AIRCRAFT ACCIDENT REPORT 1/81

DEPARTMENT OF TRADE

# Report on the accident to BAe HS 748 G-BEKF at Sumburgh Airport, Shetland Islands, on 31 July 1979

LONDON

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**Department of Trade**
**Accidents Investigation Branch**
**Kingsgate House**
**66-74 Victoria Street**
**London SW1E 6SJ**

12 May 1981

*The Rt Hon John Biffen MP*
*Secretary of State for Trade*

Sir

I have the honour to submit the report by Mr C C Allen, an Inspector of Accidents, on the circumstances of the accident to BAe HS 748 G-BEKF which occurred at Sumburgh Airport, Shetland Islands on 31 July 1979.

I have the honour to be
Sir
Your obedient Servant

W H Tench
*Chief Inspector of Accidents*

Accidents Investigation Branch

Civil Aircraft Accident Report No 1/81
(EW/C671)

| | | |
|---|---|---|
| *Owner and Operator:* | | Dan-Air Services Limited |
| *Aircraft:* | *Type:* | British Aerospace HS 748 Series 1 |
| | *Model:* | 105 |
| | *Nationality:* | British |
| | *Registration:* | G-BEKF |
| *Place of Accident:* | | Sumburgh Airport, Shetland Islands<br>Latitude 59°53'N<br>Longitude 01°18'W |
| *Date and Time:* | | 31 July 1979, at 1601 hrs |
| | | All times in this report are GMT |

# Synopsis


The accident was notified by Sumburgh Air Traffic Control (ATC) at 17.30 hrs on 31 July 1979 and an investigation was commenced by the Accidents Investigation Branch early the next morning.

The aircraft was engaged upon a charter flight from Sumburgh Airport to Aberdeen, with 44 passengers and a crew of three. Whilst attempting to take off on runway 09, the aircraft failed to become airborne and crashed into the sea about 50 metres off-shore and approximately in line with the end of the runway. The aircraft was destroyed and 17 persons, including both pilots, died by drowning.

It is concluded that the accident was caused by the locked condition of the elevators which prevented the rotation of the aircraft into a flying attitude. It is likely that the elevator gust-lock became re-engaged during the pilots' pre-take-off check, and that this condition was not apparent to either pilot until the take-off was so far advanced that a successful abandonment within the overrun area could not reasonably have been made. The re-engagement of the gust-lock was made possible by the condition of the gust-lock lever gate plate and gate-stop strip.

# 1. Factual Information

## 1.1 History of the flight

The aircraft was engaged on a series of charter flights, carrying oil company personnel between Aberdeen and Sumburgh. The inbound flight to Sumburgh had been made without incident and no significant malfunction of the aircraft had been reported. The crew, consisting of two pilots and a stewardess, then had a stopover of nearly seven hours before departing on the return flight, Dan-Air 0034, with 44 male passengers on board. The crew were reported to be in good spirits and of normal behaviour. It has not been established who was the handling pilot on this sector.

At 1548 hrs, in conditions of moderate visibility, but with low cloud, rain and a fresh easterly wind, the aircraft was taxied out to the holding point 'India', the intersection of the disused runway and runway 15/33 (see Appendix 1). Meanwhile the stewardess gave the company's standard safety briefing, using a megaphone because the passenger address (PA) system was 'screeching'. The briefing included mention of the location of the lifejackets, how they should be put on, and the method of inflation; also mentioned was the location of the emergency exits. A diagram displaying the method of donning the jackets was fixed to the forward bulkhead of the cabin.

Because of other aircraft movements, 'KF' was held at point 'India' for six minutes before being cleared, at 1557 hrs, to 'enter and backtrack' for a take-off on runway 09, which was virtually into wind. Whilst the aircraft was backtracking, ATC passed the crew the *en route* clearance, which was read back correctly by the co-pilot. The aircraft was seen to turn close to the western end of the runway and line up on the runway heading. One of the passengers has subsequently stated that at about this time he saw the ailerons moving up and down.

At 1559 hrs the flight received take-off clearance from ATC and this was acknowledged by the co-pilot. There is evidence to show that the engines were accelerated whilst the aircraft was held stationary on the brakes and that full take-off power, using water-methanol, was achieved on the take-off run, which commenced at almost exactly 1600 hrs.

Evidence from the aircraft's Flight Data Recorder (FDR) shows that the aircraft accelerated normally through the decision speed, $V_1$* (92 kts), to the rotation and safety speed $V_R/V_2$† (99 kts). The FDR read-out and a number of witness accounts evince that no rotation was carried out and that, even though the aircraft reached a speed significantly higher than $V_R$, of the order of 113 kts, it failed to become airborne.

**$V_1$ is the engine failure decision speed (normally above which the take-off is continued, below which it is abandoned). Note: All speeds quoted in this report are indicated air-speeds.*

*† $V_R$ is the speed at which the aircraft rotation (into a take-off attitude) is commenced.*

*† $V_2$ is the take-off safety speed (on the HS 748 aircraft the value of $V_R$ always equals that of $V_2$).*

About 5 seconds after reaching the scheduled rotation speed, and after passing the intersection with the disused runway, the aircraft began to decelerate. Veering gradually to the left as it crossed the grass overrun area, it then made contact with a discontinuity or 'step', approximately 40 centimetres high, at the edge of the airfield perimeter road and partial collapse of the undercarriage followed. After crossing the road in a left wing low and nose-down attitude the aircraft passed over the inclined sea defences and came to rest in the sea some 50 metres from the shore line.

The emergency services arrived at the point on the road adjacent to the crash site within two minutes of the accident. However, about a minute later the aircraft sank, nose first, in some ten metres of water, leaving only the rear section of the fuselage visible. Twenty-nine passengers and the stewardess were rescued, or managed to swim to the shore, under adverse weather conditions. Despite rescue attempts mounted from the shore, by small craft and by helicopters summoned to the scene, fifteen passengers and the two pilots died by drowning.

## 1.2 Injuries to persons

| Injuries | Crew | Passengers | Others |
|---|---|---|---|
| Fatal | 2 | 15 | – |
| Serious | – | 2 | – |
| Minor/none | 1 | 27 | |

## 1.3 Damage to aircraft

Destroyed.

## 1.4 Other damage

Minor gouging of the perimeter track occurred.

## 1.5 Personnel information

### *1.5.1 Commander :*

| | |
|---|---|
| Age: | 37 |
| Licence: | Airline Transport Pilot's Licence valid to 25 November 1986 |
| Aircraft ratings: | Aircraft Part I: Cessna 150/210, Nord 262, HS 748 |
| Instrument rating: | Instrument Rating valid to 27 July 1980 |
| Last medical examination: | 29 March 1979, Class I valid to 29 September 1979 |
| Last certificate of test: | 27 June 1979 |
| Last safety and survival test: | 27 July 1979 |

Flying experience:

Total flying hours: 6,487

Total flying hours in command: 5,492

Total flying hours on HS 748: 4,403 (of which 4,059 were in command)

Total flying hours in last 28 days: 40

Rest period prior to the duty period which commenced at 0600 hrs on the day of the accident: 14 hours

Throughout the relevant period of training and examination of this pilot, he showed himself to be competent in all respects.

1.5.2 *Co-pilot*

| | |
|---|---|
| Age: | 51 |
| Licence: | Commercial Pilot's Licence valid to 16 May 1989 |
| Aircraft ratings: | Aircraft Part I: HS 748, Cessna 150/210, PA 28/32. Part II: AT 98 (Carvair), Bristol 170 |
| Instrument rating: | Instrument rating valid to 17 July 1980 |
| Last medical examination: | 20 March 1979, Class I valid to 20 September 1979 |
| Last certificate of test: | 17 June 1979 |
| Last safety and survival test: | 13 July 1979 |

Flying experience:

Total flying hours: 4,563

Total flying hours on HS 748: 57

Total flying hours in last 28 days: 27

Rest period prior to the duty period which commenced at 0600 hrs on the day of the accident: 14 hours

In the course of his conversion training onto the HS 748 aircraft this pilot experienced some difficulty in the appreciation and usage of the check-list. Although in due course he passed the required competency checks, a company line captain who flew with him for three days during the week preceding the accident subsequently stated that he was 'inexperienced on the type, not entirely reliable in the operation of the check-list or flight calculations'. However, the company itself received no adverse reports on the co-pilot's competence during his period of line flying.

*1.5.3* *Delegation of flying duties*

A company ruling forbids the commander to delegate the handling of the aircraft during take-off or landing to the co-pilot unless:

(a) The commander has more than 100 hours in command on the aircraft type; and

(b) The co-pilot has more than 100 hours experience on the aircraft type.

**1.6 Aircraft information**

*1.6.1* *Leading particulars*

| | |
|---|---|
| Type: | HS 748 Series I Model 105 |
| Registration: | Initial registration LV-PUC, for export to Argentina; re-registered LV-HHD in Argentina; re-registered G-BEKF in April 1977 on return to UK |
| Manufacturer: | A V Roe and Co Ltd, Manchester (latterly Hawker Siddeley Aviation Ltd, now British Aerospace, Manchester Division) |
| Date of Manufacture: | 1962 |
| Previous Operators: | 1962-1974 Aerolineas Argentinas<br>1974-1977 Yacimientos Petroliferos Fiscales |
| Certificate of Airworthiness (C of A): | UK Transport Category (Passenger)<br>issued: 2 August 1977<br>last renewed: 9 July 1979<br>valid to: 8 July 1980 |
| Certificate of Maintenance: | issued 1 May 1979<br>valid to: 29 September 1979 or until the aircraft had completed 29,492 hours, whichever was the sooner |
| Total airframe hours: | 29,007 |
| Maximum certificated take-off weight: | 17,916 kg |
| WAT *limited take-off weight: | 17,600 kg |
| Actual take-off weight: | 17,376 kg |
| Centre of gravity (CG) range: | Index – 9 to – 21.8 |
| Centre of gravity at time of accident: | Index – 13.2 |
| Engines: | 2 Rolls-Royce Dart 514 turbo-props |
| Propellers: | 2 Dowty – Rotol type R 201/4-30-4/20 |

** The take-off weight as limited by aircraft weight, airfield elevation, and ambient temperature considerations.*

## 1.6.2 *Aircraft description*

### 1.6.2.1 *General*

The HS 748 is a low wing, twin engined, turbo-prop airliner.

