THE GOVERNMENT'S RESPONSE TO THE REPORT FROM THE SELECT COMMITTEE ON CHINOOK ZD 576, HOUSE OF LORDS SESSION 2001-02. (HL Paper 25 (iii))

22 July 2002

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SECTION 1: SUMMARY

1. On 2 June 1994 an RAF Chinook Mk2 helicopter, ZD 576, crashed on the Mull of Kintyre on a flight from RAF Aldergrove to Fort George, near Inverness. All on board were killed: the two pilots, the two crewmembers and the 25 passengers. This was to have been a routine, non-operational flight, to take senior personnel of the security services to a conference. The sortie was planned in advance; it was entirely appropriate for these pilots, Flt Lts Jonathan Tapper and Richard Cook, and for the aircraft, ZD576, to have been assigned this mission.

2. An RAF Board of Inquiry (BOI) was convened following the accident and carried out a detailed investigation. RAF BOIs are established to investigate the cause of serious accidents, primarily, to make safety recommendations but, at the time of this crash, to also determine if human failings were involved. The BOI's work is initially conducted by a small number of investigating officers, in this case three, and a number of more senior reviewing officers. Reviewing officers are essential to the BOI process; they have greater experience of both aircraft operations and command. They were expressly required to apply their own experience in reaching their judgement. In this case, the reviewing officers were the station commanders of RAF Aldergrove and RAF Odiham, the aircraft's home station, as well as the Air Officer Commanding (AOC) Number 1 Group and the Commander in Chief (CinC) Strike Command.

3. The Board considered data from a number of sources, including the Air Accidents Investigation Branch and Boeing (the aircraft manufacturer).

4. The RAF guidelines in force at that time said that deceased aircrew could be found negligent only in cases where there was " absolutely no doubt whatsoever". The senior reviewing officers of the RAF Board of Inquiry, while aware of the difficulty of attributing negligence to deceased aircrew, were unable to avoid the conclusion that the pilots were grossly negligent in that the pilots continued to fly the aircraft directly towards the Mull at high speed, at low level, and in deteriorating visibility. Although various factors and scenarios had been postulated by the investigating board, none were so strong that they would have been likely to prevent such an experienced crew from maintaining safe flight.

5. Following much Parliamentary and public debate concerning the reviewing officers' conclusions, the House of Lords appointed a Select Committee to consider the justification for these findings. The Committee concluded that the reviewing officers were not justified in finding that negligence on the part of the pilots caused the aircraft to crash. **The Ministry of Defence notes the Committee's report, but does not accept its conclusion.**

The Flight

6. The flight was planned under Visual Fight Rules and the aircraft took off from RAF Aldergrove at 16:42:46 UTC (Coordinated Universal Time). Visual Flight Rules (VFR) require the aircraft to be flown a specified distance from cloud and with a

specified minimum visibility. They are set deliberately to ensure that pilots can both safely navigate, see and avoid other aircraft, and avoid terrain and other vertical obstacles. In a helicopter flying below 140 knots airspeed this requires the aircraft to remain clear of cloud, in sight of the ground, and with a forward visibility of at least 1000 metres. If the aircraft increased speed to above 140 knots airspeed, then a forward visibility of 5.5 kms is required, as well as greater separation from cloud. When flying in such conditions the pilots are responsible for maintaining the minimum requirements; this is principally achieved by navigating clear of poor weather. If pilots cannot maintain these minima then they are, by definition, flying under Instrument Flight Rules (IFR). In this case the aircraft must be flown above safety altitude for the area in which it is operating. Safety Altitude is defined as being 1000 ft above the highest obstacle in the area of operation; for the Mull of Kintyre this equates to 2400 ft. If the loss of conditions for VFR is anticipated well in advance, pilots can transition to IFR and reach safety altitude using a cruise climb. This is flown at a relatively high airspeed and consequently the rate of climb is low. If VFR conditions are lost rapidly, then an emergency climb must be flown For the Chinook emergency climb, full power is applied, and the nose of the aircraft rotated above the horizon to slow the aircraft to about 80 knots; this achieves both a higher rate of climb and also a steeper climb angle, and is the optimum method to reach safety altitude.

7. The planned route was to the Mull of Kintyre lighthouse, then to Corran near Fort William, thence up the Great Glen to Fort George. The first waypoint entered on the aircraft's navigation computer was close to the lighthouse on the western tip of the Mull. A waypoint is a position entered into the navigation computer in order to assist the pilots in following their planned route. The first waypoint entered (Waypoint A) was close to the lighthouse on the Mull. The second waypoint (Waypoint B) was at Corran, some 90 nautical miles to the north, on the western end of the Great Glen. The pilots changed their waypoint (from A, to B) only 0.81 nautical miles from the lighthouse, and some 600 metres from the cliffs on the headland. At this point they should have been aware of their relative position to the high ground ahead, given that VFR demands 1000 metres visibility; at this range they were already too late to conduct a cruise climb to safety altitude. They were also too late even to conduct an emergency climb to safety altitude. However, they were not too late to have conducted an emergency climb and just cleared the terrain head of them.

8. At 16.46 a positive fix for the aircraft at 027 degrees magnetic and 7 nautical miles from the Aldergrove radio beacon was obtained following an exchange between the crew and Air Traffic Control. A large number of eyewitnesses reported the aircraft flying very low as it headed for the Antrim coast. These sightings are consistent with a high speed low level transit towards the Mull. At approximately 1655, a yachtsman whose position was two nautical miles south-west of the lighthouse, reported sighting the aircraft at between 200 and 400 feet above the surface flying in a straight line in a level attitude towards cloud covering the Mull.

9. The SuperTANS navigation system[1], which was performing normally at power-

[1] The SuperTANS navigation computer assists the pilots in determining their position, and provides bearing, distance and time-to-go information to the selected waypoints along their route. The SuperTANS is fed with information from a number of prime navigation sources, including the satellite based Global Positioning System (GPS) as well as Doppler, which uses

down, showed ZD576 to be 0.81 nautical miles from the lighthouse when the crew released its computer from that waypoint and selected the second waypoint at Corran. This conscious change of waypoint shows the crew to be undoubtedly in control of the aircraft. The change would not have been made had the pilots experienced significant difficulty in handling the aircraft, a point which the Committee accepted. Therefore, if a catastrophic event had occured, then it would have had to have been after the waypoint change, by which time the reviewing officers determined their actions had already been negligent.

10. In evidence to the Committee the reviewing officers stated that negligence had occurred by the time the pilots made the waypoint change. If they were in cloud then flight should have been in accordance with Instrument Flight Rules (IFR). If not, then they had flouted the basic rules of airmanship by flying too fast and too close towards the cloud-covered high ground of the Mull.

