bored by repetition of what they already know, while possibly not receiving important new information. It might therefore make better sense if the shuttle briefings were to concentrate on the equipment and escape routes relevant to the aircraft about to be used. We recognise that if more than one aircraft type is in use for shuttles, with schedules being re-arranged at short notice, this might be difficult to achieve in practice; nevertheless, we think that the helicopter operators and UKOOA might to advantage review the content of shuttle briefings.

#### **Personal Safety Equipment (Events 1.3 & 1.4)**

- 6.9 There is an apparent anomaly in the provision and wearing of personal safety equipment for offshore operations. The ANO requires the provision of life-saving jackets (LSJs) for both crew and passengers on all public transport flights featuring a significant over-water transit. As with fixed-wing operations, it is the responsibility of the aircraft operator to provide these, to the standard laid down in CAA Specification 5. There is no general regulatory requirement for any other personal safety equipment but the ANO makes an exception by requiring offshore aircrew to wear immersion suits when the sea temperature is below 10 degrees Celsius or at night; CAA Specification 19 sets out the technical requirements. As part of their contracts, some oil companies require aircrew to wear immersion suits regardless of sea temperature, albeit with certain concessions in hot weather.
- 6.10 Oil companies require all their passengers to wear immersion suits and to don the LSJs provided by the helicopter operators. The CAA has accepted this as a sensible additional safety measure, on the basis that the immersion suits generally conform to Specification 19 and therefore present 'no hazard' and do not prevent the LSJs from performing adequately.
- 6.11 Although this system appears to work reasonably well in practice, it has been criticised on several counts, specifically that:
- (a) It perpetuates an invidious difference between the standards of safety provision formally required for crew and passengers.
  - (b) It fails to ensure compatibility between passenger immersion suits and LSJs since, although the suits generally conform to CAA Specification 19, there is no legal requirement for them to do so.
  - (c) It leaves scope for a wide variety in the design of passenger immersion suits which can hamper the creation of standardised training and briefing.

- 6.12 It has been argued, however, that the introduction of a mandatory requirement for passenger immersion suits would create new complications because:
- (a) The responsibility for the provision of passenger suits would transfer to the helicopter operators and, although the work of issuing and maintenance could continue to be done by sub-contractors as at present and the costs would still find their way back to the oil companies, there would be an extra supervisory burden on operators.
  - (b) Passenger suits would become, like LSJs, 'aircraft equipment' and could no longer be retained by the individual when offshore for rig emergencies. They could, in practice, be issued to individuals (as in the case of crew suits but on a short-term basis), but it would be unreasonable to expect helicopter operators to be responsible for equipment that was out of their sphere of control for long periods.
- 6.13 The nub of the problem is that, for reasons of safety, there should be some means of ensuring that immersion suits worn by offshore passengers do indeed conform to an appropriate standard, and of safeguarding against a situation in which a less responsible company might, at some time, decline to provide suits for its employees. We recognise that it would be illogical for the CAA to insist on passenger suits conforming to a standard but to continue to accept a situation in which the provision and wearing of suits rests upon a voluntary arrangement by the oil companies. It thus appears that the most practicable solution would be for the CAA to extend its existing special requirement for crew immersion suits to include passengers as well; but we accept that some thought will need to be given to the way in which this regulatory change can be implemented with minimal disruption to the present satisfactory working arrangements.
- 6.14 Quite apart from the above arguments, there are acknowledged to be weaknesses in the design of immersion suits currently in use for both crew and passengers. Aircrew suits are efficient in their role of keeping the wearer dry, but are considered by many to be uncomfortable to wear for long periods, especially in bright sunshine in warm ambient air temperatures; they can be worn unzipped but would be difficult to zip up while the wearer was coping with an aircraft emergency. The most common design of passenger suit is easier to don and can be made relatively comfortable if the face seal is partially unzipped, but will not fulfil its function unless it is fully zipped up before immersion. This is, to some extent, addressed by the oil companies' 'Hood Up Zip Up' (HUZUP) rule, which requires suits to be fully zipped during over-water arrivals and departures, on the assumption that if an emergency occurs en-route there would be sufficient time to zip up before impact with the surface. Furthermore, despite general guidance issued to passengers on the subject of clothing to be worn under their immersion suits, there is at present no way of ensuring that they have sufficient thermal insulation to maintain body temperature even if their suits succeed in keeping them dry.
- 6.15 Further research is clearly required into the design of immersion suits and suitable undergarments, and the improvement of compatibility between immersion suits and LSJs. The Helicopter Safety Steering Group (HSSG) is considering the matter of standardisation, and research is under way at the Defence Research Agency (DRA) Centre for Human Sciences. This will be discussed further in Section 11, which addresses the functional performance of LSJs and immersion suits. So far as the Pre-Flight Phase of the System is concerned, our conclusion is that research needs to

take account not only of functional performance but also ease of donning, robustness in service, comfort in routine use and compatibility with the LSJ.

### **Passenger Boarding (Event 1.5)**

- 6.16 Passenger boarding is generally a straightforward and well-organised operation, supervised by the operator's ground staff or aircrew, who are able to check that LSJs are fitted correctly. Seat allocation (Element 1.5.1) is not normally necessary.
- 6.17 Complaints have been made in the past about the practice of carrying mixed passenger and cargo loads in aircraft cabins (Element 1.5.2). We have reviewed the relevant CAA instruction (AIL/0166 dated 10/8/93) which prohibits such mixing unless proper stowage is available, and consider that these new regulations are satisfactory. Some oil companies prohibit simultaneous carriage of passengers and cargo in the cabin.
- 6.18 Strapping-in and headset use (Elements 1.5.3 & 1.5.4) are well covered in the pre-flight briefing and are supervised by the operator's ground staff or aircrew. A communication system must be available to allow the crew to pass safety instructions to the passengers, but it should not impede the movement of passengers in the event of a ditching or crash. At present, passenger cabins are provided with Public Address (PA) systems, some of which involve the use of individual headsets, some of which are of the cordless type. Some aircraft PA systems are rather inadequate, and there has been comment about the possibility of headset cords offering a snagging hazard during evacuation or escape. A sub-group of the HSSG is studying the improvement of PA systems and trials of improved cordless headsets are under way. We believe the CAA should monitor both of these activities and consider more stringent regulations in the light of the results.

### **Departure Criteria (Event 1.6)**

- 6.19 After all pre-flight preparations have been completed, the flight may depart. The decision to do so rests with the aircraft captain, and is traditionally determined by considerations of aircraft serviceability, local weather conditions at the points of departure and destination, and air traffic clearance. In general, the only existing weather limitations on offshore flights are the cloudbase and visibility at the destination and alternate heliport, the aircraft windspeed limitations and a limit of 60kts windspeed over the helideck imposed by oil companies essentially for the safety of personnel on the deck.
- 6.20 In the case of offshore helicopter operations, however, the question of conditions on the surface, not only at each end of the flight but en-route, is more than usually significant. It has been suggested that some additional limits should be imposed, related to the effect that surface conditions would have on survival and rescue. For this reason, the System Table includes a Departure Criteria Event.
- 6.21 One oil company has introduced specific wind and sea-state limitations in this respect, while others have adopted more generalised guidelines which require their managers to take account of a wide range of weather-related factors in forming an assessment which could result in them holding back a flight even when the helicopter pilot is prepared to go.

- 6.22 We recognise that it is extremely difficult to devise effective rules to cater for the widely differing weather conditions experienced offshore, and appreciate that in attempting to apply such rules there would inevitably be occasions when invidious comparisons were drawn between companies operating to different platforms in apparently similar conditions. Nevertheless, we are concerned that the guidelines currently issued by most oil companies give no positive guidance about what should be considered as limiting factors. Beyond the purely aeronautical limitations referred to in paragraph 6.19 above, we do not see it as the duty of the CAA to intervene in this matter. We shall return in Section 12 to the subject of matching survival time to the availability of Search and Rescue facilities.

## **7 POST-FLIGHT (PHASE 2)**

- 7.1 The Post-Flight Phase of the System Table was inserted for the main purpose of ‘closing the loop’ for the vast majority of offshore flights which proceed uneventfully to their destination. It also serves as a vehicle for consideration of disembarkation procedures and the servicing of personal safety equipment.

### **Passenger Disembarkation (Event 2.1)**

- 7.2 Deck procedures are set out in UKOOA ‘Guidelines for the Management of Offshore Helideck Operations’, the second issue of which was produced in August 1993. These instructions include arrangements for loading and offloading passengers and their baggage, the requirement for passengers to remain strapped in until the deck is clear for disembarkation and then to spend the minimum time underneath rotor blades, wearing their LSJs until safely below deck, and the provision of escorts or hand-lines when the deck windspeed is 45 knots or more.
- 7.3 We have seen the UKOOA document and consider that it provides satisfactory guidance in regard to those procedures which are relevant to our Terms of Reference.

### **Safety Equipment – Continued Airworthiness (Event 2.2)**

- 7.4 The ANO and the relevant CAA Specifications (Spec 5 for LSJs and Spec 19 for aircrew immersion suits) require the helicopter operator to make acceptable arrangements for the continued airworthiness of personal safety equipment. This is achieved by adhering to the servicing interval which is specified for each design of LSJ and (aircrew) immersion suit.
- 7.5 All LSJs are treated as aircraft equipment. Aircrew LSJs are kept either in the aircraft or in designated stowage in the crew-room; passenger LSJs are issued on or immediately before boarding and are retrieved after landing. Aircrew are issued with two personally tailored immersion suits which they retain permanently; these are serviced in rotation, with one always available for use. Passenger immersion suits are issued before departing from shore and are sometimes retained as an item of personal equipment, available for rig emergencies, until the end of each spell of offshore duty. Although not formally covered by CAA regulations, they are in fact serviced to standards similar to those required for aircrew suits.
- 7.6 Apart from the fact that passenger immersion suits are not mandatory equipment and are therefore not subject to any formal requirement for routine maintenance

(part of the wider problem which is discussed elsewhere in this report), these arrangements appear entirely satisfactory. We visited one facility at which both passenger and aircrew suits are inspected and serviced and were impressed with the meticulous care that went into the process and the high standard that appeared to be achieved.

## **8 BEFORE DITCHING OR CRASH (PHASE 3)**

- 8.1 This Phase of the System Table covers the actions which take place when there is some period of warning, however limited, that a ditching or crash is likely to occur.

### **Communications (Event 3.1)**

- 8.2 External communications are significant in that the transmission of a distress message represents a starting point for the Search and Rescue (SAR) process. Elsewhere in this report, we discuss the equation between survival time and rescue time, and it is self-evident that the sooner the rescue services are alerted and can commence their journey to the scene of an accident, the shorter will be the time during which survivors will need to survive before they are rescued. The System therefore requires an efficient link between aircraft and the SAR organisation.
- 8.3 The National Air Traffic Services (NATS) are responsible for the network of ground stations which would receive a distress message and we have been advised that coverage over the North Sea has been improved considerably in the recent past. There has always been good coverage in the East Shetland Basin, with the Brent Log/Viking Approach service based on Cormorant Alpha (provided by IAL under contract to Shell) having direct links into the NATS air traffic unit at Sumburgh. In the central area, UKOOA has funded an offshore rebroadcasting service based on Fulmar, Forties and Brae; these units are connected to the NATS air traffic unit at Aberdeen via oil company tropospheric scatter links, enabling the Aberdeen offshore controller to communicate direct with helicopters down to 1,000ft above sea level right out to the median line. This is at present only possible during the air traffic unit's hours of operation, but there are plans to extend the period during which the service is available.
- 8.4 The southern North Sea is not so well covered, in that there is a gap to the north east of Humberside. Anglia Radar gives good coverage from the shore and has one offshore link on the Leman complex. There are ongoing discussions with NATS to provide the southern area with a similar rebroadcasting service to that already available in the central area, but the best location for the offshore equipment has yet to be decided, and it is unlikely that any improvement will be made in the southern area before the relocation of all NATS North Sea air traffic units to Aberdeen in 1995/96.
- 8.5 Another aspect of communications is the need for aircrew to issue as much warning as possible to passengers so that they can prepare themselves for a ditching or crash. This requirement is covered by the ANO and companies' operations manuals, but it is widely felt that existing PA or combined PA/in-flight entertainment systems are not entirely satisfactory. One particular problem is that audibility is much reduced when passengers have their hoods up, as they are required to do during take-off and landing. It has been suggested that one solution might be to introduce an illuminated 'Emergency' sign, similar to the familiar 'No Smoking' and 'Seat Belt'

signs, together with an ‘attention getting’ gong. This aspect is under consideration in the course of the HSSG’s review of PA systems. We believe that the CAA should monitor this review and consider a more stringent requirement.

### **Pre-Ditch/Crash Actions (Crew) (Event 3.2)**

- 8.6 Helicopter companies’ Operations Manuals cover all the actions which aircrew need to take during the available warning time before a ditching or crash; these include arming the Automatically Deployed Emergency Location Transponder (ADELT) and flotation systems, possibly preparing liferafts, checking that their own survival equipment is secure and finally adopting the recommended brace position. Although these instructions are comprehensive in relation to existing aircraft systems and equipment, and would no doubt be capable of fulfilment in the case of a premeditated ditching, they represent a statement of the ideal. If there is little or no warning of a crash, some vital actions will very probably not be carried out
- 8.7 Existing certification requirements allow flotation systems to be manually operated and do not require any form of automatic operation; apart from the Bell 212 and 214, all helicopters in UK offshore service employ manual systems. Before it will operate, such a system needs to be both ‘armed’ (in advance) and subsequently ‘activated’ (when it is required to inflate, with the aircraft on or near to the surface). In order to limit the period in which inadvertent inflation might occur, it is normal practice for the system to be armed only for a brief period during departure and arrival. This arrangement is predicated upon the circumstances of a ditching, with reasonable warning time in which the system can if necessary be armed and with the pilot sufficiently in command of the situation to activate it at the right moment This is not satisfactory for a sudden crash with little or no warning, in which the pilot may not be able to activate, or possibly may not even have armed, the system. The question of automatic flotation deployment systems (AFDS) was raised both in the AAIB report and the Fatal Accident Inquiry determination following the Cormorant Alpha accident, and has subsequently become a topic for review by HSSG. We recognise the problem of specifying a system which will activate automatically in the event of an unexpected impact with the sea but which will not be prone to inadvertent deployment in normal flight. Nevertheless, we are convinced that flotation systems need to be capable of doing their work regardless of the circumstances under which the aircraft arrives on the sea. We support the view that an acceptable compromise would be to require the provision of an AFDS which can still be made safe by means of an arming switch but which, when armed, would activate automatically upon contact with the surface. We believe that the CAA should encourage the HSSG to complete its review as soon as possible, and consider a revision of the certification requirements as a matter of priority.
- 8.8 Liferafts are carried as aircraft equipment, in accordance with Scale K of Schedule 4 of the ANO, but there are no detailed airworthiness requirements for the method of installation and release. The raft must be capable of being launched under all circumstances in which a successful ditching may be performed, but this may be demonstrated by throwing the raft from an upright helicopter on dry land. There are at present a number of possible mounting and launching options, but none appears to cater for all possible eventualities. The arguments over internal versus external carriage are finely balanced – external mounting makes it more likely that the raft will be available if the aircraft sinks quickly, but leaves it vulnerable to damage in a heavy ditching and might make it unreachable if the aircraft does not float on an even keel. Internal carriage is likely to improve a raft’s survivability in a heavy impact

and might make it possible to launch it from either side of the aircraft; however, it would require a certain amount of manhandling by passengers or crew and would preclude automatic and/or remote launching. We endorse the view, expressed in both the AAIB and Sheriff's reports, that an externally-mounted raft is more likely to be of use in the case of an unexpected and/or violent impact with the sea; under such circumstances it is highly desirable that the liferaft should be released automatically without the need for any action by crew or passengers.