### 1.6.2.2 *Propeller pitch stop mechanism*

The aircraft is equipped with propellers which are normally governed within the 'flight fine pitch' (FFP) range whilst the aircraft is airborne, but whose blade angle can be reduced to 0 degrees, or 'ground fine pitch' (GFP), so as to provide a drag force to assist deceleration during the landing run or during a rejected take-off.

In order to safeguard the aircraft against the hazard of a similarly high drag force occurring whilst airborne, each propeller is equipped with a mechanical pitch stop, known as a flight fine pitch stop (FFPS), capable, when engaged, of preventing the blade angles from reducing to less than 18½°.

Lower blade angles can, however, be obtained in each propeller by moving its FFPS to the 'withdrawn' position. This operation is achieved electro-hydraulically in both propellers when the crew operate the FFPS withdrawal lever, situated immediately behind the engine throttle levers in the cockpit (see photographs, plates 1 and 2). The lever can only be moved to the 'stops withdrawn' position after both throttles have first been moved to the closed position.

### 1.6.2.3 *Flying controls and gust-lock system*

The flying controls of the aircraft take the form of conventional ailerons, elevators and rudder operated manually by means of cables, quadrants, bellcranks and push-pull rods.

In order to prevent damage occurring to the control surfaces from strong or gusty winds when the aircraft is on the ground, each control system is equipped with an internal lock. The three locks are operated by a single pivoting telescopic lever situated on the right-hand side of the cockpit control console. Operation of this lever permits the control systems to be locked during parking and taxying, and to be released before take-off.

Photographs at plates 1 and 2 show the relative positions on the control console of the throttles, high pressure (HP) cocks, gust-lock lever and FFPS withdrawal lever. The gust-lock lever is pivoted about a lateral axis in the centre console of the cockpit so that full backward movement causes all three control locks to engage, while full forward movement caused them to disengage (see also figures 1 and 2).

The upper section of the lever, containing the handle, is mounted telescopically in the lower pivoted section and may be slid manually upwards approximately 3¼″ against the force of two return springs. This vertical upward movement is necessary before the lever can be moved away from the locked or unlocked position.

The upper section of the lever has attached to it a rectangular section strip, termed the gate-stop strip, which engages with one of two detents (known as the 'on' and 'off' detents) situated in the console at the 'controls locked' and 'controls unlocked' ends of the lever's range respectively (see figures 4 and 6 and photograph at plate 3).

Vertical upward movement of the upper section of the lever then withdraws the gate-stop strip from the detent in which it is engaged, allowing the lever to pivot to the opposite end of the range, where the telescopic section may be lowered again, once the gate-stop strip is coincident with that detent.

At any angular position between the two detents, the upper section of the lever is prevented from moving to the 'down' position by an interference between the gate-stop strip and a gate plate within the console.

Thus to engage or disengage the control locks, the lever is lifted fully upwards, moved to the other end of the range and allowed to move fully downwards. If it remains in the 'up' position, then the fully locked or fully unlocked position has not been reached. This is a design safeguard to indicate to the pilots that the gust-lock lever is incorrectly positioned.

The gate plate in the control console contains cut-outs on the left hand side of the gust-lock lever slot which form the detents into which the gate-stop strip slides when the locks are engaged or disengaged.

In normal service the gate plate is covered by a gate seal plate and the throttles, HP cock levers, FFPS lever and gust-lock lever protrude through rubber seals situated around the slots in the seal plate. Angular movement of the gust-lock lever is transmitted to three control locks by a mechanism shown in figure 1.

Freedom of the controls is normally assured by the crew, shortly before the take-off run begins, by the following actions, carried out during the pre-take-off checks and summarized in the pre-take-off check list:

1 Ensuring that the gust-lock lever is in the 'controls unlocked' (forward) position with the telescopic section 'down', ie in the 'off' detent.

2 Carrying out 'full and free' checks on rudder, elevator and aileron controls. Normally the commander, sitting in the left hand seat, checks the rudder; the co-pilot, under the supervision of the commander, checks the ailerons and elevator controls for full and free movement. The checks may be made in any order, or simultaneously.

The elevator control system is spring loaded towards the control column forward (elevator down) position, and this coincides with the position of the control system when the elevator lock is engaged. During the take-off run it is normal practice for the handling pilot to hold the control column fully forward in order to keep the nosewheel in ground contact until $V_R$ is reached. Therefore, during the take-off run, it is not normally obvious to the crew, from control feel and response, as to whether or not the elevator is free until the point is reached at which back-pressure is applied to the control column to lift the nosewheel.

### *1.6.2.4 Interlock system (see figure 3)*

An interlock is provided between the FFPS withdrawal lever and the gust-lock lever which prevents the former from moving forward into the 'stops engaged' detent when the gust-lock lever is in the 'controls locked' position.

Movement of the engine throttle controls to the take-off power position automatically moves the FFPS withdrawal lever forward to the 'stops engaged' position. However, whenever the FFPS withdrawal lever is prevented from moving to the 'stops engaged' position by the gust-lock lever interlock, forward movement of the two throttles is also limited (see photograph at plate 4) by a rocking quadrant which permits only one throttle to be fully opened at a time. Thus with a properly adjusted system it is not possible to achieve more than taxying power on both engines simultaneously until the gust-lock lever is moved away from the 'controls locked' position. The design intention was that the interlock system should be the primary safeguard reminding pilots to disengage the gust-locks by preventing take-off with the locks engaged.

1.6.2.5 *Hydraulic and brake systems*

Hydraulic pressure is supplied to the main aircraft system by means of two engine driven pumps.

The aircraft is equipped with conventional hydraulically operated brakes on all four main undercarriage wheels. Each brake unit incorporates a Dunlop maxaret anti-skid unit.

1.6.2.6 *Compass system*

The compass system provided in this aircraft comprises one master compass behind the commander's seat, and two slave units, one in front of each pilot. The design of the system is such that, whilst one of the slave units is being fed directly from the master unit, the other slave provides 'directional gyro' (DG) information only. A two-position rotary switch on the commander's left hand side panel determines which pilot receives 'compass' indications and which receives 'DG' indications.

1.6.2.7 *Auto-pilot*

The aircraft was not fitted with an auto-pilot.

## 1.7 Meteorological information

The crew had obtained a routine meteorological briefing prior to departure. The following observation was made at Sumburgh at 1605 hrs, shortly after the accident:

| | |
|---|---|
| Surface wind | 090°/22 knots |
| Visibility | 6 kms |
| Weather | Rain |
| Cloud | 3/8 300 feet<br>6/8 400 feet<br>8/8 800 feet |
| Temperature | +12°C |
| Dew point | +12°C |
| QNH | 994 mbs |
| QFE | 993 mbs |

At about the time of the take-off run, the anemograph recorded the wind as varying in direction between 070° and 100° (T) and in strength between 16 and 26 knots.

The anemometer is situated south-west of the control tower and approximately 550 metres from the mid-point of the runway, at an elevation of approximately 85 feet.

The sea state at the time was a heavy swell and breakers, with a moderate to fresh on-shore wind and a sea temperature of $+11^{o}C$.

The take-off run took place in daylight.

## 1.8 Aids to navigation

Not relevant.

## 1.9 Communications

Sumburgh Airport ATC has five radio-telephony (RTF) channels (4 VHF, 1 UHF) for movement control in the environs of the airport. In practice one VHF channel and one UHF channel are normally used. Aircraft are controlled on the 'Sumburgh Tower' frequency of 120.9 MHz and vehicular traffic, including the police and the fire service, uses 'Sumburgh Ground' on UHF. ATC can, subject to their discretion, couple these two channels, thereby enabling direct intercommunication between the users of VHF and UHF. In addition, the police have their own discrete frequencies for internal communications and a direct telephone line to Coastguard Headquarters. The Coastguard, the Search and Rescue (SAR) helicopter and the Motor Vessel (MV) Quest shared another network on frequencies 156.0, 156.8 MHz and 2182 KHz.

Prior to departure, 'KF' had established RTF communication with ATC on 120.9 MHz and the aircraft remained on this frequency throughout the attempted take-off. With one exception, all the calls from the aircraft, including the last two, were made by the co-pilot. After he had acknowledged the take-off clearance, no further communication from 'KF' was heard. Following the accident, the three helicopters 'EA', 'UD' and the SAR aircraft 'DA' were also controlled on this frequency; latterly 'DA' communicated with the Lerwick lifeboat and *MV Quest*. The 'Incident Officer' and the Fire Service used the 'Sumburgh Ground' frequency to co-ordinate the rescue.

## 1.10 Aerodrome and ground facilities (see Appendix 1)

Sumburgh Airport is situated near the southern end of Shetland. Being operated by the Civil Aviation Authority (CAA), under the provisions of Article 66(1)(b) of the Air Navigation Order (ANO) 1976 it is not required to be licensed. The Authority states that it applies the same standards to its own aerodromes as it would require from operators of licensed aerodromes. There are two operational runways: 09/27 (1084 by 46 metres) and 15/33 (1426 by 46 metres). Runway 04/22 is disused. The elevation at the threshold of runway 09 is 20 feet, falling away to 4 feet at the 15/33 intersection, before rising to 14 feet at the end. The take-off distance available (TODA) on runway 09, as notified in the Air Pilot, is 1236 metres: the take-off run available (TORA) is 1084 metres and the emergency distance available (EDA) is 1084 metres.