11. The aircraft hit the ground at a height of 810 ft, the SuperTANS system recording an initial impact power-down time of 16:59:36, and evidence clearly pointed to the aircraft having flared[2] a few seconds before impact. Boeing has now calculated that the ground speed from the Air Traffic Control fix to impact averaged 158 kts. Any decrease in speed – for example, had the aircraft slowed down prior to waypoint change – would have had to have been met with a corresponding increase in speed at other points on the flight in order to meet the timing constraints.

12. If, however, it had been the crew's intention to slow down at waypoint change (and then turn left to hug the coast), Boeing's latest analysis shows that given a normal rate of acceleration it would not have been possible to achieve the speed conditions for the final flare if the ground speed was below 80 kts at waypoint change. Continuing to use this speed as an example, to achieve 80kts, an average cruising groundspeed of 161 kts from the Air Traffic Control fix to waypoint change would have had to be achieved. To decelerate prior to the waypoint change, the aircraft would also have had to be flared at an approximately 10 degrees nose up, that is above the horizon, and maintained in this position for more than 20 seconds. The start of such an action would have been almost directly above the yachtsman yet he had reported the aircraft to be in level flight.

Technical Hypotheses

13. Assuming, again for argument's sake, that the aircraft was flying at just 80 kts at waypoint change, could some involuntary action have prevented the pilots from turning as suggested, causing its nose to lower to an accelerating attitude, which it then held for a considerable period of time, with full power being applied? If this happened it left no trace, and yet still permitted the final flare to be carried out just before impact. In our view this scenario is not plausible.

14. The Committee considered various hypotheses involving technical

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radio waves bounced off the earth's surface to determine motion, and hence position, of the aircraft. The SuperTANS, therefore, maintains a high degree of accuracy.

[2] **Flare.** A rapid change in pitch angle of the aircraft, either to slow down or climb quickly.

malfunctions, and noted in their report that both reviewing officers had accepted that the possibility of a control jam or other malfunction could not be disproved.

15. Several different theories about control jams were put forward, including the possibility of some loose article jamming the controls during steady flight. To be catastrophic this would require loss of control of all four axes[3] simultaneously, and the system's design and construction are such that this is virtually impossible to occur as a result of component failure. Furthermore, air conditions during the flight were turbulent and the handling pilot would have been constantly making control inputs and adjustments. Moreover, the Automatic Flight Control System (AFCS) constantly makes minor control inputs, so it is not possible for a catastrophic failure to remain unnoticed in flight, especially prior to the waypoint. In any event it is implausible to suggest that this then cleared itself before the final manoeuvre and left no trace.

16. The Committee noted that the AAIB investigation had found four fine metal slivers on one of the servo screens of the Integrated Lower Control Actuator. But servo screens are filters that are designed to capture debris of this type, and analysis of a fluid sample showed it would normally be considered fit for further use.

17. The AAIB were also unable to exclude the possibility of pre-impact detachment of the thrust balance spring attachment bracket and other inserts, which on post-accident examination, they found had become detached. Because the controls are hydraulically powered, this would result in a change in the feel of the controls in the pilots hands and is detectable. The aircraft is still controllable – and moreover the AAIB report indicated that the brackets were likely to have become detached during the post-accident break up of the aircraft.

18. The Committee acknowledge the position of the Ministry of Defence concerning Boscombe Down's decision not to authorise further Chinook Mk2 flight trials in June 1994 was made against a background of several engine control system malfunctions that had occurred on the ground during start up checks, which at the time had not been explained to their satisfaction. This clarification was accepted by Boscombe Down in October 1994 and test flying was recommenced without any changes to the FADEC[4] (Full Authority Digital Engine Control) system.

19. The Ministry of Defence has never denied that problems arose in the development of the FADEC software, but we reject any suggestion that the aircraft was introduced into service before it was ready. The weight operating restriction was adopted as a precautionary measure to ensure that the Chinook remained within the safe, single engine flight regime. The BOI also noted that the Chinook Mk2 had experienced a number of FADEC malfunctions, but found no evidence that any had

[3] The Chinook has four axis of control: roll, pitch, yaw and thrust. The pilots select the appropriate control input using a 'cyclic' stick and a 'collective' lever; these controls are analogous to a joystick and throttle in a conventional aircraft.

[4] **FADEC**. The principle difference between the Chinook Mk1 and Mk2 helicopters was the upgrading of the engine control with FADEC. Included in the FADEC system are 2 Digital Engine Control Units (DECUs). These computers are software controlled and allow the engine to be operated to more precise limits and, therefore, more efficiently and more reliably than mechanical based fuel controls.

occurred on ZD576's final flight. Indeed, all available evidence indicates that the engines were working normally up to the point of impact.

20. We welcome the fact that the Committee was satisfied that the E5 fault (the fault code displayed during the 1989 "Wilmington incident", and also found in ZD576's computers following the accident) is of no relevance.

21. The Ministry of Defence has examined all the alternative hypotheses put to the Committee by witnesses, but remains of the view that they are implausible, as none stands up against the known facts. All the evidence, compels the conclusion that this accident was caused through flying at a consistent high speed at low level into poor weather that the pilots had been warned to expect. The inescapable conclusion, therefore, is that this accident was a controlled flight into terrain.

Weather

22. The Committee also considered more detailed evidence given by the yachtsman, Mr Holbrook, as to weather conditions at sea to be of considerable importance in determining whether or not the crew could have visually identified the waypoint or the Mull. There are variations between the evidence given by Mr Holbrook to the BOI, to the Scottish Fatal Accident Inquiry, and to the Committee. We accept that from his yacht he could see breakers on the coastline, a point he made to the and his statements confirm that the whole lighthouse structure was not visible.

23. What is clear is that before the flight the pilots had received meteorological information, which warned of poor weather conditions in the vicinity of the Mull. All 10 eyewitnesses on the Mull reported the weather as being generally foggy and very bad. The lighthouse keeper estimated visibility to be 15 to 20 metres at most. Consequently, the investigating BOI also considered it most unlikely that the crew had visually identified the waypoint or the Mull. The Ministry of Defence's view is that the negligence finding is not dependent upon whether or not the crew could see the Mull at the time of waypoint change, or as they passed the yachtsman. What is clear is that at some point the aircraft entered cloud, which the pilots had been warned to expect, and that it did so well below safety altitude, at high speed and heading for high ground. As they approached land the pilots should have been aware that their visibility was about to reduce significantly. The finding of negligence is accordingly based upon the incontrovertible fact that they failed to take avoiding action and, despite detailed analysis, the Ministry of Defence can find no other plausible explanation.

Standard of Proof

24. The Committee concluded that the required standard of proof of negligence ("absolutely no doubt whatsoever") was not met, observing that this imports an even higher standard of proof than that applicable in criminal cases.

