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CAA Paper 87007

Report of the Helicopter Human Factors Working Group

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1. Introduction

In response to Recommendation 1 of the Report of the Helicopter Airworthiness Review Panel (CAP 491) a Working Group was formed to evaluate the extent to which incidents and accidents to helicopters were due wholly or in part to human factor causes, and to suggest what steps might be taken, within the limits of current technology, to minimise or eliminate those causes. The HARP Recommendation, the statement of the Working Group's task proposed by the Director General Airworthiness, and the detailed Terms of Reference of the Working Group are given in Appendix I, together with the Group's membership.

In accordance with the discussion in the HARP Report which led to Recommendation 1 the term 'human factors causes' was taken to refer only to the flight crew, and was defined as those causes in which the crew action or failure to act, for whatever reason, contributed to the occurrence or accident. However, because of the manner in which data for examination by the Group was extracted from the SDAU data base (Appendix II) a large number of occurrences under the heading Maintenance Error were produced. Under this heading were included 'Manufacturers' Errors' and 'Overhaul and Repair Errors'. The report refers to this fact in Appendix IV.

2. Working Method

2.1 Information Sources

In carrying out its task the Working Group sought information from the widest possible spread of sources to ensure that all relevant information was studied and to ensure that all points of view were considered. To achieve this objective the Group started with an examination of reported data held in various data banks. This written data was complemented by discussions with relevant bodies outside the CAA, and also by informal interviews with operational crews. The totality of the data acquired by these means has been used in arriving at the final conclusions. The data sources are shown in Appendix III.

2.2 Accident and Incident Reports

The principle source of incident reports was the CAA Mandatory Occurrence Reporting (MOR) data bank held by the Safety Data and Analysis Unit (SDAU) in which reports from crews, of incidents which they felt had in some way diminished safety, formed the main input. This data base was initiated in 1976 and as a major part of our helicopter experience has been since that date, and no organised data was available prior to that date, it was decided to limit the study to the period 1976-1984. Included in the data bank for that period were 203 reportable accidents (ie accidents involving serious injury or fatality, and accidents in which the helicopter was destroyed or seriously damaged) of which 24 were fatal. All reportable accidents are notified to the AIB and may become the subject of a factual report on a detailed investigation depending on the seriousness of the accident. About half the fatal accidents were attributable to human factors (see Table 1).

The MOR data base produced 826 occurrences for examination by the Group. These occurrence reports in general contained only a brief description of the incident, but it was possible to determine from these that only about 10% of the occurrences examined had a human factor content. This percentage reflected the breadth of the search of the data base (see Appendix II). Lack of detail in the data precluded the possibility of an analysis in depth of the causes of the occurrences, and it was fortunate that some members of the Group were able, in some cases, to fill in relevant details from their direct experience in the closure of the occurrence. With these limitations the data did point to some features of current helicopters which contributed to a significant number of occurrences.

In addition to the retrieval from the MOR data bank, computer outputs from a number of other data sources were received in response to requests from the Group (Appendix III). The descriptions of occurrences in these data were very sparse indeed so that only the broadest generalities could be stated as a result of their examination. The generalities tended to confirm the result of the examination of the MOR data.

2.3 Discussions with Outside Bodies

The Group also sought the views of the Helicopter Manufacturers and Avionics Industry, the Accident Investigation Branch, and the Army Personnel Research Establishment.

2.4 Interviews with Operational Crews

The Group felt it was important to seek the views of operational crews which it thought should be a valuable source of information, since they had first hand experience of the problems. The four helicopter operating companies at Aberdeen were most helpful in arranging for the Group to hold informal interviews with their crews on a voluntary basis. A number of crews from each of the operators talked freely with the Group and expressed their views. The discussion covered a wide range of subjects including the qualities of the machine, the cockpit environment and rostering and duty problems.