8.9 We believe that there are five conditions which need to be catered for in a future requirement, namely:

- (a) A facility for the crew to launch the liferaft by a single action from their normal crew position; this would not require any passenger involvement.
- (b) A facility for the raft to be launched from within the passenger compartment with the aircraft in an upright attitude. This might be performed by a crew member or, if a crew member were not available, by a passenger.
- (c) In the event of failure of a. and b. above, and perhaps with the aircraft inverted, the raft(s) should be capable of release by a crew member or passenger from outside the hull.
- (d) As a 'last chance', if all three of the above measures had failed, the raft should be released automatically after a certain period of immersion or at a predetermined depth if the aircraft sinks.
- (e) Finally, it should be possible for a helicopter to drop at least one of its rafts to survivors from another helicopter which has ditched or crashed.

8.10 Some research into methods of liferaft carriage is already being undertaken by one operator under the auspices of HSSG, but we believe that this topic is of sufficient importance for the CAA to commission a comprehensive study with a view to issuing more specific regulations for liferaft carriage and release. Guidance is needed on the general principles to be met when designing liferaft systems, along the lines indicated above, and the requirement should include the need to demonstrate each system in typical situations, for example using something similar to the Den Helder facility recently employed by Shell for cabin evacuation trials.

8.11 We have already referred to the difficulty a pilot would experience in zipping up his survival suit while coping with an aircraft emergency. One solution would be to require the suit to be fully zipped at all times during flight, but we recognise the impracticability of this in warm weather with the present design of suit. We offer no solution to this dilemma, except to suggest that continued research into aircrew suit design should have as its ultimate objective the design of a suit that is capable of being worn, in comfort, for long periods in a fully operational condition. The problem would, of course, be reduced by improvements in the flight deck environment, such as the introduction of air conditioning.

### **Pre-Ditch/Crash Actions (Passengers) (Event 3.3)**

8.12 The pre-ditch or crash actions required of passengers are well-covered in the pre-flight briefing and consist of checking the seat-belt, zipping up the survival suit (if it is not already zipped under the 'HUZUP' rules), identifying the nearest exit and adopting the brace position.

- 8.13 Of the first three, the only aspect which may require fresh attention is that of selecting the correct exit. As will be described in Section 10 of this report, the seating layouts of some aircraft are undergoing major revision and for a period there will be a mix of old and new configurations in service. This is a potential source of confusion, but we have been informed that this has been addressed by the provision of briefing videos tailored to the specific layout of the individual aircraft about to be used.
- 8.14 The brace position for helicopter passengers has been a matter of some concern, and is complicated by the existence of two types of restraint and various seat orientations relative to the aircraft axis. Passengers in forward-facing seats equipped only with conventional airline lap-straps are advised to adopt the standard forward-leaning brace position. While this is considered to give the best protection against fore-and aft impact forces (in both fixed- and rotary-wing crashes), it is not necessarily the best position for the sideways or vertical impact forces present in many helicopter accidents; furthermore, it is believed to contribute to disorientation in the subject, to the extent that his subsequent escape may well be prejudiced, particularly if the fuselage becomes inverted underwater. Passengers in seats with upper torso restraint (UTR) are advised to adopt an erect brace position with the head well back, which gives the best impact protection and also minimises the risk of disorientation.
- 8.15 The CAA has recently completed a research project which is essentially concerned with establishing an optimum brace position for passengers in forward-facing seats with lap-straps in fixed-wing aircraft. Notwithstanding the wide range of possible directions of impact forces in a helicopter crash, further research is unlikely to produce a significantly different posture from that already recommended for fixed-wing passengers, and the dilemma of injury versus disorientation would remain. UTR is now coming into use in offshore helicopters at such a rate that any work based on lap-straps could well be overtaken, and we therefore recommend that future research into brace positions for helicopter passengers should be related to the use of UTR; this would accord with our subsequent comments concerning the universal fitment of UTR. In any event, the benefits of UTR are such that the adoption of a particular brace position is likely to be of relatively less significance than it is for passengers having lap-straps only.

## **9 DITCHING (PHASE 4)**

- 9.1 For the reasons explained in Section 5, the Ditching Phase of the System has been construed to cover only a controlled descent into a 'non-hostile' sea, ie of such a nature that the touch-down can be completed without significant risk of damage to the airframe or to its externally-mounted survival equipment.

### **Flotation (Event 4.1)**

- 9.2 The immediate requirement is that the aircraft should float upright on the surface for sufficient time for passengers and crew to evacuate from the hull through the designated ditching exits, having launched the liferaft(s). This may be achieved either through inherent buoyancy or with the assistance of flotation aids, which normally take the form of inflatable bags.

- 9.3 Certification of flotation equipment is predicated on a ditching in up to moderate sea states, and has hitherto been strongly influenced by airworthiness requirements specifying that some or all escape exits should be above water-level. This has been characterised as the ‘dry floor concept’, the intention of which is that passengers and crew (who would not, except in offshore operations, be wearing immersion suits) should be able to leave the aircraft in an orderly fashion and board their liferafts without immersion in water, thereby enjoying a much better resistance to cold while awaiting rescue.
- 9.4 Experience has shown that in the offshore environment, surface conditions are very often such that, despite the correct functioning of flotation gear, the aircraft will very soon capsize. It has been suggested that the ‘dry floor concept’ contributes to this problem, on the thesis that the higher the aircraft floats on the surface, the less its stability, and that helicopters designed to float lower in the water would therefore be less liable to capsize. Proponents of this theory generally advocate mounting flotation gear higher on the hull, claiming that this would not only promote a more stable flotation posture but would render the flotation gear less vulnerable to damage in a crash and, if the aircraft failed to remain upright, would cause it to float on its side rather than fully inverted.
- 9.5 However, this simple analysis is by no means universally accepted. It has been pointed out, for example, that without the stabilising effect of the widely-spaced low-mounted flotation bags, the residual buoyancy in the aircraft hull and fuel tanks would, in fact, render it less stable unless and until it settled to its new low waterline; an aircraft floating lower in the water is more likely to be capsized by its rotor blades striking the surface; moreover, it is not necessarily the case that it is easier to escape from an aircraft that is lying on its side than from one which is fully inverted.
- 9.6 We are not competent to arbitrate on what is undoubtedly a very complex technical issue, but we recognise the extreme difficulty of persuading a helicopter, with its inherently high centre of gravity, to remain upright on anything but the calmest of seas. BMT Offshore Ltd have, to date, delivered three reports to the CAA under a continuing contract, funded jointly by CAA, UKOOA, DOT and HSE. The first of these critically reviewed previous research commissioned by the CAA, summarising the work and commenting on its findings; the second comprised a review of helicopter ditching certification requirements; the third assessed the practicality of introducing new probability-based methodology for offshore helicopter operations. The CAA is now consulting the authors of earlier studies in the light of BMT’s comments, and intends to publish a report on the work completed by BMT, together with a statement of its position on ditching certification requirements when this activity has been completed. Two further reports are currently being prepared by BMT to provide the CAA with a short authoritative document on float scoops that can be published in order to promulgate their benefits, and to investigate the feasibility of the prevention of total inversion of the helicopter following capsize. We believe that this project should be concluded as soon as possible.

#### **Crew Actions (Event 4.2)**

- 9.7 The crew actions required under this event – stopping the rotors, jettisoning exit doors, deploying liferafts and finally ordering evacuation of the aircraft – are all prescribed in CAP 360 and/or the companies’ operations manuals. These appear to have worked satisfactorily in all recorded UK incidents which fall within the RHOSS

definition of a ditching. We see no requirement for further safety measures in this area, other than to record that the question of the best location and method of deployment of liferafts is discussed in Section 8 of this report.

#### **Evacuation (Event 4.3)**

- 9.8 Evacuation drill, including the jettisoning of cabin exits and the deployment of liferafts, is well covered during crew and passenger training and the standard pre-flight briefing.
- 9.9 There has been adverse comment over the various methods in use for the jettisoning of cabin exits; different types of aircraft employ different mechanisms, and in some instances too many separate operations are required. This may not be of critical importance in the process of a relatively orderly evacuation from a helicopter which is floating upright on the surface, but it could certainly hinder escape in other circumstances. This will be addressed in Section 10 of this report.
- 9.10 The method of manual deployment of liferafts could also bear improvement. If liferafts are to be carried internally, they should be capable of single-action release and should not, as at present, need to be manhandled to the doorway. We consider that this aspect should be included in research into the best method of carrying and launching liferafts, referred to in Section 8.

#### **General Comment**

- 9.11 The efficacy of the laid-down ditching procedures is confirmed by the fact that no fatalities have been experienced in the course of ditchings involving UK-registered offshore helicopters. This aspect of helicopter safety and survival can thus be viewed as satisfactory.
- 9.12 As has been indicated, however, this success may in part be due to the conscious decision of the CAA and other aviation authorities to optimise safety requirements around the ditching case. The question that arises is whether ditchings have been over-emphasised and whether it might be desirable to move the balance somewhat in favour of the more life-threatening crash situation, which will be addressed in the next section.

### **10 CRASH (PHASE 5)**

- 10.1 For the purposes of this study, we have grouped all accidental arrivals on the surface of the sea, other than those which meet our rather narrow definition of a ditching, as a crash. This includes a controlled descent into a sea which is sufficiently rough to damage the airframe or to prejudice its ability to float upright, inadvertent controlled flight into the sea, and also the case of an aircraft rolling off a helideck.

#### **Survivability (Event 5.1)**

- 10.2 The first requirement in any of the circumstances described above is for the occupants to survive the impact in an adequate physical condition to make good their escape. The principal factors affecting their survival will be the ability of the helicopter to remain substantially intact and the design of the occupant restraint systems, including the seat and the form of harness fitted. Adoption of the optimum

brace position (as discussed in Section 8) is also a factor, depending upon the warning available before impact.

- 10.3 The design requirements for emergency landing conditions have been enhanced considerably in recent years. Older helicopters, some of which are still operating offshore, were designed to earlier, less stringent standards; the more modern types in service incorporate the benefits of progressive improvements in requirements. New helicopter types are designed to meet current standards in respect of seat strength, occupant restraint and retention of items of mass including those within the cabin as well as major components such as engines, transmissions and rotors. The CAA has sponsored an independent in-depth study of the crashworthiness of helicopters when impacting with water. The study has reviewed actual data of ditchings and both mild and severe impacts with water; a number of conclusions have been drawn which have been presented in an interim report. The CAA is reviewing the report and commenting back to the researchers, prior to considering if any regulatory action is required. We believe that this project should be completed as soon as possible, in conjunction with the flotation and stability studies described in Section 9.
- 10.4 Seat requirements are included in BCARs/JARs, and have been the subject of progressive improvement over the years. We believe that seats constructed to the latest dynamic test standards, which will be fitted to all new types of helicopter, will be sufficiently securely mounted, strong and resilient to absorb the impact forces of any survivable crash. However, previous types of seat, including those specified for aircraft types already in production and those installed in existing aircraft, were designed to meet the earlier and less demanding static test standards. Older seats in existing aircraft are being progressively replaced by better and lighter versions, albeit still only constructed to static test standards. It is not reasonably practicable to fit dynamic test standard seats to airframes that were not intended to take them, and for this reason the new airworthiness requirements are unlikely to be made retrospective.
- 10.5 Most helicopters currently in service have been constructed to regulations which require lap-strap restraints for passengers; the majority of new helicopter types and newly-manufactured helicopters are now fitted with UTR. The shortcomings of the lap-strap include the associated brace position which not only leaves the subject prone to injury in the event of high vertical deceleration, but is believed to induce disorientation which can prejudice subsequent escape. UTR not only offers greater protection against injury but involves an erect brace position which minimises the risk of disorientation. Conversion to UTR is not a simple or cheap process, because it involves the use of seats with non-folding backs, and this in turn has implications for the cabin layout and evacuation/escape routes; nevertheless, some operators have begun retrospectively to fit UTR in their offshore aircraft, and the Helicopter Management Liaison Committee (HMLC) and HSSG are studying the implications of universal fitment of UTR in the helicopter fleet. We see the fitment of UTR in all offshore helicopters as a significant contribution to crash survival and, subject to the outcome of the HMLC/HSSG study, we would recommend the CAA to consider making the provision of UTR a mandatory requirement.

#### **Flotation/Stability (Event 5.2)**

- 10.6 We have touched upon the subject of flotation and stability in Section 9, in the context of ditching. The matter becomes critical in the case of a crash or a descent

into rough sea because the occupants' chances of escape depend very much upon how long the aircraft floats and whether or not it remains upright.

- 10.7 With notable exceptions, helicopters are not designed with hydrodynamic qualities in mind, but a helicopter is more likely to float – at least for a time – if its hull remains intact after hitting the water. Helicopter hulls are designed to withstand the impact forces arising from a ditching within clearly defined parameters of forward and vertical speed; if the forces fall outside these limits, as a result of either a controlled ditching into a rough sea or an uncontrolled impact with the water, the hull is likely to suffer serious damage.
- 10.8 In accordance with the flotation parameters discussed in Section 9, flotation devices are generally mounted low on the hull or undercarriage and are therefore likely to be damaged on impact. They will then either play no useful role or, if one is damaged and the other is not, might positively contribute to the capsizing of the hull. Protection from impact damage is probably the one undisputed argument in favour of mounting flotation devices higher on the hull; this is an example of a conflict between the best solution for the ditching case and provision for a crash.
- 10.9 As a compromise between these conflicting requirements, there is the possibility of providing helicopters with additional buoyancy devices, for example permanently-inflated bags in fuselage voids or a single inflatable bag stowed either in the upper deck or even in the tail. These would be designed specifically for the circumstances of a crash, and their purpose would be to prevent the aircraft from sinking even though the fuselage might be almost totally submerged. There is no requirement for such equipment at present, and none is fitted to any aircraft in UK offshore service.
- 10.10 Improved flotation would make a major contribution to the prospects of safe escape after a crash. Although the scope for such improvement may be extremely limited in the case of aircraft now in service, and the probably catastrophic consequences of inadvertent deployment in flight of a high-mounted device would need careful consideration, it remains a possibility which should not be neglected in the current study on flotation and stability.