25. The Ministry of Defence remains of the view that the Reviewing Officers were fully justified in their conclusion and that there was evidence supporting their conclusion to the requisite standard of proof. As part of their assessment the reviewing officers in such cases were required to consider all of the evidence as a

whole before reaching a judgement and call on their own experience of military flying, and the high standard of airmanship required of RAF pilots. If this left them with no honest, or genuine, doubt that the aircrew had been negligent, it was their duty to find accordingly. It would be wrong to avoid such a finding on the basis of hypotheses for which there was no evidence and which were wholly implausible when tested against the known facts.

26. No investigation into a serious accident can ever answer every question with cast iron certainty. Negligence can operate either alone or in conjunction with other factors to cause an accident. In a case where there were deceased aircrew, the relevant Departmental guidance required the reviewing officers to be in no doubt whatsoever that their negligence was a cause (although not necessarily the sole cause) of the accident. In this tragic case, all the known facts point to that one inescapable conclusion.

SECTION 2: CHRONOLOGY OF THE FLIGHT

Chronology of the Flight

1. Chinook ZD576 was on a routine transit flight from RAF Aldergrove to Fort George, near Inverness. The flight plan indicated a route to the Mull of Kintyre lighthouse and then a course change to port on a track to the western end of the Great Glen. The first waypoint, or landmark, the pilots entered on the on-board navigation computer was the lighthouse on the western tip of the Mull, and the next was at Corran some 87 miles to the north. While most of the route was suitable for flight under Visual Flight Rules (VFR), the pilots were warned to expect poor weather in the vicinity of the Mull.

2. Chinook ZD576 took off from RAF Aldergrove at 16.42 UTC (Coordinated Universal Time), using the southerly aligned runway. The surface wind was reported as 10 knots from 170 degrees magnetic; the forecast wind for the area of the North Channel was 12-18 knots from 150 degrees at the surface, and 25 knots from 190 degrees at 2,000ft. This would have affected the ground speed of the aircraft, which is calculated by adding the tailwind component to the cruising airspeed set by the pilots.

3. After take-off the aircraft turned right on to its requested track of 027 degrees. At the request of Air Traffic Control, the crew reported leaving the Aldergrove control zone at 16:46:24; the Controller's statement reported the aircraft at 027 degrees and 7nm from the Aldergrove VOR (VHF Omnidirectional Range) radio beacon. This information provided a positive fix for the aircraft.

4. A large number of eyewitnesses between Aldergrove and Carnlough, on the Antrim coast, reported the aircraft flying very low, typically at 100 ft above the ground. The aircraft's sighted position, heading, height and speed were all consistent with a high speed low level transit on the planned track towards the Mull.

5. At approximately 1655 UTC, a yachtsman, Mr Holbrook, reported sighting the aircraft, recording his position as "2nm south-west of the lighthouse". The aircraft was "between 200 and 400 ft" above the surface in a "level attitude" and flying "in a straight line and in level flight and was proceeding towards . . the cloud localisation covering the Mull". Understandably, Mr Holbrook had no means of verifying his estimate of speed; however, his best estimate was "somewhat faster than Sea Kings in level flight", which he later clarified to the Select Committee as between 60-80 knots. Sea Kings normally operate at 100-110 knots.

The Waypoint Change

6. Data extracted from the SuperTANS navigation system, which was performing normally at power down, showed that when the aircraft was 0.81 nautical miles from the first waypoint at the lighthouse (and 0.95 nautical miles from impact), the crew released the computer from its fix on the lighthouse. They set it to indicate the bearing and distance to the next waypoint at Corran. This conscious change of waypoint, which requires three deliberate acts by the pilots, is significant as it indicated that the aircraft was undoubtedly under the control of the crew at that time. The change would

not have been made had the pilots been experiencing significant difficulty in handling the aircraft, a point which the Select Committee accepted *(para 163).*

7. Owing to what was almost certainly a small plotting inaccuracy on the part of the crew, the first waypoint was in fact displaced some 280 metres to the south-east of the lighthouse. As a result of a further small inaccuracy between the Global Positioning System (GPS) position and true position, the aircraft's heading was taking it towards the higher ground to the east of the lighthouse.

8. From the reports of eye-witnesses on the Mull, the weather there was unsuitable for flight under VFR. On seeing the poor weather ahead, the pilots should therefore have slowed down and turned away or turned back, or they should have transferred to Instrument Flight Rules (IFR) making a rapid climb to at least safety altitude at maximum power at the same time turning away from the Mull. The Committee, however, concluded that the crew had probably seen the land mass at or before the waypoint change, and that they did not intend to overfly the Mull under IFR but rather meant to fly to Corran under VFR by skirting the Mull to the west *(Para 7).* Although there is no evidence to support or disprove this suggestion, had the pilots been able to see the Mull landmass at or before the waypoint change, they would have appreciated that they were displaced to the east and also how perilously near they were to the high ground. Of course, this would not have been apparent to the pilots if, as the investigating RAF Board thought, they were in cloud and not flying VFR when they made the waypoint change.

9. In giving evidence to the Committee both the Reviewing Officers made reference to the waypoint change, stating that the negligence had occurred by the time the pilots had made the change. If they were in cloud then the pilots should have been flying in accordance with IFR. While if conditions were such as to allow them to fly under VFR, then they were flouting the basic rules of airmanship by endangering the aircraft in flying too fast, too close towards the cloud covered high ground.

10. Boeing point out that the bearing from the waypoint at the lighthouse to the waypoint at Corran is 012.45 degrees True and that at the selection of the latter, the crew would have received a left turn steering command of approximately seven degrees to make the next leg of the route. However, it is clear from the position at impact that the aircraft did not make the turn to follow the directed course to the Corrran waypoint. In fact the aircraft was also right of its original course from the Air Traffic Control fix to the first waypoint at the lighthouse. This data would seem to indicate that the pilots had made a conscious decision not to follow the directed route to the Corran waypoint.

Average Speed of the Aircraft

11. Taking account of the weather forecast for Aldergrove at the start of the sortie, the weather forecast for the immediate area of the accident, and the calculated wind speed and direction resulting from the aircraft's steering calculations, Boeing now conclude that for most of the flight the aircraft was probably flying at a relatively high indicated airspeed until the Mull coast line when it slowed slightly. However this reduction in airspeed was countered by the increase in wind strength in the vicinity of the Mull so the aircraft ground speed effectively remained unchanged.

12. Using the forecast wind speeds on the first leg of the aircraft's flight, prior to the waypoint change, a tailwind component of 9.2 knots at the surface and 24.5 knots at 2,000ft would have been present. This would have affected the ground speed of the aircraft, which is calculated by adding the tailwind component to the cruising airspeed set by the pilots. The SuperTANS navigation system recorded an initial impact power-down time of 16:59:36 and Boeing has calculated that the average ground speed from the Air Traffic Control fix at 16:46:24 to impact was between156.8 and 159.1 knots, with an average of 158.0 knots.