3. Summary of Results

Although the primary objective of the Group was to determine what available technology could do to minimise human error and assist the pilot in performing his task, the data available revealed other related problems which the Group felt it should not ignore. The results therefore include these additional problems not directly related to human factors, and these are presented in Appendix IV.

3.1 Avionics and Instrumentation

Indications of areas where increased levels of safety could be expected from improved instrumentation or new devices came from both the study of reports and the various discussions.

The general standard of avionics was criticised as being closer to that of GA aeroplanes than to airliners. The equipment used had not been designed for helicopters but adapted from existing fixed wing equipments, and suffered from a number of problems not encountered on fixed wing aircraft, largely due to vibration. It was also noted that interference on twin VHF installations, when both boxes were in use, was not uncommon.

3.1.1 Navigation Assistance

There has been a relatively large number of incursions into controlled airspace, usually by small single pilot helicopters navigating by map reading.

The principle causes of these incursions are the difficulty of carrying out navigation tasks whilst also flying the helicopter, and the lack of simple navigation aids. The effort required to maintain straight level flight of an unstable helicopter with no rotor governor occupies a large part of the pilot's attention and he is consequently less able to cope with a difficult navigation problem. Improved stability characteristics and, where appropriate, provision of rotor speed governing should enable the pilot to fly 'hands off'. The provision of a simple form of height hold and heading hold would also greatly reduce this source of error. Because of these difficulties pilot training should be aimed at producing a higher level of capability than appears to be currently achieved. Even on some larger twin engined helicopters, where the ability to fly 'hands off' would go a long way to reduce workload and discomfort, particularly on long sectors, heading and height hold facilities are not always provided (see 3.1.10). The navigation task could also be eased by the use of aids which are common on most fixed wing aeroplanes, and the installation of these aids should be encouraged.

3.1.2 Low Visbility Rig Approaches

It is common practice to rely on weather radar to make approaches to rigs in conditions of low visibility. Although the details of the procedure differ from one operator to another, they all involve descending to a decision height at a safe distance from the rig, closing to some minimum distance using the weather radar until visual contact is established, and then ascending to platform height for a landing. The accuracy of weather radar at ranges as low as 0.5 miles or less is questionable since they were neither designed nor intended to provide precision at such short ranges. Manufacturers have been unable, or unwilling to issue data on the accuracy to be expected at these very short ranges. There are a number of error sources which could be cumulative, including loss of calibration, inaccurate positioning of the radar image on the screen, reflections from parts of the structure beyond those closest to the helicopter etc, which could (and did) mislead a crew into approaching so close to the rig as to make avoidance very difficult. If weather radars are to be used for this purpose consideration should be given to their being specifically tested and approved. Additionally the use of transponders, radar beacons and reflectors should be evaluated. Operational solutions to increase the safety margins are obviously possible, but would inevitably involve an operational penalty.

3.1.3 Engine Health

Power assurance checks are carried out using the normal engine instruments. These instruments are often small and difficult to read accurately but adequate for the power check. In emergency conditions, however, where one engine is malfunctioning, the information presented to the pilot on many helicopters does not always enable him quickly and easily to identify the malfunctioning engine. The difficulty can be compounded if the torque of the malfunctioning engine is fluctuating causing the good engine also to fluctuate. In such situations corrective action can be delayed, or even the wrong action can be taken. A solution to the problem would appear to be a small 'on board' computer accepting the necessary engine parameters which could rapidly and reliably decide when either engine was malfunctioning and given an appropriate indication or warning. Such a device could probably also be extended to provide a more reliable simple and accurate power assurance check.

3.1.4 Fuel and Oil Gauging

Fuel gauging is generally poor and inaccurate, particularly on the small helicopters, where a significant number of cases or running out of fuel have occurred. In addition to more accurate fuel gauges a separate 'low fuel' warning is desirable. Pilot workload, from the point of view of fuel management, could also be reduced by fitting fuel flow meters which are generally available but, on many helicopters, not fitted. More sophisticated fuel management systems are becoming available.