A special tarmac friction/drainage surface had recently been laid on runway 09/27. A measurement of the runway surface friction taken subsequent to the accident at a speed of 35 knots, in conditions which were as nearly as possible identical to those which prevailed during the accident period, gave $\mu$ meter readings averaging 0.77. This correlates to a value of 0.65 when applied to the HS 748. The CAA 'Air Pilot' classifies the braking obtained with meter readings greater than 0.5 as 'good'.

The runway lights were on at the time of the accident take-off.

Beyond the end of runway 09 lies an overrun area consisting of a fairly flat grass surface extending for 132 metres followed by a tarmac perimeter road, 20 metres wide and running approximately at right angles to the runway extended centre line. The road also forms part of the sea defences which continue as a flat surface platform of large hexagonal concrete 'slabs', with small gaps between them, sloping down over a distance of about 10 metres to just above the low tide mark. At the time of the accident the road was about 17 feet above sea level. The concrete surface then runs level for several metres before giving way to the initial wave breaker, consisting of a series of irregularly angled blocks. Running along the line of, and about half way up, the slope is another series of large concrete blocks, forming the final wave breaker (see plate 7). The grass area adjacent to the perimeter road was subject at frequent intervals to erosion, due to the sea breaking over the sea defences. The eroded area had been filled in a number of times by the aerodrome authority, but at the date of the accident a vertical 'step' existed between the eroded area adjacent to the road and the road itself, varying in height between 30 and 45 centimetres in the vicinity of the aircraft's overrun path (see plate 8).

The current edition of Civil Aviation Publication (CAP) 168, 'Licensing of Aerodromes', recommends that, for a runway such as runway 09/27 at Sumburgh, a strip end of a minimum length of 60 metres, plus an additional 90 metres (minimum) of runway end safety area (RESA) should be provided beyond each end of the hardened surface. The width of the RESA should not be less than twice the width of the associated runway, symmetrically disposed about the extended centreline of the strip. The stated purpose of a strip is to reduce the risk of damage to an aeroplane running off the runway by providing a graded area meeting specified slopes and bearing strength requirements. The purpose of a RESA is to minimise the risks arising when an aeroplane overruns or undershoots a runway. It is specifically stated in CAP 168 that the surface of a RESA need not be prepared to the same standard as that of a runway strip but that it should not endanger aircraft.

The edition of CAP 168 applicable prior to 1978 stated these dimensions as requirements instead of recommendations and that the area (presently known as RESA) 'shall be free of significant hazards or obstructions'.

## 1.11 Flight recorders

### *1.11.1 Flight data recorder*

The aircraft was fitted with a Normalair Garrett Midas CMM/3B frequency modulated Flight Data Recorder (FDR) which was situated in the tail cone, aft of the pressure bulkhead and was recovered undamaged from the wreckage. The following parameters were recorded against elapsed time:

Pressure height: indicated airspeed; pitch attitude; roll attitude;
normal acceleration (g); magnetic heading; flap position.

A read-out of the final 40 seconds of the recording is given at Appendix 2. It was not possible to determine at exactly what point in the take-off run the recording ended. At the most recent calibration of the recorder, the parameters were recorded only as being 'within tolerance'. Combining these tolerances with the read-out tolerances results in the following estimates for overall accuracy of the parameters:

| | | |
|---|---|---|
| Altitude | ± | 50 feet |
| Heading angle | ± | 5° |
| Normal acceleration | ± | 0.3g |
| Pitch attitude | ± | 2° |
| Roll angle | ± | 2° |

During the replay of some previous take-offs and landings it was noticed that a fault in the airspeed trace was present until the landing immediately prior to the accident flight, when it apparently disappeared. The cause of the fault could not be identified, and the accuracy of the airspeed readings therefore remains suspect. For the same reason, no tolerance can be quoted.

*1.11.2* *Cockpit voice recorder*

A cockpit voice recorder (CVR) was not fitted, nor was one required to be, in order to conform with the regulations in force at the date of the accident. Under the Air Navigation Order (ANO) 1976, aircraft in the Transport category which conform to a type first issued with a type certificate on or after 1 April 1971 and which have a maximum authorised weight exceeding 11,400 kg must be fitted with an FDR and a CVR.

**1.12** **Wreckage and impact information**

*1.12.1* *The accident site*

The aircraft came to rest approximately 50 metres from the shore with the tail unit visible above the surface of the sea.

The port wing was found to have separated at the root, and the fuselage had suffered upward bending failure in the plane of the forward wing spar.

Structural damage was consistent with the aircraft having struck the water in a nose-down and port banked attitude.

There was evidence to indicate that separation of the nose undercarriage unit and the partial collapse of the port main undercarriage had occurred at the point where these units had come into violent contact with the step at the perimeter road (see plate 8).

Damage to the port propeller, nose underside and the surface of the perimeter road indicated that the aircraft had crossed the perimeter road with the underside of the nose and the port propeller in contact with the surface.

Examination of the runway surface and the grass overrun area revealed that the aircraft had left the end of the runway with all three undercarriage units in contact with the ground.

Traces of the passage of the aircraft could be detected on the runway surface from the point of over-run back for a distance of 190 metres. From the initial point of visible runway marking to the step at the perimeter road there were indications that all six undercarriage wheels were in continuous ground contact except at points adjacent to bumps and discontinuities in the ground. The markings left by the nose wheels were wide and those left by the main wheels were narrow. The markings also indicated that about 100 metres before the end of the runway, the aircraft started a gradual turn to the left. At the same time, it also started to yaw to the left, tracking in a direction which resulted in a sideslip to the right. Shortly before the end of the runway, there was evidence that the nosewheels had turned away from the longitudinal centre-line of the aircraft. Close to the end of the grass overrun, the tracks indicated a reduction in the lateral sliding.

No evidence of wheel braking action could be detected on the runway or the grass overrun area. Propeller blade slash marks on the perimeter road in line with the port undercarriage track were spaced approximately 0.68 metres apart.

Failure of the fuselage and separation of the port wing had applied tensile loads to the various control cables passing across these disruptions. This loading has caused movement of the control levers and wheels operating the cables and of the services operated by the cables. It was therefore not possible to establish reliably the pre-impact position of most of the cable operated controls, even though under-water photographs were obtained of the cockpit area before any salvage attempts were carried out.

In particular, the pre-impact positions of flying controls, trimmers and the gust-lock system could not be established.

1.12.2 *Examination of the wreckage*

The entire wreckage was salvaged and removed for detailed examination. Inevitably, considerable additional damage resulted from the action of the sea and the salvage operation.

A strip examination of both engines, together with their fuel control units and pumps, carried out after salvage, revealed no evidence of pre-impact failure.

Functional testing of the propeller control units revealed that they performed within specification.

Examination of the propellers revealed that at the time of impact both had been at a pitch position corresponding with the FFPS datum. In addition there was evidence to show that both pitch stops had been engaged at the time of the impact.

There was no evidence of fire, smoke or signs of overheating in the aircraft or its components.

An examination of the pitot-static system revealed no evidence of pre-impact failure and calibration checks of the two airspeed indicators showed them to be within the maker's specification over the speed range up to 150 knots.

Electrical tests on the micro-switches of the propeller pitch stop operating system in the cockpit console indicated that correct continuity was present through the contacts of both series switches when the FFPS withdrawal lever was selected to the 'stops out' position.

Examination of the aircraft's hydraulic system and the wheel braking system revealed no evidence of pre-impact failure. An examination of the brakes and tyres did not show any indication of abnormally heavy brake application having taken place. All tyres, except the starboard inner (which was still inflated) had deflated as a result of violent contact with a solid object.

An examination of the flying controls and their operating systems, together with the flying control trimmer systems, revealed no evidence of pre-impact failure. There was no evidence to suggest that the flying controls had been jammed by any foreign object.

The cockpit centre console had not suffered any significant impact or salvage damage and it was therefore possible to operate the associated levers and interlocks.

Detailed examination revealed that it was possible to move the telescopic section of the gust-lock lever to the fully 'down' position regardless of the fore and aft angular position of the lever (see figures 5 and 7). Once in the down position, considerable force was needed to move the lever in a fore and aft direction.

Examination of the gate plate in the control console indicated that it was basically a type 15/0.4120 plate, ie a one piece component with a paxoline facing layer which was installed on early 748 aircraft at the time of manufacture. It was noted, however, that the paxoline facing layer was no longer present, but that a steel plate had been rivetted over the basic metal component to form the profile of the HP cock slot and the left-hand side of the gust-lock lever slot. In addition, a steel strip was rivetted along the right-hand side of the slot, although of the three holes in this strip, only two were occupied by rivets. The strip was thus free to deflect sideways (being curved in vertical profile), and therefore did not contribute to the lateral location of the gust-lock lever. It has not been possible to determine when this freedom of movement first came into being.

Examination of these steel rivetted components indicated that they did not conform to the drawings for any of the standards of gate plate produced by the aircraft manufacturer and either incorporated as original parts or made available as replacement components to operators.

The distance between the 'locked' and 'unlocked' detents of the gate plate was found to be approximately 11% shorter than the minimum specified by the manufacturer.*

The gate-stop strip on the gust-lock lever was found to have a protrusion at its upper end which indicated that it was originally manufactured from a thicker strip than that used as standard by the aircraft manufacturer. The strip did not conform to the manufacturer's drawings.

Measurements were made of the gust-lock lever slot width, and the total thickness of the lever and gate-stop strip. These were then compared with the nominal dimensions and tolerances specified at manufacture by the aircraft's constructors. It should be noted, however, that the thickness of the gate-stop strip decreased slightly over the lowest 0.3 inches of its length and that the protrusion already mentioned occupied the top 0.4 inches of the strip. The bottom contact face was chamferred instead of flat.