### **Escape (Event 5.3)**

- 10.11 Escape from the hull of a crashed helicopter is one of the most critical events in the entire Safety and Survival System, and as a measure of its importance it has been broken down into 7 elements in the System Table.
- 10.12 Exit choice and orientation (Element 5.3.1) is a major subject in its own right, being dependent upon cabin design and seating configuration. In many aircraft, passengers have the option of using doors or windows, and a choice of different directions. As a matter of principle, we believe that it is important that each passenger should have easy access to one clearly identified exit, on which he can focus his attention during the moments of disorientation after impact. The seating configuration of some offshore helicopters has hitherto left much to be desired, and it is gratifying to record the strenuous efforts which have been made in the last two years, in collaboration between UKOOA and the helicopter operators, to improve this situation through a series of practical trials in a submersible mock-up.
- 10.13 These trials have shown positively that the seating layout of the Super Puma, as it existed at the time of the Cormorant Alpha accident, could be improved in terms of

escape. As a result, this aircraft's cabin has been comprehensively redesigned and, having seen the first aircraft modified to the new configuration, we are very impressed with the improvement that has been achieved. The Super Puma fleet is being progressively up-graded to the new layout, which also features a small but very valuable increase in the size of the rearmost window and other changes to the emergency exits. Dunker trials with the S76 showed that the existing seating layout was satisfactory so long as improvements were introduced into the emergency exits. Trials are scheduled soon for the Bell 212 and AS365N Dauphin.

- 10.14 In the light of this successful programme of tests and modification, we believe that it would now be appropriate for the CAA to review its certification requirements, taking account of the possible need for passengers to escape from a submerged and inverted cabin, to ensure that helicopters in offshore service have a seating configuration optimised for this role.
- 10.15 Undoing seat belts and removing headsets (Elements 5.3.2 & 5.3.3) appear to be straightforward actions, but can become difficult in the stress and confusion of a crash. (One survivor from the Cormorant Alpha crash told us that at first he forgot to release his lap strap). We have already referred to the benefits of UTR and to the use of cordless headsets, both of which are the subject of current study.
- 10.16 Movement towards an exit (Element 5.3.4) can be very difficult under water and in darkness, and there are various methods by which this can be assisted. One device currently in use is the 'EXIS' lighting, but some doubt has been cast on its efficacy. Most survivors have claimed not to have seen it, although it is by no means certain whether this was due to the failure of the lights to illuminate, turbidity of the water, or the reluctance of subjects to open their eyes when submerged in cold salt water. Nevertheless, a joint UKOOA/operators study has been launched to investigate possible causes for failure or delay in illumination. Additional measures such as guide rails and cushion grabs are being introduced in certain aircraft where location of the exit seems to be a particular problem.
- 10.17 Two problems have been identified with the jettisoning of exits (Element 5.3.5). The first and specific problem concerns main exit doors, which are outward-opening and are only required to be capable of jettison when the fuselage is upright; if the aircraft has capsized (as occurred in the Cormorant Alpha accident) the release mechanism might not operate but, even if it did, water pressure would prevent the door from being pushed open. For this reason, the primary means of escape when the fuselage is under water are push-out window exits, including those which are sometimes installed in the main exit doors; this is emphasised in training. It is difficult to envisage circumstances in which it would be practicable to use the main exit when the fuselage is not upright, and we therefore do not consider that there is any need for the CAA to reconsider the operating parameters for cabin door release mechanisms; rather, we believe that training should continue to stress the importance of concentrating on the nearest jettisonable hatch or window in a crash.
- 10.18 The second and more general problem concerns the lack of standardisation in the operation of emergency exits, which present a variety of different mechanisms, operated by tags and/or handles located in various positions relative to the exit and operating in different directions. This is the subject of study by the British Helicopter Advisory Board (BHAB). We believe this work should be progressed with urgency and monitored by the CAA with the aim of defining one standard method of exit release which could be fitted to all aircraft.

- 10.19 Experience has shown that a severe crash is often followed by rapid inversion and submersion of the aircraft, leaving insufficient time for survivors to escape from the hull before they are under water (Element 5.3.6). It has been suggested that one way of providing an extra period of consciousness would be to equip occupants with some form of underwater breathing device. This issue is discussed at Annex L, which concludes that no clear advantage would be gained and that, on the basis of evidence currently available, the CAA would not be justified in pursuing this as a regulatory measure.
- 10.20 Research by the Robens Institute also suggests that adequate thermal insulation under a properly-sealed immersion suit provides a measure of protection against thermal shock and thus increases the likely breath-hold time; although this may amount to no more than an extra 10 seconds, it could be vital and is a further reason for ensuring that offshore passengers are properly clad.
- 10.21 Having surmounted all the difficulties outlined above, it would remain for the survivor to make his egress from the hull (Element 5.3.7). In this critical final stage, it is important that his personal safety equipment is not so bulky or buoyant as to impede his progress, and is designed to present the least possible risk of snagging.

### **FAA Study**

- 10.22 At a fairly late stage in our review, we obtained a copy of a recent study of Rotorcraft Ditchings and Water-Related Impacts carried out on behalf of the United States Federal Aviation Administration.\* This study analysed 77 helicopter impacts with water from 1982 to 1989 in terms of occupant injury and death, and reached the following conclusions:
- (a) The main occupant injuries were from flailing and excessive acceleration resulting from interaction with the rotorcraft interior and insufficient structural energy absorption.
  - (b) Drowning and exposure were the main post-impact hazards. Impact injuries frequently impaired post-impact survivability.
  - (c) Structural failures of the rotorcraft were not found to be significant contributors to occupant injury.
  - (d) Flotation equipment, as is currently deployed and used, does not adequately keep the occupiable area of the rotorcraft upright and afloat.
  - (e) The techniques to alleviate injuries sustained in water impacts are similar to those required to alleviate injuries in accidents on other terrain.
  - (f) Techniques for alleviating injury in water impacts include better occupant restraint, delethalisation of the cockpit and cabin interior, energy-absorbing seats, improved performance and use of personal flotation devices and improved performance of rotorcraft flotation equipment.

\* DOT/FAA/CT-92/13 and /14 – dated October 1993

- 10.23 Most of the accidents included in this study involved relatively small helicopters (for example, the Jet Ranger) which are not representative of the types in general use for UK offshore operations; for this reason, the first conclusion is not borne out by our records of offshore accidents, where occupant injuries of the type described have not been a major factor. With that exception, we found nothing in the conclusions of this study that conflicted with our own views of the principal hazards in a helicopter crash and the methods of countering them.

## **11 SEA SURVIVAL (PHASE 6)**

- 11.1 In this Phase of the System Table, the two possible accident pathways – ditching/evacuation and crash/escape – follow parallel routes. In either case, those who have so far survived will find themselves in or on the sea and their salvation will then depend upon three critical pieces of equipment – the liferaft, the LSJ and the immersion suit.

### **Liferaft (Event 6.1)**

- 11.2 The question of liferaft carriage and release has been addressed in Section 8, and this section will therefore only consider the performance of those liferafts which have survived any impact and been satisfactorily released or launched from the aircraft.
- 11.3 As a result of previous shortcomings in the performance of liferafts carried in helicopters, the new ‘Heliraft’ was developed in 1985 and is now in service throughout the offshore fleet. Its reversible design is based upon a double inflatable ring with a floor sandwiched between, and a hood which can be erected on either side, with all equipment and attachments duplicated; it thus avoids the problem of inverted inflation suffered by previous designs. It has a high level of tolerance to accidental damage (as was demonstrated in the Cormorant Alpha accident), is of a size and weight that permits it to be handled by one person in reasonable wind and sea states, and is more readily boardable by survivors from the sea by means of a ramp and straps.
- 11.4 Recent trials with proposed new designs of LSJ have highlighted some difficulties in the use of the boarding ramps, particularly by smaller persons wearing LSJs with increased buoyancy. These difficulties have not been evident with the designs of LSJ currently in use, but some work is, in any case, being carried out to improve the ease of boarding. The Heliraft is seen as a significant improvement over earlier models, has attracted little criticism since its introduction, and may fairly be listed as one of the success stories of offshore safety and survival. Survivors who have managed to board a serviceable Heliraft are well placed to await the arrival of the rescue services in relative safety.

### **LSJ (Event 6.2)**

- 11.5 Those survivors who have not been able to board a liferaft will be dependent upon their LSJ to remain afloat until rescue arrives. Experience from the Cormorant Alpha accident, as recorded by both the AAIB and the Sheriff and as confirmed to RHOSS by one of the survivors, has revealed shortcomings in LSJ performance in extreme conditions.

- 11.6 The most serious problem has been the insecurity of fitting, which allowed LSJs to ride up and fail to provide the necessary support. Short-term solutions to this problem involve the use of crotch straps, or belts which thread through corresponding loops in the immersion suit. However, these measures have in turn highlighted the lack of harmonisation between passenger immersion suits and LSJs. In the case of aircrew, Spec 19 for immersion suits requires among other things that the suit should be compatible with the LSJ; but since passenger suits are not mandatory equipment, they are not covered by Spec 19 and there is thus no regulatory mechanism for ensuring that these two important pieces of safety equipment will function satisfactorily in combination.
- 11.7 Other weaknesses of existing LSJ specification and/or design are in the 'self-righting' capability in the case of an injured survivor floating face down, the channelling of waves between the lobes into the subject's face, the questionable value of the spray hood and some doubt over whether the current specification is adequate to ensure the most important criterion of all – a sufficient 'mouth free-board' under all likely sea conditions. There is also some uncertainty among rescue personnel concerning the identification of lifting beackets and whether they are strong enough to be used for a helicopter winch lift.
- 11.8 One further complication is that Spec 5 has to address the required performance of all LSJs used in civil aviation, most of which would not be worn in conjunction with an immersion suit. When used in conjunction with an immersion suit, an LSJ must perform according to the requirements of Spec 19; it is unlikely that one design of LSJ would perform optimally in both circumstances. We note that Spec 5, dealing with LSJs worn alone, requires testing to be carried out in disturbed water whereas Spec 19, addressing the combination of an LSJ with an immersion suit, does not. Conversely, Spec 19 requires a specific mouth freeboard while Spec 5 requires only that the mouth remains clear of the water. We consider that there should be a closer degree of harmonisation between these two specifications, and that a swim test in waves is an essential test for satisfactory performance, particularly in respect of security of attachment.
- 11.9 The issue is complex, and a considerable amount of research is still required before the design of the LSJ/immersion suit combination can be optimised. Problems yet to be solved are the achievement of self righting without excessively large lobes which would interfere with boarding liferafts or the use of life belts and lifting strops; how best to prevent LSJs from riding up in heavy seas without introducing a snagging hazard; the design of easily deployable spray hoods with minimal interference with vision and hearing; the best direction and angle of flotation; the design and identification of lifting beackets; and integration with other survival aids.
- 11.10 There is an on-going research programme at the DRA Centre for Human Sciences, and the HSSG is attempting to define an enhanced Spec 5. In the course of this work, sea trials were held early in 1994 in order to evaluate a number of new designs; regrettably none of these proved to be entirely satisfactory, and work continues.

### **Immersion Suit (Event 6.3)**

- 11.11 Immersion suits play a vital role in protecting survivors against hypothermia if at any stage they become immersed in the sea and particularly if they spend any length of time in the water; the most critical requirement is that the suit should remain watertight, and this demands an efficient seal at the wrists and face or neck. Various

designs of suit and types of seal are in use and passenger suits, although not mandatory equipment, are generally designed to meet the standard of Spec 19.

- 11.12 The question of comfort in normal use has been touched on in Section 6, and this is inter-related with the functional performance of the suit. There are two basic types of immersion suit in use today – those with a full neck seal and a diagonal zip and those with a split neck seal and a central vertical zip. They are both capable of fulfilling their role, but only if they are fully done up – and on some occasions they are not because they are too hot and/or uncomfortable to be worn in this condition throughout a flight. Any moisture within an immersion suit, including sweat, will markedly reduce its insulation. It is clearly undesirable for an item of survival equipment to be so uncomfortable in routine use that the wearer is tempted to compromise its effectiveness or, in the case of aircrew, becomes so distracted by discomfort that a flight safety hazard is introduced.
- 11.13 Immersion suits are prone to leakage, and indeed a certain leakage is allowed by the specification. However, some types of suit are suspected of leaking excessively in rough water, and we believe that certification testing should take account of this.
- 11.14 Protection of the hands is another problem; although gloves are provided in suit pockets, experience has shown that survivors very quickly become too cold to put them on. It is not practicable to require gloves to be put on as part of the pre-crash drill, because it would then not be possible to manipulate the escape hatch mechanisms. A survivor's ability to use his hands could be crucial during survival and subsequent rescue, and we believe that more research is needed into ways in which the hands might be protected.
- 11.15 An immersion suit, on its own, will not protect the wearer from hypothermia for any length of time. Protection depends also upon the thermal insulation provided by clothing worn under the suit. At present, although clear guidance is given to passengers about what they should wear under their suit, this is left entirely to the individual and no formal checks are made on the adequacy of personal clothing. Industry has developed an insulating undergarment which could be put on over personal clothing before donning the immersion suit. This is currently under evaluation, and if it proves acceptable we believe that it should be made available to passengers to supplement their own clothing when necessary.

### **LSJ/Immersion Suit Relationship**

- 11.16 We spent some time debating the relationship between LSJs and immersion suits. A spectrum of possibilities was considered, ranging from methods of improving compatibility between two essentially separate pieces of equipment to the concept of single waterproof/insulated/buoyant garment which would replace both the existing items. The balance of opinion was in favour of a less radical solution, based on the continued use of two separate pieces of kit, which should nevertheless be of standardised design to inter-related specifications and which should be tested together in representative wave conditions to ensure full compatibility. Such a course would, inter alia, have the advantage of not requiring amendment to the present regulations for the provision and wearing of LSJs and immersion suits.
- 11.17 We have already referred to the work being carried out at the DRA Centre for Human Sciences, and the HSSG's consideration of the question of standardisation. We believe that this work should be concluded as quickly as possible and that the CAA should review Specs 5 and 19 and their inter-relationship.

## **12 RESCUE (PHASE 7)**

### **Rescue Time v Survival Time (Events 7.1 & 7.2)**

- 12.1 The final Phase of the System Table involves retrieval of survivors by the rescue services to a place of safety. For this to be successful, it is clearly necessary for them to survive until they can be rescued. The two critical factors in this equation are, on the one hand, the time it will take the SAR organisation to respond, to reach the scene of the accident, to find the survivors and to retrieve them, and, on the other hand, the length of time that survivors can be expected to remain alive and in a condition to fend for themselves.
- 12.2 The DOT is the sponsoring department for the SAR system, which has to be funded from finite resources. There has been a recent review of the SAR services, which provided the basis for some rationalisation of shore-based SAR helicopter deployment, based on a standby time of 15 minutes by day and 45 minutes by night. UKOOA has subsequently carried out a study of the implications of the new SAR deployments. Taking a worst-case scenario of 45 minutes standby, an accident near the median line and a 30 knot headwind, this study arrived at a time of 3 hours to reach the scene; allowing a further hour to locate and retrieve survivors, this would result in a possible exposure time of up to 4 hours.
- 12.3 It is difficult to perform a similar calculation for survival time, because so much depends upon the circumstances of an accident, the fitness of the persons involved, and unpredictable circumstances. Nevertheless, there is a sufficient store of experience of offshore accidents and of experimental data for an estimate to be made of what might reasonably be expected in various sea temperatures, assuming that survivors were wearing immersion suits with adequate clothing underneath. In this connection, we understand that as a result of their study, UKOOA will recommend the provision of thermal liners to be worn under immersion suits when the sea temperature is below 10 degrees C.
- 12.4 The arguments for and against formal restriction of offshore flights in adverse survival conditions are rehearsed at Annex M, which attempts to strike a balance between the conflicting views. The Annex rejects the suggestion of suspending flights in conditions unsuitable for ditching, but argues the case for improved methods of ensuring that survivors of a crash or ditching would at least have a reasonable expectation of being picked up alive. It suggests that offshore managers should be provided with the means to compare realistic survival times, in the prevailing conditions, with up-to-date information on the location and availability of rescue services, so as to be able to make an informed comparison between rescue time and survival time for the critical part of each planned flight. Any mis-match between the two should then be treated as significant factor in deciding whether or not to allow the flight to go ahead. This would be within the spirit of existing instructions to offshore managers, but would give them more specific guidance than is currently available on what they should treat as limiting circumstances. A certain amount of further work would be necessary to develop this proposal into a simple, practical procedure, but we believe that it represents a balanced approach to a contentious issue.