The Aircraft at Impact

13. From their examination of the crash site and the wreckage, the AAIB reached the following conclusions:

- Initial impact was at 810 ft amsl, 594 ft below and 0.56 nm west of the summit of Beinn na Lice

- Groundspeed at initial impact was of the order of 150 knots, the track approximately 12 degrees True, and the aircraft was climbing with a flight path approximately 20 degrees above the horizontal

- At initial impact the aircraft was erect, rolled slightly left and pitched approximately 30 degrees nose-up, probably with little yaw angle.

14. Racal have confirmed that between 15-18 seconds before impact the SuperTANS data determined a height of 468 ± 50 feet. Because the encoding altimeter measures in 100ft increments, the height at this moment could have been as much as 468 +149/–50ft. The aircraft impacted at a height of 810ft. The SuperTANS showed this height to be 665ft, which is within the +149 ft tolerance mentioned previously.

15. Any analysis concerning the point of impact is problematical as power may not have been lost to certain instruments at first impact. Also the wind speed and direction should not be assumed to be constant. However, Boeing have analysed the data logged by the SuperTANS navigation system, including the last time the steering command calculations were updated (Steering command calculations are updated every second.) This shows that the last data was recorded less than a second before impact. The Select Committee is therefore mistaken in their view that, apart from Mr Holbrook, there is no other evidence of the speed of the aircraft prior to impact *(para 124).*

16. In revisiting their point of impact assessment Boeing found that, assuming the aircraft speed remained relatively constant over the period from the last steering command to the point of contact (only a matter of about 0.75 seconds), and taking account of evidence of tyre tracks and wind speed, an aircraft ground speed of 162.8 knots is derived, with an aircraft heading of 017 degrees True. This calculated value is consistent with the value of the groundspeed derived from the last displayed values of `distance to go´ (86.63 nm) and ` time to go´ (32.8 min) that were recovered from the steering command calculation.

17. If a last second manoeuvre was attempted in order to avoid impact, the rapid application of the aft cyclic stick would cause a zoom climb in which the horizontal momentum would be converted into a climb rate, and, depending upon its severity, would also result in a rapid loss of both ground and airspeed. If this explanation is applied to the difference between the recorded groundspeed of 150 knots and the "calculated" groundspeed of 162.8 knots, a derived instantaneous flight path angle of +23 degrees climb is the result. Similarly if the same comparison is made between the recorded and "assumed" values of airspeed, a derived instantaneous flight path angle of +20 degrees is reached. Both of these values correlate well with the findings of the AAIB for the probable flight path at impact.

18. Boeing's overall conclusions from their further work is that up until the last seconds of flight, the average climb rate was insufficient to clear the terrain. This was made worse by the small unexplained course change to the right, as highlighted in Boeing's further work, which placed the aircraft flight path over the area of highest terrain. An emergency pull-up manoeuvre was attempted in the final seconds, but it was initiated too late to avoid impact.

Conditions required for Chinook ZD576 to slow down before the Waypoint Change

19. In evidence to the Committee, several witnesses suggested that the aircraft may have slowed down before the waypoint change. A number of conditions would have to have been met for the aircraft to have done this:

- The aircraft would have to have travelled from the Air Traffic Control fix at a higher than average speed in order to "buy time" to slow down;

- the aircraft would have had to have begun decelerating at some distance from the waypoint change to achieve optimal efficiency, and;

- precisely at the waypoint change the aircraft would have to have immediately accelerated to achieve the impact time.

Differing from these exact conditions would have resulted in a higher speed at the waypoint.

20. Moreover, in order to achieve the required rates of acceleration and deceleration the aircraft would have to be rotated nose up, or down, to a set pitch attitude. This attitude would have to have been held, with full power applied, throughout the time of transition. This would typically be 20-35 secs for decelerating, and 20-45 secs for accelerating, from 135 knots airspeed to a hover and return respectively (using an `aggressive´ attitude of 20 degrees pitch and a `normal´ attitude of 10 degrees pitch). Furthermore if the aircraft had indeed slowed to, say, 80 knots when it was observed by the yachtsman, then the aircraft would have had to have returned to a speed greater than the average groundspeed of 158 knots by the waypoint change in order to satisfy the timing constraints.

Did the crew intend to turn left and hug the coastline?

21. Boeing's analysis shows that, given a normal rate of acceleration of +0.15g, it would not be possible to achieve the speed conditions for the final flare if the ground speed was below 80 knots at the waypoint change. To achieve 80 knots a number of conditions would apply:

- An average ground speed from the Air Traffic Control fix to the waypoint change of 161 knots would have to be achieved. At low level this would have required an average cruising airspeed of 151 knots, which is very close to the 155 knots limiting airspeed of the Chinook at low level. At 2000ft, given the wind velocity, this would have required an average cruise airspeed of 136.5 knots, but this is improbable given the consistent eyewitness reports of the aircraft's "unusually" low height over Northern Ireland, and given by the yachtsman.

- The aircraft would have to have been flared to an approximately 10 degree nose up attitude, and this position retained for more than 20 secs. The start of such a deceleration would have occurred at about 1 nm before the waypoint change, almost over Mr Holbrook's yacht which was some 2nm off the lighthouse, but he reported that the aircraft was in a `level´ attitude.

22. If the pilots had intended to continue at a lower speed after the waypoint change then, given the weather conditions, they would probably have maintained a nose up attitude to reduce speed further, or, more likely, they would have brought the attitude level to maintain the lowered speed. Power would have to have been reduced to a minimum for the period of deceleration and then increased to hold the lower cruise speed. Level flight at about 80knots in a Chinook is the most efficient cruise speed and requires the least amount of power; however, to accelerate to satisfy the timing conditions, full power would have to have been applied.

23. We know, however, that the aircraft did not turn left and hug the coast. This raises a number of questions. Did some involuntary action prevent the pilots from turning, cause the nose of the aircraft to lower to an accelerating attitude, and then make the aircraft hold that attitude for a significant period with full power applied. Also, what could have prevented the pilots from increasing their rate of climb [on their flight path a 1000ft/min rate of climb from the waypoint change would have cleared the high ground on their track]. If such an involuntary action occurred it left no trace, and the aircraft was within the envelope of controlled flight for the final flare just before impact. In our view any suggestion that a combination of malfunctions/involuntary actions lowered the nose of the aircraft and at the same time `froze´ the aircraft in the exact conditions for acceleration, is implausible.