* *Note: At the time of the accident, the relevant dimensions were not mentioned in any of the technical publications available to operators.*

The actual dimensions and the manufacturer's figures were as follows:

| | MANUFACTURER'S FIGURES | MEASUREMENTS ON G–BEKF |
|---|---|---|
| Total thickness of lever and gate-stop strip | 0.296 + .003 in<br>– 0.000 | 0.283 in (constant over most of the length of the gate-stop strip) |
| Width of Slot | 0.260 ± .020 in | 0.272 in |
| Difference between lever/gate-stop thickness and slot width | 0.016 in MIN<br>0.059 in MAX | 0.011 in |

At the time of the accident no wear limits on either the slot width or the gate-stop strip and lever thickness were supplied to operators by the manufacturer.

The post-accident condition of the cockpit control console permitted functional testing of the interlock between the FFPS withdrawal lever and the gust-lock lever to be carried out.

It was established during these tests that a throttle angle corresponding with take-off power could be obtained on both throttles when the gust-lock lever was positioned anywhere between the 'off' detent and an angular position approximately 45% of travel back towards the 'on' detent.

It was further established that the performance of the interlock system complied with the requirements specified in the manufacturer's Maintenance Manual and their Maintenance Schedule.

Failure of the fuselage and wing structure during the impact made functional testing of the complete gust-lock operating system impossible.

## 1.13 Medical and pathological information

The autopsy confirmed that the cause of death in all 17 casualties was by drowning. Everyone on board had survived the impact, although nearly everyone had sustained minor injuries of the face, the limbs or the abdomen. Of the two survivors who were detained in hospital, one had a fractured ankle due to his foot being trapped under his seat, the other had internal injuries due to flexing over his seat belt.

No medical factor which might have caused the accident came to light after full autopsy with toxicology and histology on both pilots and all 15 dead passengers; nor any factor which could be said definitely to have contributed to the accident. However, traces of the hypnotic drug Dalmane and of the tranquilliser Frisium were found in the co-pilot. The quantities were consistent with the dosage prescribed for him by his family doctor in early July, 1979. The doctor had specifically advised him not to take them when flying.

Medical opinion is that neither drug on its own, in the quantities found, should have caused any measurable deterioration in his performance, although the Frisium might have reduced his alertness and sense of urgency. There is also the possibility that there might exist some synergistic effect, whereby the effect of both drugs together would be greater than the sum of their effects separately.

The Royal Air Force (RAF) Institute of Aviation Medicine advise against the use, by aircrew, of Flurazapam and Clobazam, the principal active constituents of Dalmane and Frisium respectively. The CAA Medical Department's opinion is that Flurazapam should only be prescribed for pilots after careful warning of its short-term and cumulative effects; and that any pilot for whom tranquillisers such as Clobazam need to be prescribed is temporarily unfit to fly. This is known to airline Medical Advisers, but not necessarily to all General Practitioners. In the case of this pilot, neither his company medical adviser nor the CAA Medical Department were aware that the drugs had been prescribed.

## 1.14 Fire

There was no fire.

## 1.15 Survival aspects

### *1.15.1 Initial evacuation*

There is evidence to indicate that everyone on board was properly strapped in and survived the impact with the sea. The stewardess, who was sitting in the rear row of passenger seats on the port side, nearest the aisle, shouted to the passengers to keep calm. Almost immediately water started to pour into the cabin through the rear (port) passenger door, the split in the fuselage forward of the wing, and possibly, the front freight door and direct vision (DV) windows, which were found hanging open. It has not been possible to establish exactly how the doors became open, except that it is probable that the front freight door was opened by one of the crew. The overwing exits were opened by the passengers adjacent to them and most passengers initially attempted to leave by the exit nearest to them. However, shortly after impact, the aircraft had begun sinking nose first and further water poured in through the overwing exits and, subsequently, the main door. This caused considerable confusion and indeed near panic amongst some of the passengers. The stewardess managed to struggle to the rear main passenger door and assisted a number of passengers to leave before being, herself, forced out by another passenger.

Escape from the cabin was soon made very difficult by the steep nose-down attitude which the aircraft assumed, the rush of incoming water and the debris in the cabin. Debris also prevented access to the starboard rear door. From the evidence of the divers it must be concluded that at least 6 passengers and, probably, one of the pilots were unable to escape from the fuselage before drowning. From survivors' statements, it is concluded that 17 of them left via the rear main door on the port side, 5 via the port overwing hatch, 7 by the starboard hatch and one by the front freight door.

### *1.15.2 Lifejackets*

Because of the short time available for escape and the crush of people struggling towards an exit, most survivors did not have time to use, were unable to find, or had difficulty in extracting their lifejackets. Three people donned their lifejackets, which inflated correctly, and three others donned them but were unable to inflate them properly when using the 'toggle': one of the latter jackets was subsequently inflated by mouth. Of the 24 survivors who did not use their lifejackets, 6 reported that they were unable to extract them from their respective stowages.

Subsequently, an investigation was carried out of those lifejackets recovered after the accident, and the results are given in paragraph 1.16.3.

1.15.3 *Subsequent survival efforts*

Some passengers initially climbed out onto the starboard wing and the tailplane, but were quickly forced into the sea by the waves; the remainder made directly for the shore. The survivors were assisted to some extent by the fresh on-shore wind, but had to contend with a very choppy sea and the rapid onset of exhaustion caused by shock, cold and sea water polluted by kerosene from the aircraft's ruptured fuel tanks. Several survivors afterwards reported that conditions had been made worse by the waves and spume generated by the helicopters hovering nearby. On reaching the shore, large breakers and the irregular slippery surface of the sea defences made the climb onto dry land very difficult, despite the efforts of those on the shore to assist them.

1.15.4 *Initial helicopter presence*

Two Sikorsky S.61 helicopters (non-Search and Rescue) were in operation in the area at the time of the accident. On hearing of the emergency on the RTF (tower frequency), both offered their assistance in the rescue operation. The first arrived within two minutes of the crash, the second, four minutes later. Neither of these aircraft was equipped with a winch, but each had a jettisonable dinghy which was dropped to the survivors. The wind and waves caused both dinghies to fall out of the reach of the swimmers and overturn; subsequent efforts, by the helicopters, to blow the dinghies towards the survivors, failed. Both aircraft commanders considered alighting on the water near the wreckage but abandoned the attempt due to the severity of the condiitions and the danger of high waves striking the tail rotor. Upon the arrival of the 'Search and Rescue' helicopter, at 1613 hrs, the other two aircraft ceased over-water operation and assisted with ground support.

1.15.5 *Emergency services*

The accident was seen from the control tower and also the fire station. 'Crash Alert' action was taken immediately, at 1601 hrs, by the appropriate ATC personnel.

1.15.5.1 *Initial rescue operations*

The two appliances and the ambulance, which constituted the Fire Service 'immediate response' equipment, arrived on the road adjacent to the crash site 2 minutes after the accident. The Fire Service Landrover, towing the Zodiac inflatable dinghy, arrived on site 4 minutes later, at 1607 hrs. Upon arrival, the firemen immediately began rescue operations. Many voluntary helpers, mostly from a nearby construction site, came quickly to the scene in order to support the efforts of the official rescue services. Some of the early arrivals fastened ropes around their waists and went into the sea to assist survivors swimming towards the shore; they were helped by at least two survivors who went back into the sea to rescue others. In the hostile environment that prevailed at the shore line, distinguishing the survivors from rescuers was sometimes difficult.

1.15.5.2 *The Zodiac inflatable dinghy*

At 1607 hrs the Landrover and Zodiac, driven by the Chief Fire Officer and the Airport Manager, arrived at the scene. After sizing up the situation they came to the conclusion that, in the light of previous practice launching attempts in similar conditions, to launch the dinghy from that position would be dangerous if not impossible. The dinghy was therefore taken to a more sheltered point on the south side of Virkie Pool, some 300 metres to the northwest, and launched there, crewed by 3 volunteer firemen. At about 1610 hrs it arrived at the crashed aircraft but the crew saw no survivors. They were however able to retrieve a body from the water.

1.15.5.3 *The Police*

Immediately they saw the accident, ATC alerted the police, who then telephoned the 'Incident Officer' at his home. The police contingent met at the police station to collect radios and equipment and arrived on site at around 1610 hrs. The Incident Officer then took charge of the coordination of the rescue operation, whilst another officer went to the mortuary to receive and identify the bodies as they were brought in.

1.15.5.4 *Motor Vessel (MV) 'Quest'*

A local fishing vessel, *MV Quest*, was manned by the owner as soon as he heard of the accident. With a volunteer, he made all speed to the accident site, and assisted in the search for survivors.

1.15.5.5 *The Search and Rescue (SAR) Helicopter*

When alerted at about 1602 hrs, the helicopter 'DA', which was on standby at one hour's notice, was immediately stripped of its passenger role equipment and the winch fitted. This work was carried out by an engineer, voluntary helpers and the remainder of the crew whilst the commander went to be briefed on the detailed requirements. This task completed, the helicopter took off and arrived at the crash site at 1613 hrs.

Upon arrival, the crew saw 4 bodies floating in the water, 2 face down and 2 survivors. Whilst *MV Quest* picked up one of the survivors, 'DA' picked up the other and carried him, on the winch, to the shore. In the efforts to pick up one of the bodies, the crewman on the end of the cable swallowed kerosene-polluted water and had to be winched into the helicopter. After he had been replaced by another crew member, 'DA' took the survivor from *Quest* to the ambulance on the shoreline. Having ascertained that there was no further task, the crew returned to base.

1.15.5.6 *The Coastguard*

The Coastguard was contacted by ATC at 1604 hrs, and fired maroons to summon the lifeboat crew from the vicinity of the town of Lerwick. After necessary preparations the lifeboat cast off at 1625 hrs and proceeded at full speed to the accident site where it arrived at 1725 hrs.