### **Detection and Location of Survivors (Event 7.3)**

- 12.5 Once the rescue services have reached the scene of an accident, they need to find the survivors. This may be achieved visually or by electronic or other means.
- 12.6 At present, electronic location is provided by the aircraft-mounted ADELTA beacon and the search and rescue beacon (SARBE) with which each Heliraft is equipped. ADELTA does not have a good record of satisfactory operation in crashes (although it is hoped that recent improvements to the system will be found to have improved its reliability), and the Heliraft's SARBE will only be available if the raft has survived the crash and been freed from the aircraft. Thus, whereas finding a ditched helicopter has never been a problem, it might not always be easy to locate the scene of a crash which has occurred with little warning some distance away from an offshore platform, particularly if the aircraft has not remained on the surface.
- 12.7 A helicopter crash could potentially put over 20 people into the water. Those who had been able to board a Heliraft would have the benefit of SARBE and could be readily be located, but any who were still in the water would inevitably begin to drift apart, and some might be injured or unconscious. Experience of survivors and search and rescue crews proves that a lone person floating in the sea represents a small and very difficult target to locate. At present, passengers are not provided with personal SARBE and the only location aids they are required to carry are a whistle and a sea light – both of which owe more to the historic maritime man-overboard situation than to the present-day helicopter rescue scene. The limitations of the sea light are well known; trials have shown that a good strobe light can be seen from up to five miles away, compared with a mile or so for the standard sea light. As a result, strobe lights are now also fitted to LSJs and, additionally, some oil companies provide strobe lights in the immersion suits which they issue to passengers. We believe that it is time for the CAA to review its requirement in the light of current practice and modern technology.
- 12.8 The colour of immersion suits and LSJs is predominantly orange to aid visibility in daylight; this has been criticised by some SAR authorities, who maintain that the previously-used yellow was both brighter and less prone to confusion with floating debris. Location has also been aided by the addition of reflective tape to immersion suits. The provision to passengers of pyrotechnics has hitherto been ruled out because of the risk of accidental discharge in the cabin during normal flight. We concur with this decision.
- 12.9 The HSE has sponsored a project to study improved means of detection and location, and we believe that this must include liaison with the providers of SAR. One aspect which might yield significant benefits is the development of a computer programme to predict the probable position of individual survivors in relation to the scene of a crash, taking into account elapsed time, tide, surface wind strength and sea state.

### **Retrieval of Survivors (Event 7.4)**

- 12.10 Having been located, survivors need to be retrieved into a rescue vehicle, and this process could take one of four forms – from either a raft or the sea to either a helicopter or a surface vessel.

- 12.11 Retrieval from the sea into a helicopter is normally carried out by winching, and we have already referred to the difficulty of passing a strop over the lobes of some current LSJs and the uncertainty among crewmen concerning the strength of lifting beackets. A horizontal, or at least a sitting, lifting attitude is considered much safer for survivors suffering from the effects of immersion in cold water, and for this a double strop is required. We believe that there is scope for improvement in the information provided to all helicopter rescue crews.
- 12.12 Retrieval from a raft into a helicopter takes a similar form, although it may be somewhat easier in that the crewman can sometimes stay in the raft to organise retrieval of survivors individually or in pairs.
- 12.13 Retrieval of survivors from the sea to surface vessels has proved very difficult and dangerous in heavy seas, particularly when a survivor is not in a condition to assist the process. The fast rescue craft (FRCs) carried on board standby vessels (SBVs) are the most suitable, by virtue of their low freeboard, but have a restrictive weather window for recovery to their parent vessel. The SBVs themselves have a maximum freeboard of 1.5 metres and are equipped with scramble nets, but other vessels which might be near to the scene of an accident may have a much higher freeboard and may lack boarding and retrieval equipment. A proprietary device known as the 'Jason's Cradle' is available, but this relies upon the rescue vessel being manoeuvred alongside the survivor; in high seas this may not be practicable.
- 12.14 In suitable conditions, retrieval from raft to vessel can be effected by using an FRC to ferry survivors to the SBV where the FRC plus crew and survivors can be winched aboard. Otherwise, survivors have to leave the raft and climb direct onto the SBV. Several launch and recovery devices are under development to increase the size and weather capabilities of the rescue craft mounted on SBVs; it is possible that when these devices are available it might be possible to develop techniques suitable for the direct recovery of a Heliraft onto an SBV.
- 12.15 Research continues in various quarters into improvements to methods of retrieving survivors, and we believe that HSE should coordinate these efforts.

#### **Post Survival Debriefing (Event 7.5)**

- 12.16 Although it would not strictly be part of the rescue process, we believe that some reference should be made here to the debriefing of survivors of an offshore helicopter accident. Interviews already take place as part of the subsequent AAIB investigation, and survivors may be called upon to give evidence at inquests or their Scottish equivalent; but there is no established procedure under which the experience of individual survivors, crew or passenger, and an understanding of the behavioural patterns they exhibited, can be fed back into the safety and survival system. We have referred in Section 6 to the lack of feed-back into the training process, but we believe the issue is wider than that. Judging by our contacts with the two Cormorant Alpha survivors, we believe that there would be great potential benefit in an arrangement for all survivors to be invited to recount their personal experience of the accident and subsequent survival to human factors specialists, so that every possible lesson could be learnt. In so far as the AAIB is already tasked with the investigation of all accidents and incidents which would be likely to yield such information, and in many cases will need to interview some survivors for other purposes, we believe that it would be best placed to assume this additional function.

## **13 ASSESSMENT OF THE OVERALL SYSTEM**

- 13.1 Having worked through each of its phases in turn, it is now possible to take a broader view of the System as whole, and to form a view of its overall effectiveness. This must, inevitably, be a subjective assessment, but it can be guided to some extent by statistics of previous accidents and incidents and our knowledge of recent improvements in areas of known weakness.

### **Assessment of Individual Phases**

- 13.2 The Pre-Flight and Post-Flight Phases of the System have no serious weaknesses. The processes of passenger acceptance, training, briefing, kitting-up, boarding and disembarkation are well organised, and arrangements for the provision of personal safety equipment are satisfactory apart from the anomalous situation over passenger and crew survival suits. (Paragraph 6.13) (Event 1.4). The Pre-Flight Phase, however, also raises the issue of departure criteria and the lack of a positive process for limiting offshore operations in conditions that would preclude rescue within likely survival time. While accepting that it would not be realistic to expect all oil companies to agree a rigid framework of departure criteria, nor to prohibit flights over areas unsuitable for ditching, we are concerned that the guidance offered to most offshore managers is of a very general nature and requires them to take account of a wide range of factors on which they may have insufficient information to make a valid judgement. (Paragraphs 6.22 and 12.4) (Events 1.6, 7.1 and 7.2).
- 13.3 The Before Ditching or Crash Phase appears generally satisfactory in so far as it precedes a ditching. Crew and passenger drills are comprehensive and communications are adequate, apart from some residual gaps in radio coverage in the central and southern North Sea, and a need for improvement in the audibility of emergency warnings to passengers. (Paragraphs 8.3 to 8.5) (Event 3.1). If this phase is followed by a crash, however, it reveals inadequacies in the methods of activating flotation equipment and releasing liferafts. (Paragraphs 8.7 to 8.10) (Event 3.2).
- 13.4 The Ditching Phase is well structured and gives no cause for concern, apart from the desirability of standardising the operation of emergency exits and eliminating the need for liferafts to be manhandled towards a doorway. (Paragraphs 9.9 and 9.10) (Event 4.3) However, there is a possible conflict between the optimum flotation and stability parameters for benign and hostile sea states. (Paragraphs 9.2 to 9.6) (Event 4.1).
- 13.5 In the Crash Phase, more significant problems begin to appear. Impact survivability is less than it would be if all aircraft were built to the current standards of structural integrity and were equipped with seats constructed to the new dynamic test standards and fitted with UTR; this shortcoming will diminish over the years as new helicopter types enter service, but there are practical limitations to the scope for modifying the existing aircraft fleet. Flotation and stability are limited by the inherent top-heaviness of conventional helicopter design and by flotation systems which are intended to cope with a ditching in moderate sea states; escape has been hampered by less than ideal cabin layouts and by non-standard exit markings and jettison mechanisms. (Paragraphs 10.3 to 10.5, 10.10, 10.12 and 10.18) (Events 5.1, 5.2 and 5.3).
- 13.6 The Sea Survival Phase is of mixed quality, depending upon whether it is preceded by a ditching or a crash and the extent of prior warning available. In the case of a

ditching which, as we have defined it in Section 5, presupposes some measure of warning and a relatively benign sea state, it is likely that survivors will have the benefit of a serviceable liferaft which they may well have entered without being immersed; experience of such events shows a 100% survival rate. In the case of a crash, survivors who have managed to escape from the aircraft will probably not have the use of a liferaft, may well be wearing inadequate clothing under immersion suits which, if there has been little or no warning, may be imperfectly sealed, and will be dependent upon a LSJ which, while meeting current specifications, could be deficient in several aspects; experience shows that survival in such a case is problematic. (Paragraphs 11.6 to 11.8 and 11.12 to 11.15) (Events 6.2 and 6.3).

- 13.7 Similarly the Rescue Phase, while satisfactory in the case of survivors from a ditching in fair conditions, shows weaknesses in the ability of the rescue services to find and retrieve survivors in the severe conditions which may well prevail after a crash. With present and foreseeable deployments of the rescue services, the problem is compounded by a potential mis-match between the time taken to reach the scene of an accident remote from shore and the time for which survivors might realistically be expected to survive. (Paragraphs 12.4, 12.7 and 12.11 to 12.14) (Events 7.1 to 7.4).

### **Crashes versus Ditchings**

- 13.8 The most striking feature of the System is the marked difference between its effectiveness in regard to ditchings as compared with the far less satisfactory position in regard to what we have termed crashes. Of course, a ditching by definition presents a less hazardous situation than a crash, and it would be entirely unreasonable to expect a similar 100% record of survival in the latter case. However, it is also a fact that some important safety requirements – for example, flotation equipment and liferaft activation – have been framed around the less demanding but more easily defined ditching case, and therefore do not cater so well for the far more difficult and less predictable circumstances of a crash. Similarly, there have been instances where, for example, the awkward operation of emergency exit mechanisms has been considered acceptable on the basis they could be managed during an orderly evacuation after a ditching, without sufficient consideration of whether they could also be managed in the turmoil of a crash by individuals who may not act in a deliberate and rational manner.
- 13.9 The question that arises is the extent to which it might be possible to place more emphasis on the crash without risking the erosion of the generally very satisfactory provision made for ditching. In some instances, there is no conflict; better cabin layouts and more clearly marked and standardised exit mechanisms would be beneficial in both ditchings and crashes. However, in other areas the requirements of the two cases can be in conflict; flotation and stability parameters are the prime example. It may be that further study might produce a solution which is satisfactory for both situations; if not, it may be necessary to make a decision in favour of one situation or the other.
- 13.10 Any proposed modification to the requirements should take account of the overall risk and the benefits offered. In such consideration, two factors are relevant – the relative likelihood of the two events, and the consequences of not providing the ideal solution for one of them. In this respect, we offer the following views.

- 13.11 With regard to relative likelihood, past statistics show rather more ditchings than survivable crashes. The record of accident causes shows that, as a result of improved monitoring systems and greater component reliability, there is a downward trend of technical failure; regrettably, there is no corresponding downward trend in operational error. In fact the record shows that for the recent past the incidence of crashes for technical causes has reduced whilst those for operational error have remained steady, and that there is a suggestion that the incidence of ditchings is reducing. Since ditchings almost invariably arise from some form of technical failure, it is to be expected that the incidence of ditchings will decrease. Crashes, on the other hand, can arise from either technical failure or operational error, and therefore the incidence of crashes is not likely to decrease to the same extent. Thus, it is possible to deduce that the ratio of crashes to ditchings will increase. This would support an argument in favour of placing greater emphasis in future on measures designed to meet the crash case.
- 13.12 With regard to the consequences of not providing the best solution, the choice is less obvious. Clearly a crash is the more traumatic event, and one might instinctively opt for doing everything possible to meet that case. However, it would require a very bold decision to erode a safety measure which has been proved in the past to be capable of aiding perfectly fit survivors of a ditching, for the doubtful benefit of those involved in a serious crash from which survival might not, for other reasons, be possible. For example, abandoning the 'dry floor concept' in order to increase aircraft stability in heavy seas (if, indeed, that were proved to be a valid solution) might improve the chances of survival after a moderate impact or a ditching in a rough sea, but it could make evacuation from a gentle ditching considerably more hazardous and would be of no benefit after an impact so severe that occupants were too badly injured to escape.

### **Overall Assessment**

- 13.13 Our overall assessment of the System is that it is generally well able to meet the requirements of a ditching but that more needs to be done to improve the prospects of survival from a crash. Much work is already in train in this respect, and at present none of this involves any conflict between the ditching and the crash situations; further study would be required before taking any steps which did involve such a conflict.
- 13.14 Although there are various weaknesses in the System, which have been summarised in the preceding paragraphs, there is not one which is not already to some extent being addressed. That is not to say that all the answers have already been found or are even imminent, or that we are necessarily satisfied that enough is being done, but we have been impressed with the great efforts already being made throughout the offshore industry to remedy shortcomings that may have come to light as the result of accidents and incidents in recent years, including the Cormorant Alpha crash.
- 13.15 The final section of this report contains a number of recommendations which we believe would contribute significantly to overall improvement of the System.

## **14 RECOMMENDATIONS**

14.1 In the course of our review of the Safety and Survival System in Sections 6 to 12, we identified a number of shortcomings and discussed the work that has so far been done to remedy them; the most significant points were summarised in Section 13.