24. Various hypotheses involving technical malfunctions were put forward to the Committee, and in their report the Committee note that both reviewing officers accepted the possibility of a control jam or engine malfunction could not be disproved. They also note that whilst the Air Accidents Investigation Branch (AAIB) concluded that "no evidence was found of any malfunction that could have contributed to the accident", the AAIB were not able to exclude the possibility of a control jam given the level of system damage; and neither could they exclude the possibility of pre-impact detachment of the thrust balance spring attachment bracket

and other inserts. The likelihood of the various scenarios causing the crash are considered in section 3.

SECTION 3 : ALTERNATIVE HYPOTHESES

1. Various hypotheses involving technical malfunctions were put forward to the Committee, and in their report the Committee note that both reviewing officers accepted the possibility of a control jam or engine malfunction after the waypoint could not be disproved. These scenarios are considered below.

A Differential Airspeed Hold (DASH) Runaway

2. The Chinook has two DASH actuators. The Air Accidents Investigation Branch (AAIB) report noted that both ZD576's actuators had sustained fire damage, but neither had suffered appreciable impact damage. No.1 Actuator worked, and although No2 actuator was too severely heat damaged to be operated, strip examination found no evidence of pre-impact distress.

3. A single DASH runaway would have caused one of the two DASH actuators to extend, but the effects would be easily manageable by the pilots. A more improbable event would have been a double DASH runaway. The resulting nose down pitching movement would have been recoverable, and, more importantly, it would not have impaired the ability of the pilots to turn or yaw the aircraft using lateral cyclic movement and the rudder pedals. Similarly it would not have prevented the pilots from applying emergency torque and, if required, climbing. However the DASH actuators were found to have been only 23% extended at the time of power loss, a setting with which the results of Boeing's further work is entirely consistent. The coincidence also strongly suggests that both had been responding to the Automatic Flight Control System (AFCS) commands. Moreover, an extension of 23% would not be expected for high speed level flight, but was consistent with a transient condition during a sharp pull up manoeuvre from a high initial airspeed.

An Upper Boost Actuator Jam

4. It has been suggested that an Upper Boost Actuator on the rear rotor head could have jammed and that such a jam would cause the controls to work "out of phase". This might mean for example that a control input to demand a roll would result in a pitching movement. However a single Upper Boost Actuator jam would not affect both rotor heads, and the unaffected rotor head would still attempt to satisfy the control demand. The affect of both rotors operating out of phase would produce a "spiralling" motion, with, say the front rotor rolling the airframe whilst the rear rotor attempted to yaw or pitch the frame. The suggestion that the aircraft could thus have involuntarily manoeuvred and satisfied the known impact conditions is implausible. Furthermore, the AAIB found no evidence of an Upper Boost Actuator jam.

US "Barrel Roll" Incident

5. The Committee had received a report of an US Army Chinook which turned "upside down" at about 1100ft and righted itself at about 250 ft., thus suffering an `uncommanded barrel roll´. Although the subsequent US Accident Investigation Board concluded that they were unable to confirm a malfunction of any system

associated with the flying controls, they did suspect that the Forward Swivel Actuator (part of the Upper Boost Actuator) had jammed causing an uncommanded attitude change. The Ministry of Defence evaluated an extract from the US Army investigation report of this incident and no remedial action was required to the RAF Chinook fleet. The Chinook Mk 2s, including ZD576, had been fitted with an improved standard of actuator during the mid-life update programme which would have prevented the hydraulic oil contamination suspected to have occurred in this incident.

Hydraulic Contamination of Lower Control Actuators

6. Fine metal slivers were found by the AAIB on one of the servo screens of the yaw Integrated Lower Control Actuator. But this is not surprising as the servo screens are filters designed and positioned in the hydraulic system specifically to capture debris of this type and to safeguard its integrity and correct operation. The AAIB report concluded that these slivers did not appear to have been associated with the effects of the accident and that there were no indications to suggest that they had contributed to it.

7. The Fuels and Lubricants Department DRA Woolwich analysed a fluid sample from each system and found them to be consistent with used OM-15 reportedly the normal type for RAF service, that would normally be considered fit for further use.

Pre-impact Detachment of the Thrust Balance Spring Attachment Bracket

8. In evidence to the Committee, the AAIB said they were unable to exclude the possibility of pre-impact detachment of the thrust balance spring attachment bracket and other inserts. However, when such a fault occurs, balance spring tension is lost which, because the flying controls are hydraulically powered, means there is no feel to the controls. Pilots have described this as a change in feel of the controls of the aircraft, and is detectable. The aircraft is still controllable. While there have been incidents of failure in the bonding, there has been no reported incident of this impacting upon safe flight.

9. When Chinook ZD 576 was examined after the accident the AAIB found that most of the thrust spring attachment brackets had indeed become detached. But its report also indicated that this was likely to have occurred during the post-accident break-up of the aircraft.

A Control Jam

10. Several different theories about control jams were put to the Committee, including the possibility that some loose article jammed the controls during steady flight and did not manifest itself until the controls were moved to alter course. The Department's view (which was submitted as written evidence to the Committee - p67, Q705 - but not referred to in the Report) is that to create this type of emergency, it would be necessary to lose control in all four axes simultaneously. The system's design and construction are such that it is virtually impossible for this to occur as a result of component failure. Furthermore the AAIB noted witness marks corresponding to the collective control being set at or near full travel at impact, and

the cyclic control at 25% aft and 23% left of neutral. These settings indicate a demand for high power and nose up attitude, consistent with a last second flare.

11. Furthermore, as the Ministry of Defence pointed out in written evidence to the Committee, the air conditions during the flight were turbulent. In such weather conditions, the handling pilot is constantly required to make control inputs and adjustments. Moreover the Automatic Flight Control System (AFCS) constantly makes minor adjustments , so it is not possible for a catastrophic failure to remain unnoticed in flight, especially prior to the waypoint. In any event, the hypothesis must pre-suppose that such a jam would have cleared itself before the final flight manoeuvre and left no trace, which is not plausible.

12. As explained earlier, had the aircraft reduced speed intending to turn left at the waypoint, then to achieve the impact conditions, the aircraft would have had to have been rotated nose down to an accelerating attitude with high power set after the waypoint. The suggestion then is that, at this time, the controls `froze´ in all axes simultaneously, making a change of direction, reduction in speed or climb impossible. This condition would have to have remained throughout the significant time necessary to achieve the acceleration. To achieve all of these conditions, either multiple failures would have had to occur to both pitch the aircraft and then freeze the controls simultaneously, or the pilots voluntarily conducted at least some of these combinations. From the AAIB investigation, we know that the angle of the flightpath at impact was far greater than the slope of the hillside below the impact site; hence the aircraft must have flared in the final moments.