Because of the on-shore wind and shallow water, the lifeboat stood off and launched its inflatable dinghy to assist with the recovery of the bodies. At about this time a number of other boats also arrived at the site to give assistance, whilst divers who had been brought to the scene by helicopter, freed several bodies from the wreckage.

1.15.5.7 *Recovery*

The survivors on the water's edge were placed in all available vehicles and helicopters for transport to the Wils Ness terminal. Because the latter was more convenient to the accident site than the old, Virkie, terminal, the Incident Officer decided to continue its use as the reception centre.

In the terminal, the medical alert team from the hospital at Lerwick, two doctors from the surgery at Levenwick and a considerable number of voluntary helpers provided first aid, clothing and refreshment for the survivors. The local doctor, on being alerted to the accident, went initially to the Virkie terminal. On discovering that in fact the Wils Ness terminal was being used as the reception centre, he encountered some delay before he could find transport and cross the 15/33 runway which was in constant use.

Meanwhile, facilities were prepared at Lerwick hospital to receive the survivors who were flown there, from the terminal, by helicopter. Of the thirty survivors, 2 did not need to be taken to hospital, 20 were received and discharged, 6 were kept overnight and 2 stayed for major medical attention.

1.15.5.8 *Note on co-ordination of emergency services*

Responsibility for the co-ordination of the emergency services rests with the Home Office, through the Police, if the accident site is on land, and with the Department of Trade, through the Coastguard, if the accident occurs at sea.

## 1.16 Tests and research

### 1.16.1 *Take-off run evaluation*

An evaluation of the take-off run was carried out by specialists of the Department of Industry with the assistance of the Royal Aircraft Establishment (RAE), Bedford.

Test runs in an HS 748 aircraft at RAE, Bedford, confirmed that there was a change in static position error (PE) on throttling back the engines, and this information was used in a series of take-off runs which were simulated on a computer to compare them with the FDR airspeed data. The accident conditions were used where these had been established with certainty, the remaining parameters were varied as required to simulate a number of different cases. The results are shown graphically at Appendix 3A, and associated data at Appendix 3B. The following comments apply:

The computer run with closest agreement to the FDR airspeed and heading deviation readout was designated 'the principal run' and is represented by the continuous line in Appendix 3A. It starts at about 25 metres from the beginning of the runway, assumes a 12 knot headwind component at aircraft height, and predicates first contact with the sea about 20 metres beyond the shore line. On this run, reasonably good correlation with the FDR airspeed trace was obtained during the acceleration period, with, perhaps, some evidence of 'stickiness' in the recording. The comparison indicates that the aircraft's acceleration was normal until approximately 28½ seconds after start of take-off roll and about 5½ seconds after $V_R$, when the throttles were closed.

As regards the deceleration period, it proved impossible to obtain good agreement with the FDR trace, which if taken at face value, indicates a very gradual reduction in thrust initially, followed, after the aircraft had left the hardened surface, by an impossibly rapid deceleration. It is concluded that the airspeed trace is erroneous in the period between about 30 and 34 seconds after the start of the take-off and that this could have been due to one or both of the following events:

1. temporary 'sticking' of the airspeed trace as had occurred on previous flights
2. a change in PE caused by excessive aircraft yaw during this period.

Although no evidence of wheel braking was apparent on the runway or overrun area, it is considered that in the probable condition of the aircraft at the time, with full down elevator and high airspeed, little or no physical indication of braking would have been present. On the balance of the available evidence, therefore, it seems probable that the brakes were applied about 1 second after the throttles were closed. It must be concluded that the flight fine pitch stops were not withdrawn during the deceleration phase. They were found to have been in the engaged position at impact and there is no evidence to suggest that they might at one stage have been withdrawn and subsequently re-engaged.

Computer run 2 confirms that the aircraft could have stopped well before the end of the runway if the take-off had been abandoned at the target $V_1$ speed. Runs 3, 4 and 5 indicate that it could have been stopped in the overrun area if the take-off had been abandoned within about 2½ seconds after reaching $V_R$; but that any greater delay would have resulted in the aircraft overunning the perimeter road.

A further run, not shown on the graph, used the same assumptions as the principal run but with a headwind component of 16 knots* at aircraft height. It indicated that, for the accident take-off to end co-incidentally with the end of the FDR airspeed trace, it would have had to have started some 90 metres along the runway from the take-off end. In view of eye witness evidence that the take-off run commenced from near the beginning of the runway, a starting point some 25 metres along, as assumed in the principal run, would seem the more likely.

Run 6 was included to demonstrate the effect had the pilots used GFP in addition to wheel braking after having made the decision to abandon the take-off. The results suggest that the aircraft would probably have crossed the perimeter road at a speed some 10 knots lower than in the accident case, and that, assuming there was no intervening contact with the protruding concrete blocks, its nose would have struck the sea just off the shore line.

Using the data obtained from the principal computer run mentioned above, a separate computer programe was developed to estimate the pitch angle of the body axis of the accident aircraft when it struck the water. Based on an initial estimate attitude of about 7° nose-down when the aircraft left the road, it is estimated that its attitude on striking the sea would have been about 11° nose-down. Had the aircraft left the road with undercarriage undamaged, it would probably have struck the sea in an attitude about 5° nose-down with wings approximately level.

An attempt to correlate the propeller slash marks found on the perimeter road with the ground speeds deduced from the computer runs proved to be of little value, due to the wide possible range of propeller rpm at the time.

*1.16.2 Tests on gust-locks and associated systems*

During the investigation, a number of serviceable HS 748 aircraft were used to carry out tests on the gust-lock and associated interlock systems.

* *The average value of headwind component recorded at the time of the accident, using the standard correction for anemometer height versus aircraft height.*

1.16.2.1 The first such test was carried out to evaluate the theory that under certain circumstances it might be possible for the elevator lock to become re-engaged during the 'full and free' control checks before take-off.

The gust-lock lever was moved to a position approximately 30% of travel away from the unlocked detent. With the lever held securely in this position, the control column was cycled fully aft and then allowed to return under its spring pressure to the forward stop. With the gust-lock lever still fixed in its original position, and the control column remaining fully forward, the rudder pedals and the aileron control wheel were then moved simultaneously to full travel and returned to neutral. Thus the requirements of the 'full and free' check had been demonstrated, albeit in a particular sequence.

It was found that the elevator lock had become re-engaged.

Subsequently, further attempts to reproduce this phenomenon were carried out. It was found possible to repeat it in some, but not all, cases. The main factor that appeared to affect the repeatability of this effect was the initial position taken up by each of the lock rollers (see figure 2) when the gust-lock lever was moved to the position approximately 30% of travel from the unlocked detent. Such forward movement of the lever caused the individual locks to move away from the fully locked positions. However, it was found that the sequence of movement of the locks is not repeatable and that the relationship between lock position and lever position is only uniquely defined when the system is fully locked or fully unlocked. Thus, on some occasions all three locks will become free nearly simultaneously during forward movement of the gust-lock lever, while on others one lock may move to the fully disengaged position, or nearly so, before either of the other locks begins to disengage.

If the latter situation occurs, then it will be necessary to move the gust-lock lever further forward than in the former case, before all three locks are sufficiently disengaged to allow the 'full and free' control check sequence to be carried out. It will therefore be more difficult for movement of the aileron and rudder lock rollers, resulting from the exercising of these controls, to create sufficient movement in the lock operating cable system to make the elevator lock re-engage. Any backward movement of the gust-lock lever after the three locks have disengaged, however, will, if all three controls are biased slightly away from their locked positions (neutral for aileron and rudder, fully down for elevator), position the system so as to make more likely the re-engagement of the elevator lock on carrying out the 'full and free' checks in the sequence detailed above.

1.16.2.2 Tests were also undertaken on the throttle/FFPS/gust-lock lever interlock system of an in-service aircraft.

These confirmed that on correctly rigged aircraft it was frequently possible to achieve a gust-lock lever position between the 'on' and 'off' detents at which full throttle operation could take place with the elevator lock still engaged.

1.16.2.3 A test was carried out to establish the forces on the gust-lock lever needed to move it to the fully unlocked position if the aircraft should reach a typical rotation speed with the elevator lock still engaged. It was found that at that airspeed the elevator lock could remain engaged even though the gust-lock lever was moved fully to the 'controls unlocked' detent position; the additional lever movement was accommodated by the elasticity of the gust-lock control cables.

1.16.2.4 A further test was carried out to evaluate the control column forces needed to rotate the aircraft at or near $V_R$ with the elevator trim set in the full nose-down position using a configuration and conditions similar to those of the accident aircraft. A series of test runs indicated that a force of between 70 and 110 lb would be needed to rotate the aircraft and maintain it in the air.

1.16.2.5 During the examination of various HS 748 aircraft, it was established that operators had on occasion found it necessary, when fitting replacement gate plates, to file them or to drill holes for the attachment bolts in positions not coincident with the original pilot holes, in order, presumably, to make them fit or to ease the movement of the gust-lock lever.

1.16.3 Examination of the lifejackets recovered from G-BEKF and the lifejacket installation in the aircraft.

A detailed examination of the lifejackets was undertaken, following reports from some survivors that they had been unable to inflate their jackets. In addition, several passengers had referred to difficulty in reaching back under their seats far enough to extract their lifejackets or to having problems in opening the pouch to release the lifejacket and valise.

The approved type of pouch and valise in use produced a roughly tubular package which was mounted athwartships underneath the seats. An alternative approved installation, also designed for use with the type of seat on the aircraft, consisted of a similar package, but mounted beneath the seat along the fore and aft axis. This latter installation affords only marginally improved accessibility, but on undoing the pouch the lifejacket and valise are ejected forwards. It was noted that, in both installations, the close proximity of the seat in front presented an obstacle to bending forward sufficiently to reach the pouch. In addition, because the pouch was difficult to see, release of the valise was made more awkward, often requiring the use of both hands.