14.2 In the light of our review, we make the following recommendations, which are listed broadly in the order in which the relevant event occurs in the System Table:

- (a) OPITO should continue to monitor the content of initial and refresher survival training courses, and should ensure that lessons from actual emergencies are fed back, as suggested in Paragraph 6.5.
- (b) Helicopter operators and UKOOA should continue to monitor the content of pre-flight briefings, and should ensure that the shuttle briefing concentrates on escape from the aircraft about to be flown in, as proposed in Paragraph 6.8.
- (c) The CAA should consider extending the existing mandatory requirement for immersion suits to include offshore passengers as well as aircrew, as proposed in Paragraph 6.13, in order to ensure that all suits conform to the necessary standard and are compatible with other safety equipment.
- (d) NATS and UKOOA should complete their joint programme for improving radio coverage in the North Sea, as outlined in Paragraphs 8.3 and 8.4.
- (e) The HSSG should complete its research into improved communications between crew and passengers, taking into account alternative methods of attracting the attention of passengers in an emergency including those identified in Paragraph 8.5. The CAA should then consider issuing a more stringent requirement.
- (f) The CAA should undertake a comprehensive study into the best method of liferaft carriage and release and should consider the issue of more specific requirements, taking account of all the conditions posed in Paragraph 8.9.
- (g) The CAA should accelerate and/or coordinate current studies into helicopter crashworthiness, flotation and stability parameters and the automatic activation of flotation gear, as indicated in Paragraphs 8.7, 9.6 and 10.3. Particular account should be taken of the need to improve provision for flotation after a severe impact, including the possibility of installing extra flotation devices specifically to cater for a crash, as suggested in Paragraph 10.9.
- (h) Helicopter operators should continue with their programme of up-dating helicopter seating to the highest reasonably practicable standards. HMLC/HSSG should complete the study into the universal fitment of UTR, described in Paragraph 10.5, and in the light of this the CAA should then consider making UTR a mandatory requirement and, if necessary, carry out further study into the associated brace position as suggested in Paragraph 8.15.
- (j) UKOOA and helicopter operators should complete current trials of cabin layouts, described in Paragraph 10.13, and operators should introduce any necessary improvement as quickly as possible into the present fleet of aircraft. In the light of these trials, the CAA should review its certification requirements

in relation to the cabin layout of new types of aircraft, as suggested in Paragraph 10.14.

- (k) The BHAB should conclude its current study of emergency exit operation, mentioned in Paragraph 10.18, and the CAA should then review its requirements with the aim of defining one standard method of exit release.
- (l) The HSSG and DRA Centre for Human Sciences should continue their research into LSJ design in an attempt to find a more satisfactory standard.
- (m) The CAA should review its specifications for LSJs and immersion suits in order to achieve a closer degree of harmonisation and to eliminate the inconsistencies and shortcomings outlined in Paragraphs 11.8, 11.9 and 12.8. The new requirement should include a test for both items in an environment representing severe weather conditions in the open sea.
- (n) Oil companies should consider measures to ensure that all offshore passengers have adequate insulation under their immersion suits, if necessary through the issue of thermal liners to those who are not wearing suitable personal clothing as indicated in Paragraph 11.15.
- (o) Oil companies should review and amplify their guidance to managers concerning departure criteria for restriction of offshore flights in adverse conditions, with particular emphasis on the importance of comparing likely survival and rescue times at the most remote point of the flight, along the lines suggested in Paragraph 12.4 and Annex M.
- (p) The CAA should consider issuing a requirement for strobe lights to be carried as part of personal survival equipment, as suggested in Paragraph 12.7.
- (q) The HSE should coordinate continued research into means of locating and retrieving survivors from the sea, as suggested in Paragraph 12.15.
- (r) The AAIB should make arrangements to debrief all survivors of offshore accidents in order to feed back their experience into the safety and survival system, as suggested in Paragraph 12.16.

14.3 Finally, we would emphasise that RHOSS, as an ad-hoc group, has only been able to take a snapshot of offshore safety and survival as it stands in 1994. While in no way canvassing for permanent status, we believe that the CAA should consider establishing a mechanism through which the issues we have addressed could be kept under periodic review. In such a process, we suggest that the Event Tree and System Table appended to this report might provide a check-list against which future developments could be gauged. As well as monitoring progress on outstanding problems, we suggest that such a review would need to take account of any changes in the pattern of offshore operations, the potential benefits of new technology and the results of future research. It would also be important not to lose sight of the possibility that an improving flight safety record in offshore operations could eventually lead to a situation where some existing requirements for survival equipment and training might be relaxed.



## **Annex A Terms of Reference**

- 1 Review offshore helicopter occupant safety and survivability by considering the concept of an integrated escape and survival system and to recommend, where appropriate, changes to regulations and practices which could be considered to optimise the opportunities for successful escape and survival following both a controlled ditching and an uncontrolled impact with water.
- 2 The Review should:
  - (a) Identify, for offshore passenger operations in connection with oil and gas exploration or exploitation, the elements and relevant parameters of current escape and survival systems and their requirements including aircraft systems, occupant safety and survival equipment, escape provisions and rescue capabilities and the associated operational environment.
  - (b) Consider the elements required for escape, survival and rescue as an integrated system, to identify any incompatibilities which might prejudice the successful operation of the total system.
  - (c) Make recommendations as to what practical changes could be made in order to optimise the opportunities for successful escape and survival \* following a controlled ditching.
  - (d) Make recommendations as to what practical changes could be considered to optimise the opportunities for successful escape and survival following an uncontrolled impact with water including helideck roll off case.
  - (e) Consider the activities of relevant committees and working groups and co-ordinate as necessary to avoid omission and duplication.

\* Note Survival means that a survivor stays alive for a time sufficient to be successfully rescued.



## **Annex B Composition of Steering and Working Group**

### **STEERING GROUP MEMBERS**

AVM Brian Huxley	Independent – Chairman
Dr Andrew Cummin	DRA (formerly RAF IAM)
Mr Peter Dawes	UKOOA (BP Exploration)
Captain John Follis	BHAB (Bristow Helicopters Ltd)
Mr Tony Hutchings	CAA (until August 1994)
Mr David Menarry	HSE
Captain John Ramsdale	CAA
Mr Dennis Russell	BHAB (Bristow Helicopters Ltd)
Mr Alan Vincent	SBAC (Westland Helicopters Ltd)
Mr David Whittle	CAA
Mr Leon Winnert	CAA – Secretary

### **WORKING GROUPS**

#### **Working Group A. The Event Tree**

AVM Brian Huxley	Chairman/Rapporteur
Mr David Menarry	HSE
Mr Andrew Spring	CAA
Mr David Whittle	CAA

#### **Working Group B. The System Table**

Captain John Ramsdale	CAA – Chairman/Rapporteur
Mr Peter Dawes	UKOOA
Captain John Follis	BHAB

#### **Working Group F. Helicopter Flotation**

Mr Alan Vincent	SBAC – Chairman/Rapporteur
Captain Nick MacDonald-Gibson	Bristow Helicopters Ltd
Mr Paul Sparkes	CAA

**Working Group L. Liferafts**

Captain John Ramsdale	CAA – Chairman/Rapporteur
Mr Cliff Barrow	CAA
Mr Donald Slessor	Bond Helicopters Ltd

**Working Group M. Mobility (ie cabin evacuation)**

Mr Dennis Russell	BHAB – Chairman/Rapporteur
Mr Andrew Spring	CAA

**Working Group O. Operations (ie the operational environment)**

Mr Peter Dawes	UKOOA – Chairman/Rapporteur
Captain Michael Webber	CAA

**Working Group R. Rescue**

Mr David Menarry	HSE – Chairman/Rapporteur
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*with contributions from*

Lt Cdr Paul Hayward	RNAS Yeovilton
Mr Robert Miles	HSE

**Working Group S. Personal Safety Equipment**

Dr Andrew Cummin	DRA – Chairman/Rapporteur
Mr Dominic Cortizo	CAA
Mr Peter Redman	DRA

*with contributions from*

Lt Cdr Paul Hayward	RNAS Yeovilton
Wg Cdr Peter Sowood	DRA
Captain Steve Stubbs	British International Helicopters Ltd

## **Annex C Respondents, Contributors and Organisations Visited**

- 1 The RHOSS Steering Group visited the following organisations:

British International Helicopters Ltd

Bond Helicopters Ltd

Bristow Helicopters Ltd

Multifabs Ltd

The Robert Gordon Institute of Technology

- 2 RHOSS had the benefit of presentations from, and discussion with, the following individuals and organisations:

The Air Accidents Investigation Branch, represented by:

Mr R StJ Whidborne

The Aviation Study Group, represented by:

Dr J M B Vant

Dr D Anton

Dr J H K Grieve

Mr J S Mackay

Shell Aircraft Ltd, represented by:

Mr B Humphries

Two survivors of the Cormorant Alpha accident:

Mr A Innes

Mr G Watson

- 3 Written contributions were received from the following:

Mr T E Adam

Meggitt Oxygen Systems

Mr E Bramham

Shark Group

Prof. D H Elliott

Robens Institute

Mr J C Ferrall

Ferrall Aviation Consultancy Ltd

Mr P Hopkins

Mr A Matheson

Muir Matheson Ltd

Snr J M Marun

Sindicato Nacional dos Aeronautas, Brasil

Mr F N Piasecki

Piasecki Aircraft Corporation

Mr D Shelton-Smith

Loctite Luminescent Systems

Mr R Spiller

MSF

Capt P K Vaid

## **Annex D Evidence from Cormorant Alpha Survivors**

In the course of its 4th and 7th meetings on 26 January and 29th April 1994, the RHOSS Steering Group interviewed two survivors from the Cormorant Alpha accident, identified in this working paper as Survivors A and B. The paper records the salient points of the discussions, which in both cases broadly followed the chronological sequence of the RHOSS Event Tree.

### **TRAINING AND BRIEFING**

Both survivors had undergone the full helicopter escape and survival course at the Robert Gordon Institute of Technology (RGIT), and both had subsequently attended refresher courses – in the case of Survivor A only a month before the accident. Both considered that the courses had been good value and had contributed to their survival, although the underwater escape simulator bore little or no resemblance to the passenger cabin of real helicopter.

Both survivors had had the full pre-flight briefing before leaving for their spell of offshore duty, plus short briefings before each shuttle flight. They considered that the briefings were thorough and useful, although the on-shore briefing related to the S.61 and not to the Super Puma used for offshore shuttles. Survivor A said that in the past some passengers had not paid attention to the briefings, but nowadays they were conducted in a more disciplined climate and if anyone appeared not to be concentrating the briefing was stopped and restarted. He did not feel that the tone of the briefings was likely to intimidate the average offshore passenger. Survivor B commented that the short shuttle briefings were adequate provided there was not an accident! He added that frequent longer briefings would probably be counter-productive, but that it might be better to concentrate on reminding passengers of the escape exits rather than repeating the instructions on how to don the survival suit.

### **SAFETY EQUIPMENT**

Both survivors were wearing a standard zip-up neck seal immersion suit. Like most of their fellow passengers, Survivor A had not zipped the neck fully because of the acute discomfort of the zip pressing under the chin; as a result, his suit had admitted a certain amount of water during his time in the sea. Survivor B, who was fully zipped before take-off and spent most of his survival time on the inflated ring of the raft rather than immersed in the water, remained bone dry apart from some moisture at the collar.

Unusually, Survivor A had checked the light on his Life Saving Jacket (LSJ) before departure on the accident flight. Several other passengers had followed his example and one of them, having found his light to be unserviceable, had had to try several spare LSJs before finding one with a light which worked.

Survivor A had changed from his working overalls into the casual clothing that would be worn when off-duty in the accommodation. He commented that, although aware of the importance of warm clothing for sea survival, passengers tended to be influenced by the duration of the forthcoming flight.

For shuttle flights expected to last only a minute or two, it is neither reasonable nor practical for them to don the same amount of clothing as they would for a long transit; one could become very hot and uncomfortable climbing the many steps to the helipad. Survivor B was rather better clad, with jeans, long sleeve shirt, sweat shirt and a working thermal.

## **MOBILITY**

Survivor A had been sitting in the foremost starboard seat in the cabin, and had been aware shortly before impact that the aircraft was going to hit the sea. He commented that his choice of seat would normally have been a bad one, because in the seat configuration then in use, he would have been unable to reach the jettison handle for the window at his side. In the event, the force of impact burst the window inwards, and after releasing his harness without difficulty, he was able to grasp the outside of the airframe through the window aperture and lever himself out.

Survivor B was in Seat 12 aft of the door and had had no sensation of descending until the aircraft hit the sea. The first indication was a bang and the ingress of water at the rear of the cabin. The water was up to his chest in a matter of seconds, but he had time to take a couple of deep breaths before becoming immersed. He lunged for the nearest exit, which had fortunately blown in, but was restrained by his seat belt which he had forgotten to release. While he was undoing it, two others went out of the same exit, and he then followed them. He did not see any EXIS lighting, but it was reasonably bright underwater and he was wearing safety glasses (which he lost going through the exit).

## **LIFE RAFT**

Having reached the surface, Survivor B inflated his LSJ and initially went to the undercarriage of inverted helicopter, which was still protruding above the surface. Fearing that he would be trapped under it, he then made his way to the damaged and partially inflated life raft, which Survivor A had already boarded. Because of its condition, the latter had had no difficulty in climbing aboard, but found that he had to climb to the far end to stay out of the water. Very soon the raft was overturned by a wave, and he found himself back in the water with his leg entangled with the rope securing the survival pack. He was freed from this by Survivor B, but then lost contact with the raft and the other survivors.

Survivor B, together with three others (the two aircrew and another passenger) remained with the raft and after it had been released from the helicopter they spaced themselves evenly around its circumference, rendering it fairly stable in the heavy sea. Survivor B managed to climb onto the inflated ring and clung there until rescued.

## **LSJ**

While briefly in the life raft, Survivor A had inflated his LSJ, which seemed reluctant to deploy fully until he had forced apart the Velcro securing the right-hand lobe. Back in the water, he found that the LSJ, which had no crotch strap, tended to ride up until it was tight under his chin and armpits. He was obliged to maintain a continuous paddling motion with his arms in order to keep his head above water, and had the clear impression that if at any time he had raised his arms, the LSJ would have slipped up over his head and been lost. He managed to place the strobe light on his head, where it remained secure until his rescue.

Survivor B did not experience the same difficulty with his LSJ, as he was not dependent on it for buoyancy. His strobe light was serviceable, but as soon as he put it on his head it was washed away by the first wave.

Both survivors dismissed the spray hood as depriving the wearer of sight and sound which was essential in fighting the elements and trying to keep in touch with other survivors.

## **SURVIVAL**

Although he had not been aware of cold during his escape from the aircraft, once back in the water Survivor A began to suffer badly from the cold. His hands became numb and useless, and he was unable to put on the gloves from his immersion suit. He found that he was facing down-wind, and had to battle constantly to surmount the waves which approached him from behind, often without warning. His vision was restricted to a narrow slit between the bottom of his hood and the top of his LSJ and immersion suit. He smelt and saw a helicopter, which then departed, and was occasionally able to see other survivors down-wind when he and they happened to be simultaneously at the top of the swell. He noticed that he had begun to yawn, and in retrospect believed that this indicated that he had been reaching the limit of his endurance.

Survivor B was not aware of being cold for the first half-hour, but his hands were numb and he was obliged to cling to the raft with his arms. He and his companions experienced increasing distress at the apparent lack of rescue efforts, and this had a particularly adverse effect on one of the aircrew who was still in the water and who eventually died. The other passenger was swept away (but survived). For the last 10 or 15 minutes Survivor B was on his own and was beginning to get very demoralised; he sensed the onset of hypothermia.