Oil contents gauges are generally not fitted on flight decks, and loss of oil through leakage or any other cause can go undetected. The provision of a 'low oil' warning on the flight deck should be considered.

3.1.5 Landing Gear

Many short sectors are flown without retracting the gear and as a result pilots have failed to extend the gear for landing on some flights when it has been retracted. A gear-up warning properly related to the operational procedures should avoid this problem.

3.1.6 Wheel Brakes

Landings from the hover are normally made with wheel brakes on, with a consequent danger of performing a run-on landing with brakes still applied. Consideration should be given to the provision of a suitable 'brakes on' indication.

3.1.7 Loading Indication

The performance of helicopters, particularly when operating from oil rig platforms, is such that there is little margin for error. The possibility of becoming airborne with a gross weight error endangers the operation. A number of cases of gross loading error have occurred and a direct means of measuring load should be sought.

3.1.8 Intake Blockage

Several incidents and one accident have occurred through a loss of power due to blockage of the engine intakes for a variety of reasons. Blockage of the intake sufficient to cause loss of power should result in significant pressure changes in the intake. These pressure changes should be able to drive a warning device before the power loss becomes critical in cases where the blockage is progressive.

3.1.9 Autorotative Landing Guidance

Autorotative landings require precise judgement and are extremely difficult to perform particularly in emergency situations where the pilot needs to take account of external factors as well as controlling the helicopter. Even in training where it is most probable that the autorotation is anticipated and the weather and visibility reasonably good there has been a significant number of occurrences. The height at which to start the flare depends on rate of descent, forward speed, weight and surface conditions. Some guidance (from a computer receiving those parameters) would be desirable for daytime operations, but the greatest benefit would be at night or in poor weather conditions.

3.1.10 Automatic Stabilisation Systems

A criticism of some autostabilisation systems currently in operation was the inadequate redundancy provided in relation to the handling qualities following a first failure. With the increased sector lengths now being flown crews may have to cope with these degraded handling qualities for considerable periods. Consideration should be given to amplifying the requirements which relate the reliability of autostabilisation and associated systems, eg hydraulic and stick trim systems, to the handling qualities following failure, taking account of the long sector lengths and the operating conditions which may be encountered.

Coupled modes which enable the helicopter to be flown 'hands off' greatly reduce the pilot workload and hence fatigue, which would be particularly valuable on the longer sectors. Although coupled modes are available as an option on some autopilots this equipment is not always fitted.

3.1.11 Loss of Rotor rpm

Loss of rotor rpm can lead to situations from which recovery may be difficult or impossible. Consideration should be given to providing a warning of loss of rotor rpm on helicopters not now having this facility. It has been suggested that a collective shaker would be a useful back up to other warning systems, and could also provide some degree of protection against dangerous rpm loss. Its potential should be investigated.

3.2 Design Detail

The points raised under this heading are primarily concerned with the impact of particular design features on the crew.

3.2.1 Windscreens and Windscreen Wipers

Windscreen wipers are poor in general and have been compared unfavourably with those fitted to fixed wing transports or even cars. The large range of conditions over which the wipers have to operate poses considerable design difficulties, which are aggravated by windscreen curvature. With airflow conditions over the windscreen varying enormously from hover to cruise, and the need to cope with light drizzle, heavy rain, sea spray etc. the control of wiper pressure and direction of screen washer spray are major problems.

Research by industry into these problems has indicated promising approaches to the elimination of some of these difficulties, in particular the attachment of the washer spray bar to the wiper blades has been shown to cope with the more adverse conditions of flow over the windscreen. Further research and development should be pursued.

3.2.2 Heating and Ventilation

Ventilation and temperature control is bad on many helicopters. The general discomfort to the crew due to solar heating is greatly increased when immersion suits are worn. Although air conditioning systems are available on most helicopter types they are heavy and expensive and therefore involve a very high economic penalty. The provision of air conditioning on the flight deck alone could be achieved by suitable adaptation of the light weight and relatively cheap systems which are common on many general aviation aeroplanes. This is a possibility which should be examined.