Forty-eight adult and two infant lifejackets were carried in the aircraft. A total of forty-seven jackets were recovered, forty-six adult and one infant. Of the ten jackets recovered and already out of their valises, eight, including the infant lifejacket, had discharged gas cylinders. One of the ten had a large tear in the fabric adjacent to the inflation head, thus precluding further testing. The remaining nine jackets were tested by inflating them, those which had exhausted gas cylinders being re-equipped with correctly charged ones. Eight, including the infant jacket, inflated correctly but one failed the inflation test due to the gas leaking through the oral valve. Detailed examination of this valve revealed that grit and salt deposits were fouling the valve seat, a condition consistent with past immersion in the sea. The exhausted cylinders which had been removed were all found to have been screwed into the heads tightly and, with the exception of that belonging to the infant jacket, all had their diaphragms pierced in a manner consistent with normal operation of the gas inflation system. The infant jacket gas cylinder was exhausted, although the diaphragm remained intact.

In summary, the examination did not provide any specific indication as to why any survivors' jacket should have failed to inflate. However a number of factors related to the lifejackets and their use, although not necessarily relevant to survival in this accident, are noteworthy:

The lifejacket stowage on G-BEKF, athwartships beneath the seats, although in accordance with the Flying Services Type 2001 seat overhaul and maintenance manual, did not afford easy access. However the alternative stowage, fore and aft beneath the seats, could be considered only marginally better.

The permissible time period between inspections of some lifejackets already ten years old was four years, subject to 5% sampling at two years, although Dan-Air inspected all jackets annually.

Individual instruction cards concerning the use of lifejackets were not supplied, a single card being mounted on the forward wall of the aircraft cabin. This could be said to comply with Article 13(5) of the ANO, although the placard was not easily readable from the rear of the cabin. It is understood that the CAA is considering an amendment to the ANO in respect of this item.

The 'overnight' leak test of lifejackets as performed by some operators, including Dan-Air, although apparently approved by the jacket manufacturer and the CAA, does not appear in the manufacturer's approved overhaul manual.

The contents of the infant lifejacket gas bottle had apparently leaked away. It is understood that this type of gas bottle has now been redesigned.

## 1.17 Additional information

### *1.17.1 Miscellaneous information relevant to the HS 748 gust-lock system.*

#### *1.17.1.1 Inspection of the gust-lock system on, and subsequent to, the aircraft's return to UK.*

Before granting a Public Transport category C of A to the aircraft on its return to the United Kingdom, the CAA required the operator to carry out a programme of work on the aircraft and on the technical documentation. This included a Maintenance Schedule alignment check on the aircraft, a check of CAA mandatory modifications embodied and embodiment of those not already present, together with the carrying out of all Mandatory Service Bulletins for the type.

No requirements related specifically to the gust-lock system,and there was no specific requirement to remove the control console gate seal plate and thus reveal the gate plate.

At the time of the accident, the manufacturer's Maintenance Schedule did not require the gate seal plate to be removed at any time, and none of the various gate plate modifications available from the manufacturer were classed as mandatory. Therefore there would not appear to have been any occasion during the initial inspection of the aircraft on its return to the United Kingdom or during subsequent maintenance operations when examination of the gate plate was specifically called for by the manufacturer or the CAA.

#### *1.17.1.2 Maintenance records*

An examination was undertaken of the limited number of technical records available for the aircraft relating to the period of some 15 years when it was in Argentina.

Work cards covering the time in which the aircraft was in British ownership were also examined. These indicated that the aircraft had been maintained in accordance with the Dan-Air Maintenance Schedule, which does not differ significantly from the manufacturer's Maintenance Schedule.

No evidence was found in either set of records of any repair or modification action carried out on the gust-lock lever gate plate or the lever itself. Subsequently senior engineering personnel of Dan-Air have sworn affidavits to the effect that no repair or modification to the gate plate or lever was made by Dan-Air.

*1.17.1.3* *Technical log entries*

Entries in the technical log for the aircraft over a 6 month period up to the date of the accident include the following references to problems encountered with the operation of the gust-locks:

1 February 1979

Elevator and aileron gust-locks disengage unless pointing into wind. Ailerons and elevators both need checking for snatch damage

28 February 1979

Elevator lock difficult to disengage

12 March 1979

Elevator gust-lock reluctant to disengage

4 April 1979

Flying control locks do not disengage cleanly, will clear with movement of lever

13 April 1979

Aileron locks disengage, even in light wind conditions.

In cases where entries referred to difficulties in disengaging locks, remedial action took the form, on 28 February 1979 and 4 April 1979, of lubrication of the gust-locks at the rear, followed by operation of the lock system, which was found to function satisfactorily.

In the case of the 12 March entry, the 'Action Taken' section states:

'Suspect due to wind loading on elevators: The elevators seemed to be engaged all the time. Ground functioned several times, operation 'Satis'.'

The technical log notes that a Check A of the aircraft was due on 30 July 1979 and a further note in the 'Action Taken' section indicates that a Check A was carried out on that date. At the time of the accident there was no record of any outstanding defect.

*1.17.1.4* *Other relevant accidents and incidents – see Appendix 4*

*1.17.1.5* *Manufacturer's modifications to the HP cock/gust-lock gate plate prior to the accident*

At the time of the manufacture of G-BEKF, the standard design of the gate plate in the control console was a one-piece component with cut-outs forming the gates and detents for the HP cock controls, propeller brake control and gust-lock lever.

In 1965 a modification classified by the manufacturer as 'desirable' was introduced. This involved cutting away the existing gate plate in the areas of the HP cock slots, followed by drilling the plate for the installation of eight anchor nuts. Two plates of a new design were then secured to the original plate with bolts. Each plate contained a new HP cock slot, and the right-hand side of the right-hand plate formed one edge of the gust-lock lever slot. This modification was introduced because the original plate was difficult to change when worn.

In 1968 the modification was revised in that the detachable plates were replaced by steel plates of a new design with reinforcements to the HP cock lever and gust-lock lever detents. In 1971 a further modification classified by the manufacturer as 'optional' was introduced, which replaced the plates by a thicker design of 10 gauge one piece steel plates.

Since the accident, it has been established that a number of operators have experienced considerable difficulty with the installation of both the latter designs of gate plates; also that, once installed, considerable variation between aircraft existed in the resulting gust-lock lever slot width.

1.17.2 *Subsequent action*

1.17.2.1 *Manufacturer's Service Bulletins issued since the accident*

(i) On 17 August 1979, an Alert Telex Service Bulletin was issued by the manufacturer and made mandatory by the CAA for all UK registered aircraft. It was transmitted to all operators and required compliance to be achieved within 7 days of its receipt.

It detailed dimensional checks to be carried out in the gust-lock lever gate plate area to ensure that sufficient distance between the locked and unlocked detents existed. It also required certain checks to be made of the relationship between the width of the lever slot and the thickness of the gust-lock lever itself.

A check for the possible presence of damage or of unapproved repairs to the gate plate or lever was also called for. If the dimensions checked did not comply with those stated, a new gate plate was to be fitted and the system re-rigged in accordance with the Maintenance Manual.

The Bulletin also called for a check of free movement of the elevator lock with the gust-lock lever in the 'off' position, to be followed by a re-rigging of the system in accordance with the Maintenance Manual if the lock movement exceeded that specified in the Bulletin.

(ii) In March 1980 a Mandatory Service Bulletin was issued to all operators superseding the Alert Telex. This introduced new checks in the console area together with replacements or modification if found necessary as a result of implementing those checks. In particular a minimum interference dimension between the gate-stop strip and lever thickness and the slot width was introduced. This figure was 0.035 inches.

Checks on the free movement of the elevator lock with the gust-lock lever in the 'off' position, already mentioned in the Alert Telex, were repeated and amplified. Reference was made to certain checks to be carried out on the throttle/FFPS/gust-lock lever interlock.

Comments were requested from operators, world-wide, on the results of their inspections.

(iii) In November 1980 the March 1980 Service Bulletin was revised and re-issued in the light of operator's comments. In addition, the new Bulletin mentioned forthcoming revisions to the Maintenance Manual affecting the setting up of the interlock between the throttles and the FFPS control. These were intended to eliminate any possibility of inadvertent withdrawal of the FFPS lever with the throttle levers in any position other than fully closed.

1.17.2.2 *The overrun area for Runway 09 at Sumburgh Airport*

The CAA has taken steps to consolidate the eroded area at the far end of the RESA (see paragraph 1.10) to prevent the repeated formation of a step between the eroded area and the perimeter road which forms part of the RESA.

1.17.2.3 *The CAA have taken the following additional action subsequent to the accident:*

(i) in August 1979, they issued Notice to Air Operator's Certificate (AOC) Holders No 4/79 requesting operators whose aircraft are fitted with mechanical flying control locks to remind pilots of the importance of checking flying controls for full and free movement after the locks have been disengaged. It was emphasised that this check should be no less thorough if it is carried out while the aircraft is turning on to the runway or is about to commence its take-off run;

(ii) they consulted their Consultant Engineers regarding the possible re-design or elimination of the protruding concrete blocks forming part of the sea wall, without serious detriment to the sea defences. However, the Engineers recommended that no change should be made on these lines, but rather that a further 40 blocks should be constructed at the south east corner to enhance the sea defences;

(iii) the advice of the Coastguard service was sought on various alternative means of projecting lifelines to survivors in the water.

1.17.2.4 Dan-Air now provide safety leaflets for passengers in other HS 748 aircraft and are preparing them for all other aircraft types which they operate. They are fitting CVR's in their HS 748 fleet.

1.17.2.5 The British Helicopter Advisory Board is issuing guidelines to operators of helicopters, which are not SAR equipped, flying in the vicinity of an accident.

1.17.2.6 In April 1980 an Inquiry under the Fatal Accidents and Sudden Deaths Inquiry (Scotland) Act 1976 was held at Aberdeen before Sheriff Alisdair Macdonald.