## **RESCUE**

Eventually, Survivor A saw, and was seen by, a rescue vessel. As it approached him, he was fearful that it would run him down, but it was manoeuvred very skilfully so that he was close alongside. A number of ropes had been lowered, but he was unable to grasp them. Believing that this might be his only chance of rescue, he managed to twist an arm and a leg around the ropes, and was finally hauled aboard. In the process, his head was banged against the side of the ship. His subsequent harrowing experience of the crew's attempts to resuscitate him during a failure of the ship's electricity supply lies outside the RHOSS remit.

Survivor B was the last to be rescued, but was in the best physical condition. He was eventually winched (using a single-strop lift) into a civilian helicopter and was returned to Cormorant Alpha. Here he was put in a warm bath and given medical attention, but soon had to give way to more serious cases. He commented on the distress caused to survivors by Tannoy announcements of the casualty status. Later he was airlifted to Lerwick, accompanied by a first aid worker; he said that if he had been in a stronger frame of mind he would have refused to go, especially as he now had no survival equipment and would certainly have perished if there had been another accident.

## **SURVIVORS' COMMENTS**

At the conclusion of his interview, Survivor A was invited to offer his views on the additional safety measures that he felt would be of greatest value. He made the following points:

- 1 The design of the LSJ issued to him was totally inadequate. It is essential that provision should be made to prevent it riding up over the survivor's body. A weak or unconscious survivor would certainly have drowned before rescue arrived.
- 2 Provision should be made for retrieving survivors onto rescue vessels in high sea-states, and in circumstances when they are scarcely able to help themselves.
- 3 Consideration should be given to the requirement for a stand-by helicopter to be permanently available for rescue purposes within the offshore field.

## **CONCLUSION**

The RHOSS Steering Group was impressed by the clarity and objectivity of both survivors' accounts, and gained the very clear impression that their survival was due largely to their own stamina and presence of mind, allied to a very large measure of good fortune. Of the two, Survivor B was somewhat better clad and was lucky to find himself in a position where he was able to remain out of the water for much of the time. This undoubtedly contributed to the length of time he was able to remain conscious and to his relatively good physical condition after rescue.

Both were fortunate enough to be close to open escape hatches through which they were able to make their exit within a few seconds of impact. It is significant that both are strong and confident swimmers who were able to remain clear-headed and in control of their breathing when under water, both in the initial evacuation from the aircraft and subsequently during their frequent immersion under heavy waves.

Finally, the value of the RGIT training and of the subsequent routine briefings was confirmed by both survivors.

## **Annex E Other Committees and Groups**

The following committees and groups are currently involved in various aspects of helicopter safety which have some relevance to the terms of reference of RHOSS.

### **1 HELICOPTER MANAGEMENT LIAISON COMMITTEE (HMLC)**

#### **CAA and North Sea operators**

To provide a forum for the mutual exchange of information and advice on airworthiness and operational matters between the CAA Safety Regulation Group and the UK offshore helicopter operators.

### **2 OFFSHORE HELIDECK OPERATIONS STEERING GROUP (OHOSG)**

#### **BHAB, BROA, CAA, IADC, OPITO, UKOOA, HSE(observer)**

To develop industry guidance on helideck operations, specifically relating to training, equipment maintenance and the provision of personal protective clothing.

### **3 HELICOPTER SAFETY RESEARCH MANAGEMENT COMMITTEE (HSMRC)**

#### **BHAB, CAA, DOT, HSE, UKOOA**

To award and monitor research contracts relevant to helicopter safety.

### **4 HELICOPTER SAFETY STEERING GROUP (HSSG)**

#### **BHAB, CAA, UKOOA, North Sea operators**

To provide co-ordinated progress to improve helicopter safety in both operational and technical matters.

### **5 OIL INDUSTRY ADVISORY COMMITTEE'S HELICOPTER LIAISON GROUP**

#### **CAA, HSE, IADC, UKOOA, Unions**

To advise on the development and operation of safety for offshore helicopter operations under the Health and Safety Acts.



## Annex F Fatal Offshore Accidents

This Annex summarises the 8 fatal accidents involving UK-operated offshore helicopters since 1976. The figures against 'Fatalities' indicate the number of deaths/the number of persons on board. Four accidents have been assessed as 'non-survivable'; in each case the impact was so severe that it would not be realistic to expect improved safety and survival measures to have resulted in any reduction in fatalities.

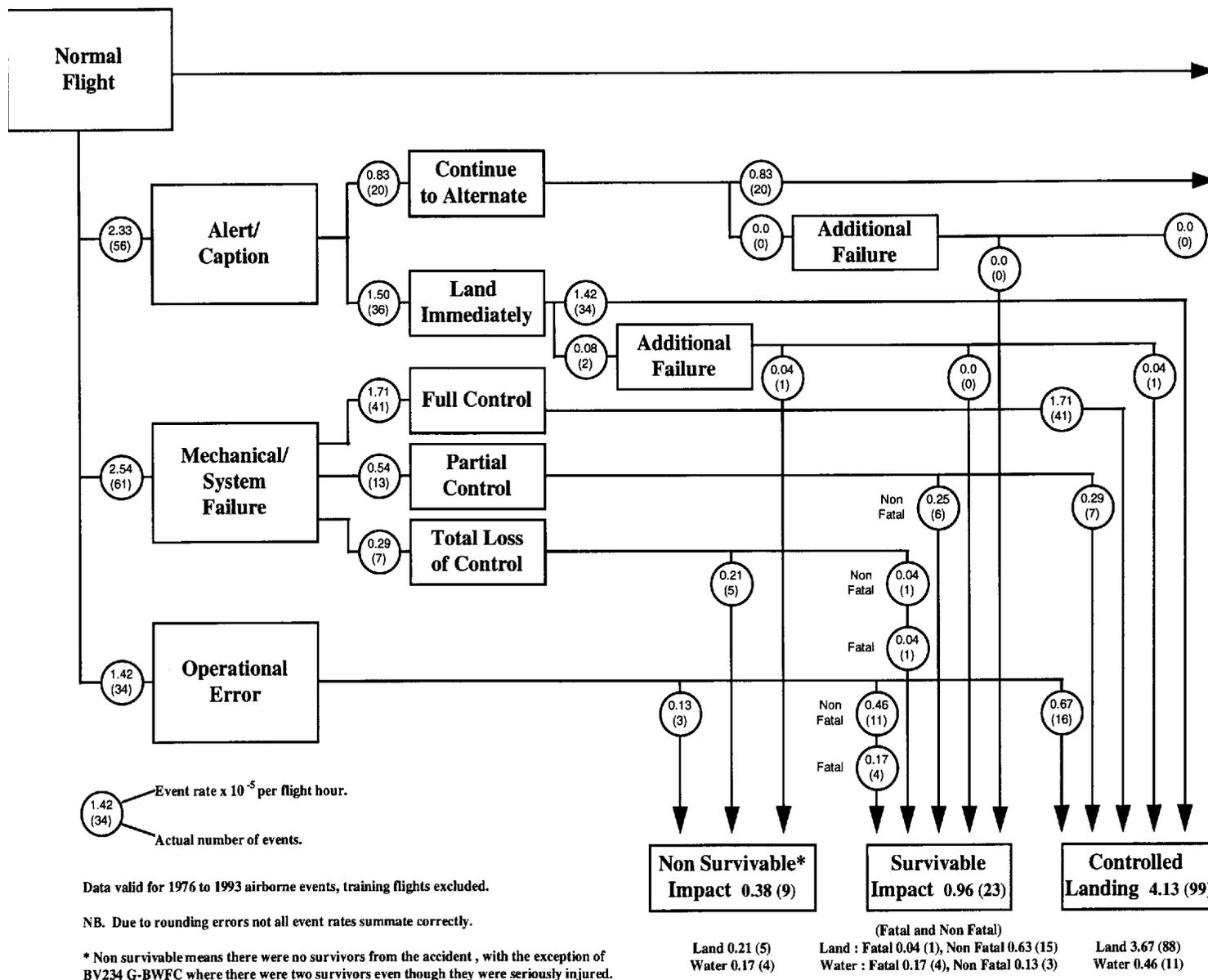
- 1 *Date:* 21/04/76      *Type:* S58T      *Registration:* G-BCRU      *Fatalities:* 1/10  
Fell into barge after forced landing on helideck following detachment of tail rotor.  
Single (passenger) fatality resulted from impact injuries and subsequent fire.
- 2 *Date:* 12/08/81      *Type:* B212      *Registration:* G-BIJF      *Fatalities:* 1/14  
Hit sea after pilot lost control in poor visibility.  
Single (passenger) fatality occurred in sea – not wearing immersion suit.
- 3 *Date:* 13/08/81      *Type:* Wessex 60      *Registration:* G-ASWI      *Fatalities:* 13/13  
Crashed into sea after engine or transmission failure.      **Non-survivable**
- 4 *Date:* 14/09/82      *Type:* B212      *Registration:* G-BDIL      *Fatalities:* 6/6  
Struck sea in bad weather at night.      **Non-survivable**
- 5 *Date:* 20/11/84      *Type:* B212      *Registration:* G-BJJR      *Fatalities:* 2/2  
Crashed into sea after mechanical failure.      **Non-survivable**
- 6 *Date:* 06/11/86      *Type:* BV234      *Registration:* G-BWFC      *Fatalities:* 45/47  
Crashed into sea following failure of rotor transmission.      **Non-survivable**
- 7 *Date:* 25/07/90      *Type:* S61N      *Registration:* G-BEWL      *Fatalities:* 6/13  
Fell into sea after striking crane jib and crashing into helideck.  
All six (two crew and four passenger) fatalities due to impact; all failed to escape from the aircraft

8    *Date:* 14/03/92        *Type:* AS332L        *Registration:* G-TIGH        *Fatalities:* 11/17

Crashed into sea following loss of airspeed in strong wind.

Five (passenger) fatalities failed to escape from the aircraft; six (one crew, five passenger) fatalities occurred in the sea after escape.

The 19 fatalities in survivable accidents give a general indication of the scope for saving lives through improvements to the safety and survival system. It is not a precise figure, as it is based upon past experience over 18 years, including accidents to aircraft types no longer in service; some of the fatalities might have been caused by impact injury which could not have been prevented, while others might have been attributable to deficiencies in the system which have already been remedied.





## **Annex H Review of Relevant Accident Data**

### **INTRODUCTION**

A total of 17 accidents, listed at Appendix 1, which were considered to be survivable or potentially survivable, have been examined. The BV234 accident near Sumburgh has been excluded as although there were two survivors, this was entirely fortuitous.

The accidents considered are mainly restricted to those which occurred in the North Sea and adjacent areas, involving common public transport types, since 1970. Earlier accidents have not been evaluated as the aircraft safety equipment standards are considered too unrepresentative.

This evaluation has been restricted to the period after ditching or impact, covering evacuation of aircraft, use of survival aids, and rescue. It does not include problems due to aircraft stability or flotation characteristics if the flotation system functioned correctly.

Problems taken into account are those mentioned in the text of each accident report, and are not restricted to those which have resulted in a Safety Recommendation by the investigating authority.

### **Problem Classification**

Survival related features have been classified as follows:

- A Flotation Gear Inflation System
- B Flotation Gear Floats
- C Sea Anchor
- D Seats/Furnishings (including seat belts)
- E Emergency Escape Means (emergency doors/windows and operating mechanisms)
- F Internal Lighting
- G Internal Communications (PA systems etc)
- H Passenger Briefing
- I Survival Suits
- J Lifejackets
- K Liferafts
- L Liferaft Equipment
- M Liferaft Deployment
- N Location Aids (lights, ADELTA, SARBE etc)
- O SAR (surface vessels, aircraft and shore organisation)
- P Communications (after impact/ditching, during SAR operations)

The performance of each feature has been examined and where problems were identified in a report, they have been classified as follows:

- 1 Damage on Impact
- 2 Damage after Impact (while in use etc)
- 3 Malfunctions due to Design
- 4 Malfunctions due to Maintenance
- 5 Deficiency in Design (inadequate performance etc)
- 6 Deficiency in Provision
- 7 Human Error (Training Deficiency) – Crew

- 8 Human Error (Training Deficiency) – Passengers
- 9 Human Error (General) – Crew (including rescue personnel)
- 10 Human Error (General) – Passengers

Design problems have been differentiated as ‘malfunction’ or ‘deficient’ depending on whether the problem actually occurred or was recognised as likely to occur.

The Matrix at Appendix 2 plots Survival Features against Problems, which allows easy identification of significant problem areas.

## CONCLUSIONS

The following areas would seem to require further evaluation:

- |   |   |              |
|---|---|--------------|
| 1 | Deficient design of liferaft deployment means | (6 mentions) |
| 2 | Deficient design of location aids             | (6 mentions) |
| 3 | Deficient design of lifejackets               | (5 mentions) |
| 4 | Deficient design of emergency doors/windows   | (5 mentions) |
| 5 | Deficient provision of SAR facilities         | (4 mentions) |
| 6 | Deficient design of seats/furnishings         | (4 mentions) |
| 7 | Deficient provision of location aids          | (4 mentions) |
| 8 | Human error of SAR personnel                  | (4 mentions) |
| 9 | Malfunction due to design of location aids    | (4 mentions) |

It is noteworthy that ‘Deficient Design’ of equipment and escape facilities provides the majority of problems. However, looking at the number of times particular aspects are mentioned gives a different order of merit, as illustrated in the bar-chart at Appendix 3.