Spurious Engine Fail Captions

13. Witnesses also drew the Committee's attention to spurious engine fail captions which, it was alleged were frequent occurrences and not well understood at the time of the accident. In December 1993 Boeing had advised the MOD that they were aware of this problem. They confirmed that "The nuisance trip of the "ENG FAIL" light poses no flight safety concern since it provides cockpit indication only and does not affect engine control". Boeing recommended that all Mk2 flying continue and that a caution, which they detailed, be placed in the `Flying Limitation´ section of all Forms 759s for Mk2s. A signal was issued on 15 December 1993 amending the Aircrew Manual to include the caution recommended by Boeing. The signal was reissued on 1 February 1994. Such a nuisance failure could not have contributed directly to the accident.

FADEC Problems and Boscombe Down

14. The Ministry of Defence welcomes the Committee's acknowledgement of its position *(para 44)* that Boscombe Down's decision not to authorise further trials flying in June 1994 was made against a background of several engine control system malfunctions that had occurred on the ground during start up checks. As the Committee's report outlines, these had not at that point been explained to Boscombe Down's satisfaction by the aircraft or engine Design Authority. The necessary clarification was completed and accepted by Boscombe Down on 24 October 1994. Test flying was recommenced without any changes to the aircraft FADEC system, or

any additional operating limitations. Operational flying continued within the weight restrictions applied.

15. The recommended restrictions were adopted as a precautionary measure. These included limiting the weight of the aircraft to 18,000 kgs, which would enable the aircraft to land safely on one engine should the need arise. In fact 90% of operational activities fell within this limit, which was amended on 1 March 1994 to increase the maximum all-up mass of the aircraft to 22,700 kgs when carrying under-slung loads.

16. Similarly, on the introduction of the Chinook Mk2 into service, icing trials had not yet been completed and as a precautionary measure a restriction was placed on the aircraft preventing operations in air temperatures below +4 degrees C in potential icing conditions. The +4 degree C isotherm in the area of the Mull on the evening of the accident was at 3,500 ft, so the icing restriction should not have had a limiting affect on the pilot's actions, as the minimum safe altitude over the Mull was 2,400ft. The aircraft was cleared to operate in conditions down to -10º C in clear air in March 1994, and to -6º C in icing conditions in July 1994.

17. As the Committee acknowledge, the memo dated 3 June 1994 which noted that there were still reservations about FADEC's performance, was a working level document. The fact that Boscombe Down could not verify the software using their preferred method of analysis (which was neither mandated nor included in the FADEC development contract) should not be taken to imply that there was any inherent problem with its design.

18. The Ministry of Defence has never denied that problems arose in the development of the FADEC software - indeed faults were to be expected. But we cdo not accept the implication that the aircraft was introduced into operational service before it was ready for such use (*..at the time of the crash there were still unresolved problems in relation to the FADEC system …- para 47).* Although there were some issues still to be resolved, the operating restrictions outlined above ensured that the Chinook remained within the safe, single-engine, flight regime, thereby minimising the effect of any possible malfunction.

19. The RAF BOI also noted that the Chinook Mk2 had experienced a number of malfunctions associated with the FADEC engine control system, but concluded that there was no evidence that any such malfunctions had occurred on ZD576's final flight. Indeed, all the available evidence (including that from the AAIB report) indicates that the engines were working normally up to the point of impact.

E5 Code and Wilmington Incident

20. The Ministry of Defence welcomes the fact that the Committee is satisfied the E5 fault had no relevance to the accident.

21. The "Wilmington incident" occurred in January 1989 at Boeing's test facility on a Mk1 Chinook during development testing of FADEC. The test used pre-production software and was aimed at demonstrating FADEC's performance under degraded mode testing to simulate battle damage. A software fault displayed during test was incorrectly determined by the contractors as one the design should have

accommodated without hazarding the aircraft. They proceeded with the test and, as a result, an overspeed incident occurred which overstressed one engine and the transmission / rotor system, thus seriously damaging the aircraft. If adequate test procedures had been in place, damage would not have occurred, and it was these procedures which were the cause of the arbitration claim against Boeing and Textron Lycoming.

22. Following the Wilmington test the software was amended; hence a similar incident could not have caused the Mull of Kintyre accident. We welcome the Committee's acknowledgement that the presence of the E5 code is irrelevant.

Conclusion

23. The Ministry of Defence has examined all the alternative hypotheses put to the Committee by witnesses but remains of the view that these are implausible. All the known evidence is entirely consistent with a continuous high speed transit at low level, on an essentially straight flightpath. There is not one single piece of known fact that does not fit the conclusion that this tragic accident was a controlled flight into terrain.

SECTION 4 : WEATHER

1. The Ministry of Defence notes that the Committee consider the more detailed evidence now given by the yachtsman as to weather conditions at sea (and the probability that the crew would have seen the lower part of the Mull) to be of considerable importance. The Committee consider that this was evidence the reviewing officers did not have before them when considering the RAF investigation board report.

2. Prior to ZD576's final flight, meteorological information had been faxed to the crew indicating that conditions suitable for a low level VFR flight would exist over the majority of the route, but that over the coastal areas there would be an occasional risk of less favourable, but acceptable, conditions. There was also a risk of conditions being sufficiently poor to preclude VFR flight. Along the planned route these conditions would have been expected around the Mull, with a specific risk of a 30% probability of weather below VFR limits being forecast for Machrihanish.

3. The pilots were therefore forewarned of the possibility of poor weather in the vicinity of the Mull, which they should have been expecting. All 10 eyewitnesses on the Mull itself reported the weather as being generally foggy and very bad. The lighthouse keeper estimated visibility to be 15 to 20 metres at the most, and commented that the fog was very patchy.

4. The yachtsman told the RAF Board of Inquiry at the time that when he had seen the Chinook (some 2 nautical miles SW of the lighthouse), visibility was about one mile and limited by haze. He also stated that he could see clearly the breakers and hear the fog horn. His evidence to the Fatal Accident Inquiry (FAI) was more comprehensive, and he indicated that while there was cloud completely obscuring the top of the Mull, he could make out the bottom of the white lighthouse perimeter wall but not the top of it. This is similar to evidence given by witnesses on the Mull at the time of the crash.

5. The Ministry of Defence notes Mr Holbrook's evidence to the Committee that the pilots would have been able to see the position of the lighthouse on approach to the Mull. But according to the evidence offered to the Fatal Accident Inquiry, at the time he saw the helicopter he believed he was about two miles south west of the lighthouse and that the aircraft was ¼-½mile away, at a height of 200-400 ft. He estimated the speed of the aircraft to be 60-80 knots, although in evidence to the RAF Board of Inquiry (BOI) he suggested that it was travelling " ….. somewhat faster than Sea Kings in level flight ….", which is typically an airspeed of some 100-110 kts. Mr Holbrook also indicated to the Fatal Accident Inquiry that he watched the helicopter for only some 25-30 seconds, during which time he was manoeuvring his yacht around fishing boats (although in evidence to the BOI and to the Committee, Mr Holbrook indicated that his sighting of the aircraft was limited to a five second view (*Q 594)).*

6. While noting that the Committee accepted Mr Holbrook as a reliable and

convincing witness, the Department would stress that the estimates of distances/time were offered to the FAI some 18 months after the accident, and indeed now vary in one respect from evidence given to the Committee. We believe this is understandable, and are not matters for which Mr Holbrook can be criticised. But we do suggest that this highlights the difficulty in making reliable estimates of distance and time based on relatively fleeting observation.