3.2.3 Rainwater Leaks

Most flight decks leak badly in flight through rain. The resultant damage to avionics systems and documents, crew discomfort etc are hazards. This situation should not be allowed to persist, it is a design/maintenance problem and should be tackled as such.

3.2.4 Noise and Vibration

The levels of noise and vibration to which the crews are exposed appear to be accepted as inevitable, but it is recognised that they contribute to crew fatigue which is a major problem. An operational research programme on these problems is currently in hand by the Medical Section of the CAA in conjunction with NASA. The reduction and suppression of vibration has been, and continues to be the subject of a number of research programmes.

3.2.5 Seats

Of all the points of criticism raised by the operational crews the discomfort of the seats attracted by far the greatest attention. Some research carried out by industry has shown that if one is constrained to remain seated for long periods, then any seat, even the most comfortable armchair, will get progressively more and more uncomfortable after about 4 hours.

However, some seats become uncomfortable much earlier, and the factors responsible include:-

- Vibration transmission characteristic
- Lack of arm support
- Lack of thigh support
- Lack of adjustable seat back angle
- Load spreading of seat cushion
- Inadequate fore and aft adjustment.

Improved seats incorporating some or all of the desired features are available for several types of helicopters as optional extras, but in many cases, these have not been fitted.

Operators should be encouraged to fit seats providing a level of comfort commensurate with the sector lengths being flown.

The subject of seat comfort was researched by Industry some years ago. The results of this work should be reviewed and any further research seen to be necessary to form the basis of new requirements for crew seats should be carried out.

On a number of occasions unwanted movement of seats has occurred. Positive seat locking should be guaranteed.

3.2.6 Pilot's View

Due to the nose high attitude at low speed and the high instrument panel coaming the view on one particular helicopter is restricted and becomes marginal on some rig approaches. This is a long term design consideration, and should be covered by appropriate requirements.

3.2.7 Space and Stowage

Adequate space for essential documents within reach of the crew is lacking on most helicopters. There is also a stowage and handling problem for the large amounts of paperwork required on each sector. Flight deck space is very limited on most helicopters, but it may be possible on some to introduce useful modifications to alleviate this problem.

3.2.8 Crew Clothing and Equipment

The snagging of crew clothing, life jackets etc., on switches and controls represents a permanent hazard on the flight deck. There is no formal control over this interface in the civil field but in the military field this interface is closely regulated. It merits attention in civil helicopters, particularly in view of the special clothing worn by crews on North Sea Operations.

3.2.9 Collective Friction Control

There is a dangerous tendency for some collectives to drift up or down when not held by the pilot. This is a problem of both friction adjustment and collective balance, and is a design feature which could be improved both in terms of its initial characteristics and its consistency in service.

3.2.10 Labelling Terminology

The terminology used in labelling controls and switches is not always consistent. The words used do not always relate clearly to the configuration selected, eg some rotor brake controls and some hydraulic switches.

3.2.11 Tail Rotor Failures

Existing emergency procedures following tail rotor control or drive failures are often inadequate. Suitable procedures for existing aircraft should (where they are lacking) be devised for inclusion in the Flight Manual and where possible incorporated in the training programmes for the type.

For future helicopters the design of the tail rotor and its controls should be improved, for example, failures leave the rotor at a known fixed pitch.

3.3 Operational Considerations

Since the bulk of UK helicopter operations take place over the North Sea the comments in this section arise mostly from that area. A number of operational considerations which are commented on below, such as meteorological information, helideck turbulence etc have not changed much since North Sea Operations started, but in recent years there has been a significant increase in the sector lengths being flown which has made pilot fatigue a dominant consideration.