Appendix 1 – List of Accidents

Appendix 2 – Matrix

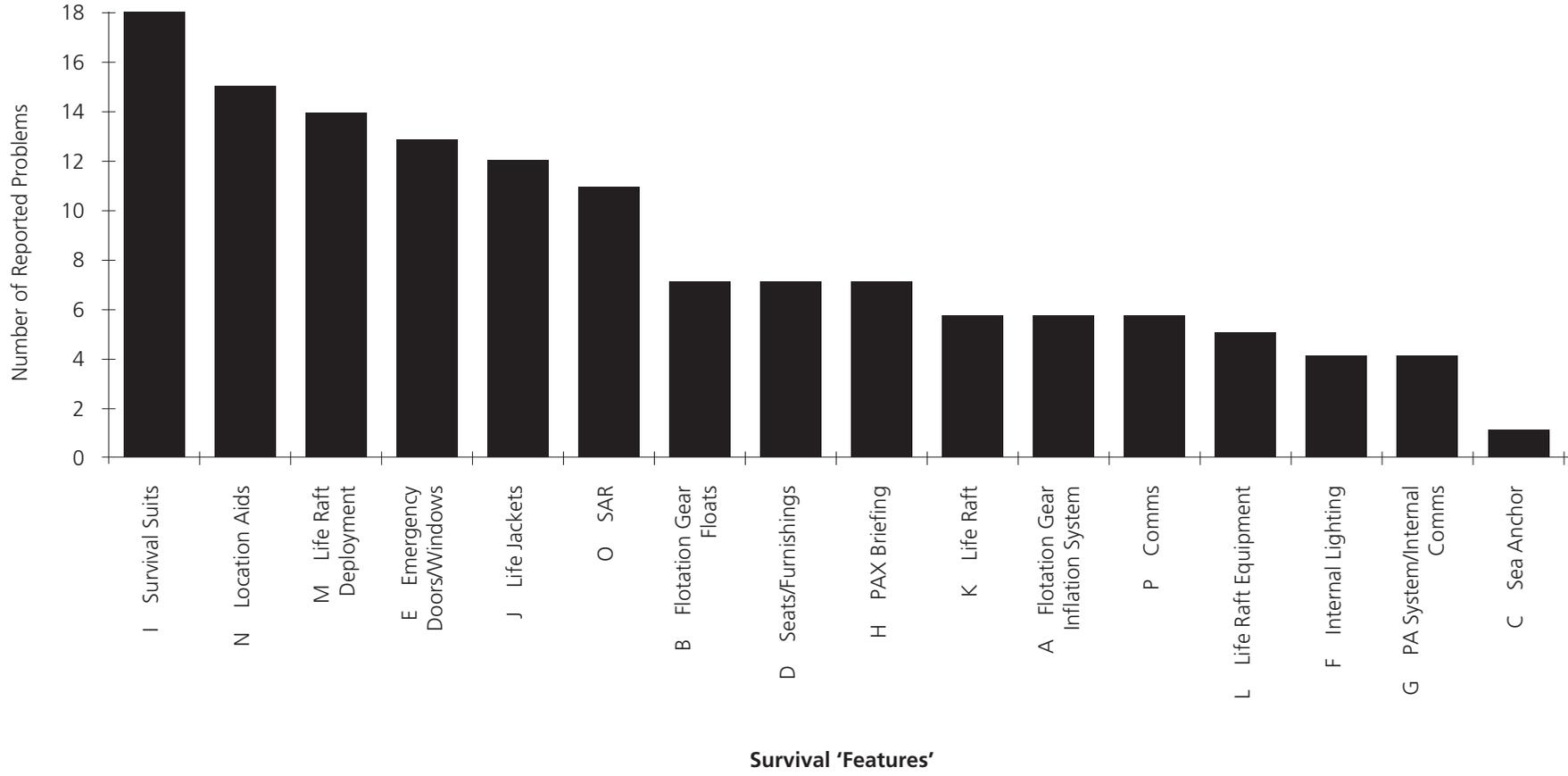
Appendix 3 – Problem Classification Bar-chart

## APPENDIX 1 LIST OF ACCIDENTS

1	WESSEX	G-ATSC	North Sea	8/3/76
2	S61	G-BBHN	North Sea	1/10/77
3	S61	G-BEID	North Sea	31/7/80
4	Bell 212	G-BIJF	North Sea	12/8/81
5	S61	G-ASNL	North Sea	11/3/83
6	S61	G-BEON	Scilly Isles	16/7/83
7	Bell 212	G-BARJ	North Sea	24/12/83
8	Bell 212	OY-HMC	North Sea	2/1/84
9	BV 234	G-BISO	North Sea	2/5/84
10	BO 105	G-AZOM	North Sea	24/7/84
11	Bell 214ST	G-BKFN	North Sea	15/5/86
12	S61	G-BEID	North Sea	13/7/88
13	S61	G-BDII	Hebrides	17/10/88
14	S61	G-BDES	North Sea	10/11/88
15	BO 105	G-BGKJ	Shetland Is	25/4/89
16	S61	G-BEWL	North Sea	25/7/90
17	AS 332	G-TIGH	North Sea	14/3/92

APPENDIX 2 MATRIX

<i>Problem</i>		1	2	3	4	5	6	7	8	9	10	<i>Total</i>
<i>Feature</i>		<i>Damaged</i>		<i>Malfunction</i>		<i>Deficiency</i>		<i>Human Error</i>				
		<i>On Impact</i>	<i>After Impact</i>	<i>Design</i>	<i>Maint</i>	<i>Design</i>	<i>Provision</i>	<i>Training Deficiency</i>		<i>Other</i>		
								<i>Crew</i>	<i>Pax</i>	<i>Crew</i>	<i>Pax</i>	
A	Flotation Gear Inflation System	2				2	1	1				6
B	Flotation Gear Floats	3	1			2	1					7
C	Sea Anchor			1								1
D	Seats Furnishings	1		1		4	1					7
E	Emergency Doors/ Windows	1	1	2	1	5		1	2			13
F	Internal Lighting					2	2					4
G	PA System/ Internal Comms			2		1	1					4
H	Pax Briefing					1	2		3		1	7
I	Survival Suits		1	2	3	3	4	2	2	1		18
J	Life Jackets		1		2	5	1	1	2			12
K	Life Raft	1	3			1			1			6
L	Life Raft Equipment		1	2		3	1	1				8
M	Life Raft Deployment	1		1	1	6	3	1			1	14
N	Location Aids			4	1	6	4					15
O	SAR					2	4	1		4		11
P	Comms					2	3			1		6



APPENDIX 3 PROBLEM CLASSIFICATION BAR-CHART



## **Annex J Event Tree**

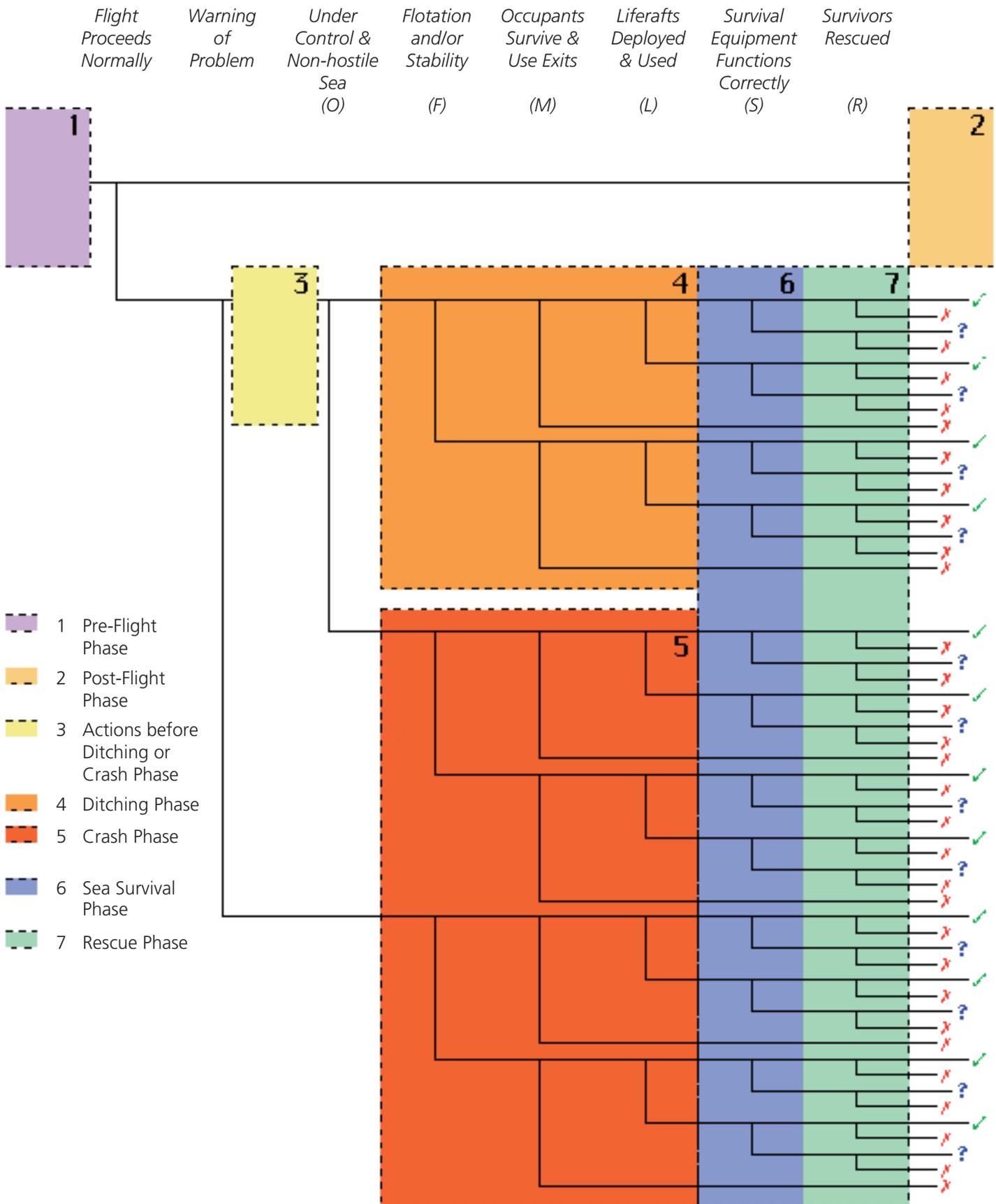
The diagram, on page 60, is a pictorial presentation of the Event Tree, described in Section 5 of the report.

The convention adopted in this Tree is that events proceed horizontally from left to right, with each failure of the system represented by a vertical line. Six of these failure 'nodes' are identified at the top of the diagram by the capital letters O, F, M, L, S and R which correspond to the specialist fields of RHOSS working groups – Operations, Flotation, Mobility, Liferafts, Survival Equipment and Rescue.

The coloured boxes represent the 7 Phases of the Safety and Survival System – Pre-Flight, Post-Flight, Before Ditching or Crash, Ditching, Crash, Sea Survival and Rescue.

At the end of each pathway, on the extreme right-hand side of the diagram, is a tick, a cross or a question mark. These indicate, respectively, that the subject will, will not, or might survive.

# Event Tree



<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
<b>PHASE 1 – PRE-FLIGHT (For Nodes, see Event Tree)</b>						
<b>1.1 Passenger Acceptance</b>						
1.1.1	Age	M	Min 18 No max.	Medical provides adequate screening for physical suitability.		None
	Size	M	Employers require			
	Fitness	M	routine medical.			
1.1.2	Training	M/S	OPITO-approved course and periodic refresher training.	Lack of feed-back from real emergencies.		OPITO to consider feed-back when reviewing training.
<b>1.2 Passenger Briefing</b>						
1.2.1	Full	M/S	Before each transit	Satisfactory	Regular review	None
1.2.2	Shuttle	M/S	Every 24 hours	May not be same type of a/c. Need to stress exits.	Regular review	UKOOA to review content of brief
<b>1.3 Wearing of Safety Equipment (Crew)</b>						
1.3.1	Immersion Suit	S	Required by ANO. CAA Spec 19.	Thermal stress. Discomfort.	HSSG considering standardisation. Research by DRA.	See 6.3
1.3.2	LSJ	S	Required by ANO as aircraft equipment. CAA Spec 5 (and in combination with survival suit Spec 19).	Satisfactory		See 6.2

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
1.4	<b>Issue of Safety Equipment (Passengers)</b>					
1.4.1	Immersion Suit	S	No legal requirement. Provided by employer. CAA assess 'no hazard'. Most meet Spec 19.	No CAA regulations. Risk of incompatibility with LSJ. Inadequate undergarments.	As for 1.3.1	CAA to consider regulation.  See 6.3
1.4.2	LSJ	S	Required by ANO as aircraft equipment. CAA Spec 5.	Spec 5 does not address combination with immersion suits provided by employer.		See 6.2
1.5	<b>Passenger Boarding</b>					
1.5.1	Seat allocation	M	By operator's staff or crew if necessary.	Satisfactory		None
1.5.2	Luggage and cargo stowage	M	Only in cabin if proper stowage available.	Current regulations satisfactory.		None
1.5.3	Strapping in	M	Supervised by operator staff/crew.	Satisfactory		None
1.5.4	Headset	M	Supervised by operator staff/crew.	Possible snagging during evacuation/escape. Some PA systems poor.	Trials of cordless headsets. HSSG PA study.	CAA to monitor  CAA to monitor
1.6	<b>Departure Criteria</b>					
1.6.1	Weather/Sea state	O	Helideck limit 60kt. One oil company has precise weather limits. Others have general guidelines.	Standard rules desirable but difficult to define.		See 7.1 and 7.2

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
<b>PHASE 2 – POST FLIGHT</b>						
If emergency in flight, go to Phase 3						
2.1	<b>Passenger Disembarkation</b>					
2.1.1	Deck crew procedures.	O	UKOOA guidelines for Helideck management.	New procedures satisfactory		None
2.1.2	Passenger route	O	Laid down by Oil Companies – depends on weather and landing direction	Satisfactory		None
2.1.3	Baggage collection	O	UKOOA guidelines	Satisfactory		None
2.2	<b>Safety Equipment – Continued Airworthiness</b>					
2.2.1	Immersion Suit (Crew)	S	ANO and Spec 19. Service/inspection requirement defined.	Present arrangements satisfactory.		None
2.2.2	Immersion Suit (Pax)	S	Employer responsible. Serviced as for aircrew.	No legal requirement		See 1.4.1
2.2.3	LSJ (Crew & Pax)	S	ANO and Spec 5. Service/inspection requirement defined.	Present arrangements satisfactory.		None

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
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**PHASE 3 – BEFORE DITCHING OR CRASH**

If no warning, go to Phase 4

**3.1 Communications**

3.1.1	External (Mayday)	O	NATS responsible for ground stations.	Northern area good. Some limitations to radio cover in central/southern area.	On-going work to improve cover.	NATS/UKOOA to continue to make improvements.
3.1.2	Internal (Warn pax)	M(S)	ANO and Ops Manual require use of PA (or PA/IFE) system.	Some PA systems poor. Audibility reduced by hoods. Possible need for 'attention getters'.	HSSG PA review.	CAA to monitor and consider more stringent requirement.

**3.2 Pre-Ditch/Crash Actions (Crew)**

3.2.1	Arm emergency systems	F	Operations manual	Satisfactory		None
3.2.2	Arm flotation systems	F	Operations manual	Automatic activation in crash desirable.	HSSG study	CAA to review requirement.
3.2.3	Prepare liferafts	L	Operations manual	Improved carriage and activation needed, including automatic release after a crash.	Limited research into methods of carriage.	CAA to sponsor comprehensive study and define specific requirements.
3.2.4	Prepare suit	S	Wearer's responsibility	Discomfort of suit in heat. Difficult to zip up and fly	DRA study	Further research into suit design.

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
3.3	<b>Pre-Ditch/Crash Actions (Passengers)</b>					
3.3.1	Fasten/tighten seat belt	M	Ordered by crew	Satisfactory		None
3.3.2	Prepare suit	S	UKOOA HUZUP guidelines.	Satisfactory		None
3.3.3	Identify exit	M	As briefed	Possible confusion over choice of exit while seat layouts are in the process of change.	Briefings tailored to specific aircraft	None
3.3.4	Adopt brace position	M	Standard brace position specified by CAA assumes use of lap strap and is based on fixed-wing crash forces.	Helicopter crash forces may be different.  Head down position may cause disorientation.  Upright posture needed for UTR.		UTR the long-term answer; see 5.1.2.  CAA to consider research into brace position for UTR.