The Sheriff determined that the cause of death in the case of all 17 casualties was through drowning as a result of the aircraft accident. He noted that, on the evidence available, it was not possible to reach a final view as to the cause or causes of the accident. He was satisfied that all the rescue and emergency services provided after the accident were prompt and effective and called for no criticism. He made recommendations to the CAA concerning:

(i) the manner of stowage of lifejackets in HS 748 aircraft and the adequacy of pre-flight instructions as to their location and use;

(ii) the carriage of Cockpit Voice Recorders in aircraft such as the HS 748.

The Sheriff further stated that he felt bound to make these recommendations because of certain evidence laid before him; but there was no evidence that the accident or any death would have been prevented by a different method of stowage of lifejackets, or by improved pre-flight instructions as to their location and use, or by the presence in the plane of a cockpit voice recorder.

1.17.3 *Pilot response times*

1.17.3.1 In order to obtain further data on pilot response times, an experiment was undertaken by the RAF Institute of Aviation Medicine (IAM) using a flight simulator with visual attachment and the ability to lock the elevator control at any time and in any position. A gust-lock lever was not fitted. Extracts from the report on the experiment are given at Appendix 5.

In summary, seven practising airline pilots and one RAF pilot of varying experience and age were told that the experiment concerned measuring response times to various (unspecified) emergencies. After a detailed briefing they were given an uneventful solo flight followed by a number of circuits and landings during which engine failures on take-off were simulated. On the final take-off, the control column was locked shortly before $V_R$.

The average response time between the call 'Rotate' and the pilot touching the throttles was 2.7 seconds; the average time between 'Rotate' and the onset of brake pedal pressure was 3.4 seconds.

1.17.3.2 *Psychologist's opinion*

A psychologist from the RAF Institute of Aviation Medicine was consulted concerning the estimated time interval between the aircraft reaching $V_R$ and the probable time of throttle closure. An extract from his opinion is as follows:

'I believe that there are three main factors which contributed to the 5 second delay between $V_R$ and the throttle closure on this aircraft, namely:

(i) the time which would be required for both pilots to identify an unprecedented problem and assure themselves that increased back pressure on the stick would not cure it;

(ii) the inevitable small but possibly significant delay between the aircraft reaching actual $V_R$ (99 knots), the call to this effect, and the onset of response by the controlling pilot;

(iii) the radical change of thinking, or 'set', required of a crew whose training and experience would lead them to have every expectation and belief that after $V_1$, any problems would have to be dealt with in terms of the aircraft becoming airborne. The hostile nature of the overshoot at Sumburgh could only have heightened such an attitude.

In view of the above considerations, I feel that the 5 second delay in question is not only unsurprising, but may be regarded as a reasonably prompt response to an extremely unusual and unfortunate emergency.'

1.17.3.3 *Relevant aspects of previous accident reports*

In an accident to a CL44 aircraft LV-JSY at Miami International on 27 September 1975, the take-off was abandoned at very high speed, and the aircraft overran the 9350 foot runway and was destroyed.

The United States National Transportation Safety Board (NTSB) report concluded that an external lock had been fitted to the starboard elevator in lieu of the aircraft's internal lock for that surface, which was unserviceable. The external lock had not been removed prior to the attempted take-off*; the effect on reaching $V_R$ would have been to prevent the commander rotating the aircraft without excessive pressure on the control column. Calculations showed that the take-off was not rejected until at least 5½ seconds after $V_R$, and possibly as late as 14 seconds after $V_R$.

In an accident to a Convair 880 at Miami on 16 December 1976, the crew were forced to abandon the take-off when a forward-of-limits centre of gravity prevented rotation, and the aircraft overran the runway by 320 metres. The US Federal Aviation Authority (FAA) subsequently contended that the captain had unnecessarily delayed abort (abandon take-off) procedure after $V_R$ by making a trim adjustment and trying again to lift the aircraft nose. In reversing this ruling, the NTSB stated that crew training demands that after $V_1$ ('take-off committal speed') aborting is no longer considered an option.

1.17.4 *Sumburgh Airport Emergency Procedures*

1.17.4.1 A study of the Airport Emergency Orders (38 pages) current at the time of the accident showed that there was no mention of casualty collection points, medical control centres, or of special procedures to be followed in the event of an off-shore accident, nor was there mention of detailed procedures for the recovery of survivors.

However, according to the Airport Authority, practices including simulation of aircraft accidents off-shore and use of the appropriate emergency procedures had taken place prior to the subject accident.

1.17.4.2 The revised Airport Emergency Orders (70 pages), issued in January 1980, include references to the subjects mentioned above, omitted from the previous edition of the Orders.

* *The flying control surfaces on the CL44 are servo-tab operated. Therefore when the aircraft is at rest, full fore-and-aft movement of the control column can be achieved regardless of whether the elevator surfaces are free.*

# 2. Analysis

2.1 The evidence from the eye-witness accounts indicates that the take-off was abandoned at a late stage, well after $V_1$ had been attained, when the flight should have been continued and the climb-out commenced.

It was established from analysis of the FDR airspeed trace that acceleration was normal for the first 28½ seconds of the take-off run and, when the engines and propellers were examined subsequently, no evidence of any malfunction was found. Nor was there any evidence of crew incapacitation, or of fire or smoke. The absence of rotation and evidence from the aircraft's ground tracks indicated the distinct possibility that a problem occurred associated with the elevator controls. In relation to these controls, possible sources of trouble are as follows:

(i) mis-set elevator trimmer

(ii) cable or pulley breakage

(iii) jamming by foreign objects

(iv) failure to move the gust-lock lever from the 'on' position and to carry out 'full and free' checks

(v) gust-lock lever moved to a 'false detent' position short of the correct 'off' detent with the result that the elevator controls either did not disengage or became re-engaged during the 'full and free' checks.

The various possibilities are considered in more detail below:

(i) The elevator trimmer may have been left in or near the fully nose-down setting and the handling pilot had been unable to rotate the aircraft. However, flight tests showed that, with the trimmer in this position, the pull force required to rotate the aircraft into a climbing attitude could be achieved by an average pilot using both hands. Indeed, the forces were such that some degree of rotation could be achieved by a pilot using one hand;

(ii) a cable or pulley in the elevator control system might have broken. A thorough examination of the wreckage showed no evidence of such pre-impact failure;

(iii) the elevator control system became jammed at some point either by a foreign object or by a mechanical failure in the system itself. However, no evidence could be found on either score. Moreover, for the accident to follow, it would pre-suppose in addition that the jamming occurred after the pilots had carried out their 'full and free' checks, or that they did not complete them;

(iv) the gust-lock lever was not moved away from the 'on' position and the 'full and free' checks were not carried out. This cannot have occurred since the interlock between throttles, FFPS lever and gust-lock lever would have prevented take-off power from being achieved until the gust-lock lever had been moved forward by a considerable proportion of its total travel;

(v) the gust-lock lever was moved forward to a position short of the 'off' detent and the telescopic section lowered, giving the lever the appearance of being in the 'off' position and, also, freeing the throttles, although achieving insufficient forward movement of the gust-lock lever to free the elevator lock. A 'full and free' check on the elevator was then omitted;

Incorrect positioning of the gust-lock lever would have been possible on the accident aircraft. Omission of the 'full and free' check on the elevator is a possibility that cannot be ruled out, but is considered unlikely because, of all the checks that a pilot has to complete, the 'full and free' checks prior to take-off could be considered the most vital. Additional evidence is provided by the statement of the passenger who saw the ailerons moving up and down at about this time; this suggests that at least one part of the checks was carried out;

(vi) the gust-lock lever was moved forward and down as in (v), but in this instance sufficiently far forward to free the throttles and allow the 'full and free' checks to be completed in a manner such that the elevator lock subsequently became re-engaged.

Possible troubles associated with the gust-lock system are discussed in detail below.

## 2.2 The gust-lock and associated systems

*2.2.1* On initial examination of the gust-lock system, it was postulated that the 11% shortfall in distance between the 'on' and 'off' detents could have been the cause of the elevator lock not withdrawing. However, on further investigation, it was established that a considerably greater shortfall would be needed in an otherwise correctly rigged aircraft before the elevator lock could remain engaged with the lever in the 'off' detent or, alternatively, that the 11% shortfall would have to be accompanied by severe mis-rigging of the control cables.

Subsequent examination of the cockpit console disclosed that the condition of the gust-lock lever gate-stop strip and the gate plate was such as to permit the lever to be moved in its slot to the fully down position at any point between the locked and unlocked detent (see paragraph 1.12.2).

Such a condition, combined with a pilot action of moving the lever forward whilst applying downward pressure to the upper telescopic section, can result in the lever being moved to a position having the general appearance of being 'off' when, in fact, the lever has not reached the 'off' detent. Since the telescopic section would be 'down' and the gate seal plate and rubber seals render the locked and unlocked detents invisible, the pilot might be misled into assuming that this is an indication that the lever is in the 'off' detent. Thus this particular safeguard against incorrect positioning of the gust-lock lever would be nullified. Further investigation showed that on an aircraft with the cable system correctly rigged, a lever position more than approximately 25% of travel back from the 'off' detent can allow the elevator lock to remain fully engaged.

The mechanical safeguard against failure to release the locks before take-off is the interlock intended to prevent the throttles from moving to the take-off power position with the gust-lock system engaged. However, it was discovered that, on the accident aircraft, free movement of the throttle levers to the take-off power position was possible when the gust-lock lever was in a range of positions from the 'off' detent to a point approximately 45% of travel back towards the 'on' detent.

The performance of the interlock system complied with the manufacturer's requirements and indeed the manufacturer has stated that the system was not intended to give protection when the gust-lock lever is positioned between the 'on' and 'off' detents. Protection against this contingency was intended to be provided by the fact that, whilst in any intermediate position, the lever would be standing unmistakably proud.