3.3.1 Flight Deck Environment

Flight deck design deficiencies identified in paragraph 3.2 above mean that helicopter flight crews are often at a disadvantage in the conduct of their task compared with crews on a fixed wing aeroplane of similar seat/range capability. Where these deficiencies combine together in one machine and additionally, as on the North Sea, the crews fly long sectors in protective clothing, the disadvantages may be severe.

3.3.2 Meteorological Data

The provision of accurate meteorological information to North Sea helicopters is probably more critical than in fixed wing operations, but the equipment and facilities are generally to a lower standard. In addition the gathering of data on the rigs is often a secondary task for untrained personnel who have other duties. Advance information on the conditions prevailing at destination would be of considerable help to crews. The provision of a North Sea Volmet could satisfy this need.

3.3.3 Helideck Turbulence

The problems due to rig induced turbulence and hot turbine efflux have been known since helidecks became operational. Their characteristics are assessed by means of wind tunnel models, but the read across from model to fullscale is not clearly established nor is the overall effect on the helicopter of helideck turbulence. Pilots generally are familiar with the characteristics of the rigs to which they operate and know which are the wind conditions which cause problems. To be aware is half the battle, if the correct wind data is available. But there remains a problem of large variations of wind vector and transient temperature changes over the deck resulting in a current operational problem. The effects of turbulence on the helicopter are primarily a question of performance and these need to be quantified.

3.3.4 Paperwork

The amount of paperwork to be dealt with by the crew becomes excessive on the short inter rig flights on the North Sea. This usually involves the non handling pilot acting as a clerk rather than performing his correct monitoring task. The implications for safety are evident. Some other means of dealing with the "housekeeping" should be sought.

3.3.5 Scheduling and Flight Times

Pressure on operators results in an unusual scheduling pattern which is not specifically addressed in CAP 371. This gives rise to a number of problems when the rules given in CAP 371 are used. For example, typical early starts which the oil companies demand, require crews to be in their immersion suits at 6.00 a.m. in the cockpit at 6.15 a.m. with little chance of leaving the cockpit until arrival back at base 7 hours later. This procedure can be repeated on 4 or 5 successive days disrupting sleep patterns and leading perhaps to extreme fatigue.

A recent review* of duty times achieved in North Sea helicopter operations in 1984 concluded that a 20% reduction in the limits on annual, 28 day and daily flying hours would produce no significant change in actual duty time achieved. The report further concluded

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* Survey of Flight and Duty Times Achieved in North Sea Helicopter Operations in 1984 Report dated 7th February 1985 (ref 10A/21/08) prepared for the Flight Time Limitations Panel by Flight Ops.

that "It seems unlikely that the main cause of, or remedy to, any current disquiet of North Sea helicopter pilots will be found in CAP 371". The disquiet which does exist amongst crews is due largely to fatigue and the prospect of continuing at the same high level of stress into the foreseeable future. Some effort is necessary to resolve this problem.

4. Recommendations

Arising from its work the Group makes the following recommendations which are divided into those matters for which the Group feels that changes to Airworthiness and Operational Standards are considered to be appropriate, and others which the Group considered should be encouraged but not necessarily made mandatory. However the Group recognises that further detailed consideration is needed before proposals for such change can become CAA policy.

4.1 Airworthiness Standards

4.1.1 Low Visibility Rig Approaches

If weather radar is to continue to be used for low visibility rig approaches, then consideration should be given to requiring each equipment so used to be specifically tested and approved. Its accuracy and suitability should be established at the ranges to be used and all error sources taken into account. The use of transponders, radar beacons and reflectors should be evaluated in a suitable research/development programme (see 4.2.1).

4.1.2 Automatic Stabilisation Systems

The requirements which relate the reliability of autostabilisation systems to the residual handling qualities following a failure should be amplified. Research work, probably in simulators to establish acceptable levels of handling characteristics in relation to the probable duration of the flight, will be necessary.