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
<b>PHASE 4 – DITCHING</b> Controlled descent into non-hostile sea. If uncontrolled or into hostile sea, go to Phase 5.						
4.1	<b>Flotation</b>					
4.1.1	Inflation of flotation gear	F	Manual or automatic activation accepted.	Satisfactory for ditching.		See 3.2.2
4.1.2	Optimum level	F	'Dry floor' concept	Need for optimum stability.	CAA/UKOOA/DOT/HSE research	Research to be accelerated
4.2	<b>Crew Actions</b>					
4.2.1	Stop rotors	O	Operations manual	Satisfactory		None
4.2.2	Jettison exits	M	Operations manual	Satisfactory		None
4.2.3	Deploy remote-activated rafts	L	Operations manual	See 3.2.3		See 3.2.3
4.2.4	Order evacuation	M	CAP 360/Ops Manual	Satisfactory		None
4.3	<b>Evacuation</b>					
4.3.1	Evacuation drill	M	Standard training	Satisfactory		None
4.3.2	Jettison cabin exits	M	Standard training	See 5.3.5	See 5.3.5	See 5.3.5
4.3.3	Manually deploy/inflate liferafts	L	Standard training	Should require one-handle activation; no lifting.		See 3.2.3

Go to Phase 6

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
<b>PHASE 5 – CRASH</b>						
5.1	<b>Survivability</b>					
5.1.1	Seat crash-worthiness	M	Some seats of older design; some newer.	Not practicable to fit dynamic standard to existing aircraft.	Progressive refit with newer seats.	Operators to refit with best seats practicable.
5.1.2	Pax restraint	M	Standard lap strap; UTR for new aircraft.	Poor restraint against side and vertical forces. Risk of disorientation in brace position.	Progressive refit with UTR. HMLC/HSSG studying universal fitment.	CAA to review restraint criteria.
5.2	<b>Flotation/Stability</b>					
5.2.1	Hull integrity	F	BCARs/JARs define impact parameters.	Vulnerable to impact forces outside design limits.	Crashworthiness study.	Continue study
5.2.2	Flotation gear	F	Most types need to be armed and activated by crew.	No automatic inflation. Vulnerable to impact damage. Optimised for ditching.	HSSG study CAA/UKOOA/DOT/ HSE research	See 3.2.2 See 4.1.2
5.2.3	Additional buoyancy	F	None at present.	Improved post-crash buoyancy desirable.	As above	See 4.1.2

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
5.3	<b>Escape</b>					
5.3.1	Exit choice & orientation	M	Training and briefing	Pax do not always have easy access to adjacent exit. Seat configuration critical.	Operators/UKOOA trials and cabin layout revision.	CAA to review requirement for new types
5.3.2	Unstrap	M	Standard lap strap	Possible injury and/or disorientation. UTR preferable?	See 5.1.2	See 5.1.2
5.3.3	Remove	M	No specific PA system requirement.	Possible snagging	See 1.5.4	See 1.5.4
5.3.4	Move to exit	M	Training and briefing	Difficult to find in dark and/or underwater. EXIS slow to activate?	Guide rails and cushion grabs. Operators/UKOOA study.	CAA to monitor
5.3.5	Jettison exits	M	Main exits to open when aircraft upright. Push-out windows when aircraft not upright or submerged.	Acceptable, but activation non-standard between aircraft types and some hard to operate.	BHAB study of exit operation.	CAA to monitor and possibly specify
5.3.6	Escape from flooded cabin	M	Training and briefing	Very limited time under water. Breath-hold reduced by cold shock.	Research by DRA, Risk v benefit of breathing equipment.	Breathing equip't not recommended Thermal insulation beneficial.
5.3.7	Leave aircraft	M	Safety equipment design needs to minimise snagging risk.	Requirement is well-recognised.		None

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
<b>PHASE 6 – SEA SURVIVAL</b>						
6.1	<b>Liferaft</b>					
6.1.1	Inflation	L	Heliraft in general service	Satisfactory	None	None
6.1.2	Boarding	L	Heliraft ‘Double-sided’	May be difficult for small person with large LSJ.	Improvements to ramp	None
6.2	<b>LSJ</b>					
6.2.1	Security	S	CAA Spec 5	Some LSJs insecure	HSSG seeking enhanced Spec 5.	Studies to be completed.
6.2.2	Self-righting	S	CAA Spec 5	Marginal if unconscious	Ongoing studies at DRA.	CAA to review Spec 5 and harmonise it with Spec 19.
6.2.3	Buoyancy	S	CAA Spec 5	Marginal mouth free-board		
6.2.4	Spray hood	S	CAA Spec 5	Doubtful value		
6.2.5	Compatibility	S	CAA Specs 5 & 19	Not guaranteed		
6.3	<b>Immersion Suit</b>					
6.3.1	Dryness	S	CAA Spec for crew suits only	Various designs and types of seal. Need for standardisation and compatibility with LSJ.	HSSG considering standardisation. On-going research at DRA.	CAA to review Spec 19.
6.3.2	Insulation	S	No requirement at present	Thermal liner needed if clothing inadequate.	Industry development.	Oil companies to provide.
6.3.3	Hand protection	S	Gloves in suit pockets	Difficult to don		Revised Spec to include better hand protection.

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
<b>PHASE 7 – RESCUE</b>						
7.1	<b>Response Time</b>					
7.1.1	Distance. Weather. Day or night.	O	DOT review of SAR determines response time.	Finite SAR resources. Unrealistic to expect instant cover everywhere.	UKOOA study	See below
7.2	<b>Survival Time</b>					
7.2.1	Sea state. Temperature. Wind strength.	O	Oil companies' guidance to managers	No certainty survivors will survive until rescued. LSJ/survival suit use and performance critical.	Possible provision of thermal liners.	Oil companies to amplify guidance on departure criteria.
7.3	<b>Detection and Location of Survivors</b>					
7.3.1	Radio/radar. Visual. Other means.	R	ADELTA/aircrew SARBE. Sea light for all. Strobes voluntary.	SARBE/pyrotechnics not suitable for passengers.	HSE Detection and location project.	HSE to coordinate research. CAA to review sea light requirement.
7.4	<b>Retrieval of Survivors</b>					
7.4.1	Water to helicopter	R	No formal requirement	Possible incompatibility between LSJ and lift strops.		See 6.2
7.4.2	Raft to helicopter	R	No formal requirement	As above		As above
7.4.3	Water to vessel	R	No formal requirement	FRC's weather window limited.		HSE to coordinate research
7.4.4	Raft to vessel	R	No formal requirement	Equipment incompatibility.	Development of raft retrieval system.	Continue to develop system.

<i>Event</i>	<i>Element</i>	<i>Node</i>	<i>Current Requirement</i>	<i>Assessment</i>	<i>Work Being Done</i>	<i>Action Required</i>
7.5	<b>Post-Survival Debriefing</b>		No formal requirement	Need for experience to be fed back into the system.		AAIB to establish procedure for survivor interviews.



## **Annex L Breathing Aids for Underwater Escape from Helicopters**

### **INTRODUCTION**

Escape from a submerged helicopter may take longer than the time that a victim can be expected to hold his breath – especially if the water is cold. There are two main approaches to this problem. One approach is to provide helicopter passengers and crew with an underwater breathing aid; an alternative approach is to make escape so simple that it can be carried out on a single breath hold. In formulating its views on breathing aids the Group has taken into account the relative merits of these two approaches.

### **ASSESSMENT OF CURRENTLY AVAILABLE BREATHING AIDS**

The Group considered two main types of breathing aids: compressed air devices and rebreathing bags. Compressed air devices were in military service and there was limited anecdotal evidence to support their efficacy. However, there was concern about the risk of injury associated with breathing compressed air underwater, a risk that was likely to be greater amongst inexperienced users. Because of this, using a compressed air device successfully would require thorough training. But the training itself could be hazardous, particularly in a civilian population lacking the fitness and selection of the military, and there was a case for having stand-by recompression chambers and the expertise to run them available at the training centres. Of the 30,000 or more individuals requiring training only a minute proportion would ever need to use the device in a real emergency, making even a small training risk unacceptable. An additional concern was that the weight of the cylinder might lead to injury on impact and some designs were considered to be a snagging hazard. Lesser problems included the need for regular inspection and maintenance.

The Group considered that simple rebreathing bags had a number of potential advantages over compressed air devices. In particular, provided the bag was filled with only one breath, there were none of the problems associated with breathing compressed gas underwater. Being light, rebreathing bags were also unlikely to be hazardous on impact and their simplicity meant that maintenance was easy. However, no simple rebreathing bags were yet in service and the Group identified a number of drawbacks. To be used successfully some rebreathing systems required a complex sequence of manoeuvres. It was considered that frequent training would be needed for these to be carried out reliably and that this training might not be without risk. Furthermore, it was important for the subject to take a breath just before immersion which, as the Cormorant Alpha accident had demonstrated, was not always possible. Concern was also expressed that some rebreathing bag assemblies might be snagging hazards and that there might be adverse effects on buoyancy. Lastly, there was concern about the limited time that could be spent underwater on just one breath and, although there was some experimental evidence that rebreathing bags might still be of some use, there was agreement that it did not follow that there would be a net benefit in the survival situation. In particular, there was a feeling that the complex manoeuvres required to operate some bags might not be carried out successfully in a real incident and that the victim might be better off concentrating on making good his escape.

## **CONCLUSION**

The Group considered that there was no clear advantage to be gained from the introduction of underwater breathing equipment and that, on the evidence currently available, the CAA would not be justified in pursuing this as a regulatory measure.

The Group took the view that the chances of successful underwater escape might be more reliably improved by measures aimed at facilitating egress. This was consistent with the overall philosophy, set out in Section 4 of the report, that the greatest emphasis should be given to systematic improvements rather than to burdening individuals with extra personal equipment.

## **Annex M Weather Criteria**

- 1 In their investigations of the Cormorant Alpha accident, both the Sheriff of Grampian, Highlands and Islands and the AAIB considered the effect of weather conditions and sea state on survival and rescue. The Sheriff recommended the CAA, with others, to consider the restriction of helicopter flying operations in adverse weather conditions, while the AAIB recommended the Health and Safety Commission to address the need for operators of offshore installations to take account of the effects of weather conditions on the likely effectiveness of search and rescue facilities.
- 2 The logic behind both of these recommendations is as follows. Regulatory authorities recognise that ditchings and crashes, though rare, do occur from time to time, and for this reason require operators to provide a comprehensive range of safety equipment, procedures and training. However, there are occasions when weather conditions in offshore areas are such that a safe ditching would be impossible, survival time in the sea would be very much reduced, and rescue would be extremely difficult or impossible. If the safety provisions are necessary under normal conditions, it is illogical to permit flights to take place in conditions such that they would be of no avail. Therefore, it has been argued, flights should be prohibited in conditions that preclude a safe ditching or would not allow survivors to be rescued.
- 3 The counter-argument runs as follows. There is an element of risk in all forms of transport, but it is considered 'safe' when the risk is assessed as being at an acceptably low level; occasional accidents, tragic though they are, do not invalidate this policy unless they occur at a frequency that discredits the original risk calculations. Fixed-wing public transport flights take place globally over oceanic and mountainous areas which would not permit a safe ditching or forced landing. Similarly, Group A public transport helicopters routinely fly without restriction over wooded and hilly terrain, in cloud, and over countryside covered in dense fog, where a safe autorotational landing could not be performed. Offshore helicopter operations are not radically different from other forms of rotary-winged public transport; such extra risks as they do carry (related to the hostile environment and the repeated exposure of individual passengers) are already handsomely discounted by the provision of extra safety equipment and training. Moreover, operations over rough seas are not necessarily more dangerous than similar flights over land; for example, if the Cormorant Alpha accident had occurred at an airport, it is most unlikely that anyone would have survived the impact. It would therefore be perverse to apply any restrictions to offshore flights that are not applied to other equivalent forms of public transport.
- 4 Both of the above cases are, of course, over-simplified, but they serve to illustrate the essential steps of the arguments for and against some form of weather restriction. This issue has occupied more discussion in the RHOSS Steering Group than any other topic, and has been the one on which unanimity was most difficult to achieve. Nevertheless, the following broad principles were agreed:
  - (a) The risk of a ditching is no greater than that of a forced descent over equally inhospitable terrain in non-offshore public transport helicopter flights. Furthermore, surface conditions in the North Sea vary to such an extent that it would not be reasonable to expect offshore managers to be aware of ditching conditions along the whole of the planned track. It would therefore be neither logical nor practicable to attempt to impose any restriction on offshore flight solely on the basis of weather or a sea state which would preclude a safe ditching.

- (b) Notwithstanding the above, it would not be defensible to allow flights to proceed in conditions such that, if an accident were to occur, survivors did not have a realistic expectation of being picked up alive. Therefore it is necessary to develop a procedure by which offshore managers can check that rescue services could reach the scene of an accident within the time that survivors could reasonably be expected to survive.
- 5 It was agreed that in view of the wide dispersal of offshore platforms and the great variety in offshore helicopter operations, it would not be practicable to establish a single procedure to cover all situations. Nevertheless, it was considered that, as a minimum, offshore managers should be conscious of the length of time that survivors wearing serviceable lifejackets, immersion suits and suitable clothing could be expected to remain alive in the sea at a given temperature, and of the time it would take the available rescue services to find and retrieve them. They could not reasonably be expected to take account of short-term fluctuations in the availability of SAR helicopters, nor of conditions along the whole extent of a flight from shore; however, the critical point would be the most remote part of the planned track, which would almost always be in the area of the offshore platform, where managers would be well aware of local conditions and should know how long it would take SAR services, at normal availability, to reach the scene. This issue has already been addressed in broad terms in the recent UK00A study, which posed a worst-case situation of a 4-hour rescue time and matched this to a theoretical survival time of something over 4 hours in sea temperatures as low as 4 degrees C, provided adequate thermal insulation was worn. This should be incorporated in general company instructions to offshore managers, for example in providing guidance over the circumstances under which the wearing of thermal insulation should be compulsory, and should be reflected in local instructions as appropriate to particular offshore locations.
- 6 Much experimental work has been done on immersion suit effectiveness, leak rates and body core temperatures, and the various published tables of survival times against sea temperatures have been reflected in the UK00A study. Expert opinion is not unanimous, however, and there is some suspicion that the tables are optimistic in that they are necessarily derived from experiments in safe conditions and do not take full account of the degrading effect of post-accident conditions in the open sea – for example the effects of shock and the loss of insulation due to excessive leak rates and the presence of body fluids within the suit. There appears to be scope for further research in this area which, if it were to reveal less favourable survival times than those currently accepted, might necessitate reconsideration of the conclusions of the UK00A study.
- 7 The question of the suitability of surface conditions for the retrieval of survivors was also considered. Whereas the limitations of surface rescue vessels in high sea states as well-recognised, SAR helicopters are generally capable of performing their function in any weather conditions – apart from surface fog en-route – in which offshore helicopter operations would be carried out. As in the case of rescue time versus survival time, it was agreed that it would be impracticable to lay down precise criteria, but the need to consider the ability to retrieve survivors should continue to be reflected in oil companies' guidance to their managers. It was noted that, following the Cormorant Alpha experience, a more realistic attitude now prevailed concerning the use of helicopters for other than essential purposes in marginal weather conditions.