7. It is also the case that the investigating Board considered it most unlikely that the crew had visually identified the waypoint or the Mull. On the other hand Group Captain Crawford (in his remarks at Part 3 of the BOI report) believed that the crew saw the Mull and that it was this sighting that prompted the waypoint change. In reaching their judgement the senior Reviewing Officers were aware of this difference of view, but did not consider it affected the negligence finding. Furthermore, they have been aware of Mr Holbrook's further evidence (to the FAI) for some six years, but did not and do not consider that this affects their conclusions.

8. What is clear is that at some point the aircraft entered cloud, which the pilots had been warned to expect, more than 2,000ft below safety altitude, at high speed for a helicopter, and heading for high ground. Although there may be uncertainty as to precisely the point at which this occurred, it is clear from witnesses on land that the Mull was shrouded in cloud. Consequently, as they approached land, the pilots should have been aware that their visibility was about to reduce to significantly below VFR requirements. Their duty at that point was immediately to have slowed down, turned left or to have otherwise turned away from the Mull, and established safety altitude as quickly as possible. They did not do so and the negligence finding is founded on the incontrovertible fact that they failed to take any avoiding action on approaching deteriorating weather.

9. The finding of negligence is not dependent on whether or not the crew could or could not see the Mull either at the time of the way point change, or when they passed Mr Holbrook's yacht. At the way point change, which itself took three separate successive actions in the cockpit, the aircraft was under the control of the pilots and only about 600 metres or seven seconds flying time from the coast of the Mull. This was perilously close, given the height and speed of the aircraft and the weather conditions. The negligence judgement was accordingly based upon the reviewing officers' professional view that the pilots, by continuing to fly close to the cloud-covered high ground of the Mull without taking avoiding action, had failed in their duty of care to their 25 passengers. They were left in no honest doubt that the pilots were flying negligently.

SECTION 5 : SUMMARY OF BOEING'S FURTHER WORK

- See Separate accompanying folder for the full report of Boeings further work

1. At para. 175(c) of the Select Committee's Report their Lordships pointed out what they alleged to be "deficiencies" related to the original Boeing simulation work undertaken in support of the BOI:

- it did not take account of FADEC, and;

- it used a postulated speed and rate of climb which have been shown to be incompatible.

2. In the light of such remarks, and the position taken by the Select Committee, the Department commissioned further work from Boeing, the manufacturer of the aircraft. The results of this work re-enforce the validity of the original simulation work and further, emphasise that the simulation formed a small element of the large body of information available on the accident. The original Boeing simulation was not essential to the determination that the pilots were negligent, but factual evidence pointed compellingly to a controlled flight into terrain. Boeing's further simulation was undertaken using the latest, more advanced model (known as BH-Sim) and fully reflects FADEC technical parameters and flight performance.

3. Amongst the company's observations/comments as a result of this additional work were:

- The original Boeing simulation was an analysis tool, not a factual reconstruction and should hardly be considered "defective". The analysis programme used in the original simulation did not itself model FADEC, but the simulation was adjusted to reflect engine responses comparable to FADEC.

- The original modelling used a nominal Longitudinal Cyclic Trim Actuator (LCTA) schedule for the forward and aft rotors, rather than a more realistic range schedule, which skewed the results for airspeed on the high side. Boeing's latest work reflects the broader LCTA schedules verified in test flights.

- Data from the SuperTANS navigation system, which was not available to Boeing when they did their original work, shows that the airspeed immediately prior to impact was approximately 135 knots.

- The Chinook Mk2 can theoretically achieve a 150 knots/1000 ft per min rate of climb without exceeding engine limits. (There is a difficulty in setting up and maintaining maximum engine torque; as well as known errors in engine torque gauges which can under register by 3-9%.) This probably resulted in Witness A's claimed performance. When approaching close to the margin limits of the Chinook such data can only be validated on a fully instrumented aircraft.)

- The indications of the post impact rotor speed on the Rotor RPM gauge do not reflect the pre-impact speed.

- Excessive rotor coning does not occur until very low rotor speeds are reached. Sqn Ldr Burke's claim that this would occur close to 91% is very misleading. Boeing's further work shows that at 50% RPM, the coning angle would be about 15 degrees. At 90% RPM it is only about 4.5 degrees which is only 1 degree greater than normal for an aircraft of ZD576's weight.

- Data from the Digital Electronics Unit (DECU) of the second engine showed no evidence of torque or temperature exceedance and the matched power conditions of the engines post-impact indicate that there was no sustained emergency power demand. No other evidence indicated any FADEC or engine faults.

- It is extremely improbable that there could have been a multi-axis lower control jam that rendered the aircraft incapable of turning or climbing at its maximum emergency capability after the waypoint change, and which then subsequently cleared to allow a last second pitch-up manoeuvre.

- Speculation on a number of possible alternative, but relatively improbable, explanations for what might have happened to Chinook ZD 576, pales when compared to the classic controlled flight into terrain (CFIT) causal chain established by the BOI.

4. Amongst Boeing's re-affirmations as a result of the additional work were:

- That the aircraft maintained its intended flight path up to the waypoint change

- The flight on average was conducted at an essentially constant airspeed that tended towards the high end of the normal cruise speed range.

- Large variations in airspeed during the flight, for example those associated with a significant reduction in airspeed at the waypoint change, are generally precluded by the compensating actions that would have been necessary to achieve the high average airspeed.

SECTION 6 : STANDARD OF PROOF

1. The Committee concluded that, when judged against the required standard of proof of "absolutely no doubt whatsoever", the reviewing officers were not justified in finding that negligence on the part of the pilots caused the crash *(para 174).* The Department remains convinced that the reviewing officers were fully justified in their conclusion and that the standard of proof was met.

Regulations and Guidance

2. The Committee noted that Board of Inquiry (BOI) procedure is governed by rules made under section 135 of the Air Force Act 1955 and the Queen's Regulations for the RAF *(para 13).* Chapter 17, paragraph 1270 of the latter, in force at the time of the accident, stated that: *"For guidance in respect of boards of inquiry, AP3207 (Manual of Flight Safety) should be consulted."* AP3207 in turn required that where human factors were judged to have been a contributory factor in an accident, then the board must determine whether the factor constituted error of judgement, or negligence. Further AP3207 stated that "*only where there is absolutely no doubt whatsoever should deceased aircrew be found negligent"*. These words were drafted by, and intended to be comprehensible to, non-lawyers. Plainly they were meant to send a clear message.