4.1.3 Flight Deck Environment

During certification more account should be taken of the levels of noise and vibration, and the control of temperature on the helicopter flight deck.

4.1.4 Crew Seat Design

Some past research work on the optimisation of seat design should be resurrected and pursued possibly to form the basis of new requirements for crew seats.

4.1.5 Locking of Crew Seats

Positive locking of crew seats must be guaranteed. The relevant requirements and their application should be reviewed.

4.1.6 Labelling Terminology

A greater degree of consistency should be achieved in the terminology used in labelling controls and switches.

4.1.7 Document Stowage

Improved means of stowage for charts, manuals and other documents should be required on all future types, and such changes as are practicable made to existing types.

4.1.8 Collective Control

The ability to release the collective control without the possibility of it drifting should be required.

4.1.9 Pilot's View

The requirements for the pilots view from the flight deck should be amplified taking account of the nature of helideck operations.

4.1.10 Windscreen Wipers

The requirements relating to windscreen precipitation clearance should be strengthened so that more effective windscreen wipers are provided, and where appropriate windscreen washers.

4.1.11 Engine Malfunction Indication

The possibility of developing a dedicated on board computer to give rapid and reliable indication of engine malfunction on twins should be pursued.

4.1.12 Fuel Gauges

Improved fuel gauging should be required, and the provision of fuel flow information should be encouraged.

4.1.13 Low Fuel, Oil, Hydraulic Fluid Warning

Warning devices to indicate a low state of fuel, oils and hydraulic fluid should be developed with a view to upgrading standards, and included where practicable on existing helicopters.

4.1.14 'Brakes On' Indication

A suitable 'brakes on' indication should be required, and where practicable should be provided where not already fitted.

4.1.15 'Gear Up' Warning

A suitable 'gear up' warning should be required, and where practicable should be provided where not already fitted.

4.1.16 Rainwater Leaks

The elimination of rain water leaks on flight decks which is a design/ maintenance problem, should be investigated.

4.1.17 Low Rotor Speed Warning

A warning of loss of rotor rpm should be required and where practicable should be provided where not already fitted.

4.1.18 Tail Rotor Failures

The emergency procedures specified in Flight Manuals for tail rotor failures should be reviewed, and the requirements relating to the design of the control systems should be improved.

4.2 Operational Standards

4.2.1 Low Visibility Rig Approaches

The definition of acceptable operational procedures for a given level of weather radar equipment performance will also require a development programme.

4.2.2 Compatibility of Crew Clothing and Equipment

A procedure for assessing the compatibility of crew clothing and equipment with the flight deck should be developed to reduce the likelihood of snagging switches or controls.

4.2.3 Meteorological Information

The means by which essential meteorological information is provided to crews should be reviewed.

4.2.4 Helideck Turbulence

The magnitude and characteristics of helideck turbulence and its effect on the performance and handling of helicopters needs to be assessed to enable suitable operational rules to be established. The two aspects of this problem will require separate research programmes.

4.2.5 In Flight Paperwork

Some means of relieving the crew of the burden of in flight paperwork should be sought, and necessary changes to requirements introduced.

4.3 Other Recommendations

4.3.1 To enable pilots to carry out navigation tasks helicopters should have 'hands off' flight capability comparable with equivalent fixed wing aircraft, provided if necessary by artificial means. (Note: The fitting of simple automatic heading and height hold functions should be encouraged).

4.3.2 The use of navigation aids to the same standards as those used on comparable fixed wing aircraft should be encouraged.

4.3.3 A direct means of load measurement, perhaps by strain gauging the rotor shaft, should be investigated.

4.3.4 A warning device to indicate intake blockage, based perhaps on suitable pressure measurements in the intake, should be investigated.

4.3.5 The possibility of providing guidance for engine off landings particularly for night flying and conditions of poor visibility should be investigated.

4.3.6 The possibility of adapting air conditioning systems, such as are currently used on general aviation aeroplanes, for use on helicopter flight decks should be investigated.

Note: Some of the subjects referred to in these recommendations are already the subject of research or development work, and these are listed in Appendix V.

TABLE 1

The MOR data base yielded 826 occurrences for the period 1976-84, of these 203 were reportable accidents of which 24 were fatal and 14 resulted in serious injury. In all 24 cases where there were fatalities and in 9 of the 14 serious injury cases the helicopter was destroyed. The following table gives an overview of the flight phases in which the 203 accidents occurred.

	All Accidents		Fatal Accidents		Serious Injury	
Crop Spraying	51	25%			2	14%
In Flight	46	23%	19	79%	1	7%
Landing	26	13%			1	7%
Approach	21	10%			4	29%
Hover/taxi	17	8%	2	8%	3	21%
Initial Climb	12	6%			2	14%
Autorotation	8	4%				
Take-off	6	3%	3	13%	1	7%
Other	16	8%				
	203		24		14	

The causes of the fatal accidents were split equally between mechanical failures and human error, but most of the latter were operational in character eg flying into obstructions, flying in meteorological conditions for which the pilot was not qualified or pilot disorientation.

APPENDIX I

Recommendation 1 of the HARP Report:-

"That the CAA initiates a special study into the detailed causes of the significant number of helicopter accidents attributed to 'human error' to see where technology might contribute to useful improvement".

Statement of the Working Groups Task:-

"To attempt to determine, by a review of helicopter accident and incident data, areas where human error (eg crew actions/inactions, standards of flight deck equipment and warnings, flight deck ergonomics) have been a factor in the accident/incident; to propose improved design and build standards in the light of the current and foreseeable technology to reduce the risk of future 'human error' accidents. To report to the Director General Airworthiness by December 1985 at the latest".

Working Groups Terms of Reference

(1) Examine UK accident and incident records to assess -

  (a) Contributory causes
  (b) Whether any additional data given to the pilot could have helped.
  (c) Whether the cockpit ergonomics and information sources were adequate and in a suitable form.
  (d) Whether any factors external to the flight deck contributed.

(2) Examine accident and incident data from other sources in the same framework.

(3) To assess any other relevant data.

(4) To suggest directions in which improvements of existing information sources might be sought, and to suggest what new information should be given to the pilot.

(5) To suggest what physical improvements to the pilot's well being, the flight deck environment, and the sources of physical workload might be possible.

(6) To report back regularly to DGA.

Membership of the Working Group:-

Mr H D Ruben (Chairman)	Airworthiness Division
Dr R M Barnes	Medical Department
Capt. J E Ramsdale	Operations Division
Mr N Talbot	Airworthiness Division
Mr D V Warren	Airworthiness Division

APPENDIX II

WORKING METHOD OF DATA EXTRACTION FROM THE SDAU DATA BASE

Occurrences entered into the SDAU data base are described by a series of keywords. Each keyword describes one aspect of the occurrence, and each occurrence is described by as many keywords as are necessary to cover all aspects. All keywords are organised in a lexicon. A selection of occurrences on the basis of any desired keyword can be made from the data base. For the purpose of this study reported here the selected keywords were 87 PERSONNEL (Sub-groups of this keyword cover all human factors related items) and 88 FLIGHT HANDLING. In order to ensure that this limited selection included all occurrences relevant to the study a comparison was made, over a 3 month period, between the limited selection and a retrieval of all the helicopter occurrences on the data base. This comparison showed that the limited selection did include all human factors related occurrences. However, it also included many occurrences (about 90% of those selected) which were not human factors related and the Group could not overlook other factors which were seen to be the cause of significant percentages of the total occurrences examined. The Group's comments on these other factors are given in Appendix IV. The fact that only 10% of the occurrences selected had a human factor content is an indication of the breadth of the search of the data base, and is not otherwise a relevant statistic.