3. The Committee observed that these words imported an even higher standard of proof than that applicable in criminal courts where the relevant standard is proof "beyond reasonable doubt", and was far higher than that required for a finding of negligence in civil litigation, proof "on the balance of probabilities" *(para 14).*

BOI Procedure

4. As part of their assessment, the decision-maker or reviewing officer concerned with such cases was required to consider all of the evidence as a whole before reaching a judgement. If this consideration left him with no honest, or genuine, doubt that the aircrew had been negligent, it was his duty to find accordingly. The "absolutely no doubt whatsoever" test was intended to be capable of practical application, and in the view of the Department required a distinction to be drawn between honest or genuine doubt and implausible conjecture. Thus it was not permissible to avoid a finding of negligence by recourse to an hypothesis for which there is no evidence and which is revealed as wholly implausible when tested against the known facts.

5. A sufficiently detailed picture of the circumstances of any particular accident, pointing conclusively towards aircrew responsibility was clearly necessary before a finding of negligence could properly be made. This was so in respect of the Chinook accident. Even though an investigation into any serious accident will inevitably be unable to answer every technical question with absolute certainty, this does not mean that the established facts when taken together cannot compel a particular conclusion.

6. The reviewing officers considering the Chinook accident had access to the very

thorough report on the accident investigation which included a detailed technical statement prepared by the AAIB. They also had available to them evidence from a wide range of experts, including a Principal Psychologist, the Meteorological Office, the engine, airframe and equipment manufacturers, as well as the witnesses who were in the area at the time and others who saw the aircraft prior to the crash.

7. All of the available information was considered by the Reviewing Officers. They were also able to call on their own considerable professional knowledge and experience of military flying and of the high standards of airmanship required of RAF pilots. In reaching their finding they examined various factors and scenarios; but in their professional judgement none of these could have prevented such an experienced crew from maintaining safe flight. Consequently, they reluctantly concluded that the pilots could and would have avoided the accident had they followed a different course of the action to the one they chose to pursue. The Reviewing Officers' judgement, reached with regard to the strict requirements concerning such findings, was that this constituted gross negligence.

8. The Committee was not called upon to offer an opinion on the cause of the crash, and consequently was not required to take a view on whether negligence was the sole effective reason for the tragedy. Nonetheless, the Committee's conclusion was that a valid finding of negligence could only have been made by the Reviewing Officers if all other plausible explanations for the crash could be ruled out. *(para 14)*

9. The Ministry of Defence does not agree with this analysis. Negligence is causative of damage if it operates either alone or in conjunction with other factors to cause the damage. A motorist who drives along a suburban street far too fast and crashes his car is still negligent, even if brake failure cannot be ruled out as a contributory factor. In the case of the Mull accident, the standard of proof required the Reviewing Officers to be in no doubt whatsoever that the pilots' negligence was a cause (although not necessarily the sole cause) of the accident. Most aviation accidents are the result of a combination of factors that operate in conjunction to cause the loss.

10. It is sometimes difficult to distinguish between factors working in conjunction to cause an accident, and the situation when a subsequent event causes a crash and in doing so eliminates or excludes the causative impact of a prior act of negligence. If an aircraft crashes because of the explosion of a bomb on board, any prior or contemporaneous negligent flying by the pilots could plainly not be causative of the crash. The Mull accident does not fall into this category. In this case, after full consideration of all the evidence, the Reviewing Officers ruled out all other plausible potential causes which could have operated independently of negligence to cause the crash. They were left in no honest or genuine doubt that the pilots were negligent, and were therefore duty bound to reach the conclusion that they did. As they told the Committee negligence occurred in their view at or before the waypoint change by which time the pilots had failed in their duty of care and airmanship. They had not before then taken action to avoid the cloud-covered cliff that they must have known was ahead but rather had flown on, too fast and too close towards the Mull, thus exposing their aircraft to unacceptable risk.

11. The hypothesis that the pilots might subsequently have lost control of the

aircraft as a result of a control jam, an uncommanded flying control movement or another technical difficulty *(paras 167-171 and 173)* did not (even if true) mean that the pilots' negligence ceased to be a contributory cause of the crash. Similarly, the negligence finding did not depend upon whether or not the crew were in control when the flare was carried out by the aircraft in its final seconds (although the Department is of the view that all available evidence points overwhelmingly to this being the case).

Determination of Negligence

12. The Department also notes the Committee's reference *(para 146)* to extracts from Annex G to Chapter 8 of AP3207. This passage (from para 2 of Annex G) offers two questions as guidance to a Board of Inquiry (when assessing human failings) in distinguishing between those irregularities, which had no direct connection with the cause of the accident and those that had.

13. The second question (*Ought the person to have foreseen that their action or their failure to take action would in all probability occasion the final event?")* has been taken by the Committee to be of crucial importance (*para 147).* The Committee suggests that if the answer is negative, the negligence finding is unsustainable.

14. The Ministry of Defence does not agree that the answer to this single question – offered as part of a package of guidance to Boards – is determinative of whether there could ever be a finding of negligence. Were their Lordship's approach correct, only dangerous flying where the pilot should have foreseen that a crash was more probable than not could ever be found to have been negligent; dangerous flying exposing an aircraft merely to a very serious risk of crash, falling short of a probability could never be negligent, even if that risk were to materialise. In the Ministry of Defence's view, a proper reading of the rest of the guidance serves to demonstrate that this would be an unrealistic and inappropriately narrow approach to the question of negligence. It is notable that the Annex (para 4) indicates that a Board should rely on its own knowledge of human behaviour and acceptable Service standards in reaching its decision. Furthermore it defines negligence as "The omission to do something which, in the circumstances, a reasonable person would do; or the doing of something which in the circumstances, a reasonable person would not do or would do differently." It comments too that a duty to take a very high degree of care is rightly imposed on a person flying an aircraft. In such circumstances what might be trivial in other fields may, when associated with aircraft operations, amounts to negligence which justifies severe criticism.

15. The Ministry of Defence considers that relevant questions to determine negligence (also included in the guidance in the Annex at paragraph 6) are whether the pilots possessed the necessary degree of skill and knowledge to maintain safe flight; and whether they failed to exercise the degree of care required in the circumstances. These are the tests that the Reviewing Officers correctly applied, and which led them to determine that the pilots should by waypoint change, have slowed down, and climbed to a safe height, or turned away. The fact that they had not done so pointed inevitably towards their finding of negligence.