APPENDIX III

DATA SOURCES

All organisations which might be able to contribute were asked to make available to the Working Group all data relevant to its task. A number of positive responses were received, but in general the data lacked the detail necessary to establish whether the cause of the occurrence contained a human factor element.

Data base output was received from:-

West Germany
Sweden
NTSB
Sikorsky
US Navy

The Working Group also made visits for informal discussions with:-

Accident Investigation Branch
Aerospatiale Helicopters
Westland Helicopters
Army Personnel Research Establishment
ESASC

British Airways Helicopters	Discussion with operational crews at Aberdeen
British Caledonian Helicopters	
Bristow Helicopters	
Bond Helicopters	

APPENDIX IV

As explained in Appendix II, of the occurrences examined about 90% were not human factors related, and these were seen to include four major causes. The search of the MOR data base did not specifically address these causes so there is no guarantee that all relevant occurrences were retrieved:-

1. Crop Spraying

Most fixed wing aeroplanes used in this role, have been specially designed for the purpose. By contrast standard helicopters have been adapted by the addition of spray gear and tanks etc. the spray bars being almost the lowest point on the aircraft. There have been consequently a large number of accidents due to the spray gear touching the crop. A minimum safe height warning could alleviate this problem. Another frequent source of accidents is collision with obstacles, mostly power cables.

The fact that a quarter of all reportable accidents were due to this cause emphasises this point.

2. Training

The tuition of helicopter pilots differs from fixed wing tuition, firstly because of the inherently greater difficulty of flying helicopters, and secondly because a large percentage of tuition time is spent close to the ground. Thus, compared with fixed wing, the probability of a misjudgement is greater, and the consequences more severe. This is reflected in the large number of training occurrences. It is questionable whether the helicopters used for training are well suited to that role, and also whether training programmes are sufficiently rigorous and far reaching. For example, a number of occurrences have resulted from a rapid action by the pupil which the training pilot has been unable to correct before hitting the ground. Practice autorotative descents have also resulted in many occurrences. The ability to survive an engine failure from points on the avoid curve requires considerable expertise and experience, and is probably beyond the capability of the newly licensed pilot. Consideration should be given to supervised refresher courses for continuation training.

3. Maintenance Errors

Under this heading are included 'Manufacturers' Errors' and 'Overhaul and Repair Errors'. It was surprising to see so many occurrences caused by incorrect assembly not only in maintenance but also at the manufacturing stage. The high frequency of maintenance error occurrences reflects more on the sensitivity of helicopters than on the quality of the maintenance, but it does imply that the maintenance and inspection of helicopters needs to be to a higher standard.

4. Doors, Hatches, etc

The number of occurrences where doors etc. have become detached in flight is startling, and given the hazard potential of such occurrences it is remarkable that more serious accidents have not resulted. This is a design feature that needs to be monitored more closely.

APPENDIX V

Actions in Hand

A number of areas covered in this report are the subject of current actions either in research or development.

Vibration

The main rotor is the principle source of vibration due primarily to the inherent asymmetry of the disc loading. A number of different approaches to the reduction and suppression of vibration have been the subject of long term research programmes. Future helicopters will greatly benefit from this work, and in some cases the application to existing helicopters is a possibility.

Radio Altimeter

The fitting of radio altimeters to helicopters has now been made mandatory, although many helicopters had previously been equipped with them.

Radar Approaches

A review of approach procedures which rely on the use of weather radar is in hand by the Operations Division.

Helideck Turbulence

A comprehensive research programme addressing the two main problem areas is under discussion between CAA and Industry.

Flight Time Limitations

As an interim measure the maximum scheduled hours in any flying duty period have been reduced by 1. Further changes are under consideration.

Direct Loading Measurement

Investigation of a direct means for measuring loading is in hand at the RAE.

In Flight Paperwork

A hand held computer for use on military helicopters has been produced, and its development for civil use is possible.