It is reasonable to assume from the evidence that on the accident aircraft it would have been possible to put the gust-lock lever to a position that was sufficiently aft from the 'off' position for the elevator lock to remain engaged, but was none the less well forward and did not stand proud to give the normal indication of the unsafe state of the locks. It would thus have had the general appearance of being in the 'off' position. At the same time the throttles would have been free to be fully advanced to the take-off power position. Nevertheless, it is considered less than likely that the above sequence of events precipitated the accident, because a locked elevator condition should normally have been discovered if the pilots had completed their 'full and free' flying control checks prior to take-off.

Subsequent analysis of the operation of the system, however, indicated that the action of carrying out 'full and free' checks in a particular order could, under certain defect conditions, result in *re-engagement* of the elevator lock even though it was initially free, with no restriction of movement detectable during the check. This phenomenon was demonstrated during the tests described in paragraph 1.16.2.1. In those tests, the first action was to move the gust-lock lever to a position some 30% of travel short of the 'off' detent and to fix it securely in that position. This simulated the effect that could be shown to result from the defect found in the accident aircraft, ie the fact that the telescopic gust-lock lever could be lowered at any fore and aft angular position between the locked and unlocked detents and would then become firmly lodged at that angular position.

When the 'full and free' checks were then carried out in the order specified in the tests, it frequently, but not invariably, resulted in no restriction being detectable in any of the flying controls, even though the final stage of those checks could cause the initially free elevator lock to re-engage. In view of the standard operating technique of accelerating the aircraft to rotation speed with the control column held at the forward stop position (coinciding with its position when the elevator is locked) the crew could remain unaware that the control column could not be moved back, until the relevant rotation speed was reached.

As described earlier, the throttle interlock on the accident aircraft would not provide a warning of a partly engaged lock situation until the lock lever was at least 45% of travel short of the 'off' detent. The tests indicate that accidental re-engagement of the elevator lock during 'full and free' checks could occur at gust-lock positions more than approximately 25% of travel back from the 'off' detent. Thus on the accident aircraft there was an area of lever travel between 25% and 45% away from the 'off' detent, within which the lock lever may have been fully lowered and so appear to be in the 'off' position, the 'full and free' checks may have revealed no control restriction, the elevator lock may have re-engaged during those 'full and free' checks and the throttle interlock would not have prevented take-off power from being achieved on both engines. Although it cannot be proved that the above pattern of events actually took place, they are consistent with the observed and recorded behaviour of the aircraft and with the established condition of the gust-lock lever and the setting of its throttle interlock system. They must therefore be considered the most likely cause of the aircraft's failure to rotate. Furthermore, from tests carried out after the accident it was established that if the take-off run had begun with the elevator lock engaged, it might not have been possible to disengage it by gust-lock lever movement once the aircraft had attained a speed approximating to rotation speed.

2.2.2 *The premature lowering of the gust-lock lever*

The premature lowering of the telescopic gust-lock lever was made possible because of a lack of interference between the gate-stop strip on the lever and the gate plate on the left hand side of the lever slot. An examination of these components on the accident aircraft showed that they did not comply with the manufacturer's tolerances for new components.

The factor controlling the interference between the lever and the slot is the difference between the total thickness of the upper telescopic section of the operating lever, including the gate-stop strip, and the greatest width of the lever slot measured between the 'on' and 'off' detent positions. In the accident aircraft, the measured interference was found to be 0.005 inches less than the minimum figure which would satisfy the manufacturer's tolerances specified for new aircraft. In addition a chamfer existed on the bottom edge of the strip and its lower 0.3 inches was slightly tapered in thickness. There were, however, no wear limits specified on these dimensions, and the Maintenance Schedule produced by the manufacturer did not call for periodic inspections of the gate plate. Thus any wear could remain undetected.

It must therefore be concluded that either the interference provided by the manufacturer's components should have been greater or the manufacturer should have prescribed suitable wear limits and periodic inspections.

An examination of the gate plate showed that it had been repaired or modified by the addition of plates rivetted on both sides of the slot and that the plate on the right hand side had come loose as a result of the loss of one of the securing rivets. Neither the gate-stop strip nor the rivetted plates complied with the manufacturer's design drawings.

Examination of the technical records of the aircraft during the last two years, which covered the period it had been on the British register, revealed no evidence of any component changes or repairs to either the gate plate or the lever and gate-stop assembly. The records covering the preceding 15 years, during which it was in Argentine ownership, are less comprehensive but do not mention repairs or modifications to those components. Similarly, correspondence with the Argentine authorities indicated that they had no evidence of such work being undertaken while the aircraft was under their jurisdiction. Thus it proved impossible to establish with certainty how or where the non-standard work had originated although, in view of the comprehensive nature of Dan-Air's technical records and their evidence given in affidavit (paragraph 1.17.1.2), it seems most likely that it dated from before the aircraft was returned to the UK. It was further noted that a sister aircraft, belonging to the same Argentinian operator which had owned G-BEKF had, in 1967, suffered an over-run accident on take-off. As part of their rectification action, that operator had subsequently, with the knowledge of the aircraft's manufacturer, rivetted a stainless-steel strip to the locking slot thereby forming a 'new locking slot for the lever'. This repair appears from documentation raised at the time, to have had some similarity to the non-standard gate plate modification on G-BEKF.

It is apparent that the non-standard parts fitted to G-BEKF were not discovered during the inspection of the aircraft by the operator, in conjunction with the CAA, when the aircraft was re-imported into this country. Normally the CAA require a check to be carried out on an aircraft's documentation and modification state at the time of its importation, in order to ascertain its condition. To take the matter considerably further and inspect every detail of the intricate systems of a modern aircraft for non-standard parts or unapproved re-work is beyond the reasonable bounds of practicality. Since the CAA had apparently received no reports which might have alerted them to potential problems with the gust-lock system on HS 748 aircraft, it is not unreasonable that they did not prescribe specific requirements for an inspection of the gate plate area on the aircraft in question. Since there was no requirement in the manufacturer's Maintenance Schedule to remove the gate seal plate in order to inspect the gust-lock lever gate plate, the presence of the faulty components were never discovered before the accident.

2.2.3 *Significance of problems previously reported on G-BEKF*

Although in the period leading up to the accident, the technical log of the aircraft had a number of entries relating to difficulties experienced in operating the gust-lock system, these items were apparently rectified at the times of occurrence. The fact that such difficulties occurred on a number of occasions did not draw special attention to G-BEKF, apparently because difficulty of gust-lock operation was a common problem within the fleet and was largely accepted as being a characteristic of the design.

It is possible that the presence of a throttle baulk, together with the use of 'full and free' control checks as a standard pre-take-off checklist item may have created a false sense of security on the part of the operators. It could hardly have been conceivable to them that the problems encountered were the manifestation of a fault that could cause one of the control locks to become re-engaged after a 'full and free' check had apparently been carried out successfully.

Nevertheless, the technical log entries relating to the gust-lock problems on G-BEKF emphasise the vital importance of maintenance personnel making themselves aware of any problem areas which recur and ensuring that they are analysed in sufficient depth to establish the underlying cause of the particular problem. However, it should be recognised that without a very thorough knowledge of the functioning of the gust-lock system, coupled with very observant inspection, it is unlikely that the potential hazard of premature gust-lock lever lowering which allows elevator lock re-engagement during 'full and free' checks, would have been discovered on this aircraft. Such detailed knowledge of this peculiarity of the gust-lock system was not to be expected of the maintenance personnel of typical operators. The information is not incorporated in the manufacturer's Maintenance Manual in a readily understood form, and the only people with sufficient information to appreciate the significance of the kind of problems noted in the technical log of G-BEKF would have been the manufacturer's design engineers. The latter would not normally have known of the presence of such technical log entries, however, unless the entries obviously related to problems so severe as to cause the operator to contact the manufacturer for detailed technical assistance. With the information available to the operator prior to the accident, the problems noted in the log could not reasonably be considered to be in this category.

2.2.4 *Significance of other incidents and accidents (see Appendix 4)*

2.2.4.1 *Incident to LV-HHH at Concordia, Argentina, 21 March 1967*

This incident was attributed by the manufacturer to a combination of defects in the aircraft's gust-lock system, in conjunction with the failure of the pilot to carry out 'full and free checks' on the flying controls. This failure to carry out the checks was, strongly denied by the crew.

The description of the manufacturer's representative at the scene mentions that the locking slot was very badly worn at the 'off' position, allowing the lever to be put to an apparently 'off' position when approximately 0.2" short of full travel. During rectification, a re-inforcement was fitted to the locking slot by rivetting a stainless steel plate into place. This formed the 'new locking slot for the lever'. Although the manufacturer's explanation for the incident is entirely feasible, and the remedial action taken evidently prevented a recurrence, it neglects the possibility -- which apparently had never been considered at that date – that the condition of the slot might have permitted lowering of the gust-lock lever between detents and that the fitting of a reinforcement strip corrected the defect. Therefore the likelihood of re-engagement of the elevator lock during the 'full and free' checks cannot be discarded any more than can the pilot's report that he had completed such checks.

It must be concluded that there remains a possibility that the LV-HHH incident was caused by the same set of factors as may have caused the G-BEKF accident.

2.2.4.2 *Accident to VT-DXO at Rajkot, India, on 7 March 1975*

From the evidence available (summarised in Appendix 4) it appears that the Indian Inspector of Accident considered the possibility of the elevator gust-lock not having been fully released. The idea was refuted by the manufacturer in correspondence with the operator, principally on the grounds that the throttle baulk would have limited throttle movement to less than take-off power. Investigations since the accident to G-BEKF have, however, confirmed that this is not a reasonable assumption, ie the baulk cannot be relied on to give warning of a single lock in an engaged position and the manufacturer has since stated that it was never designed to do so.

Subsequently the operator concerned suggested to the manufacturer that the accident might have been caused as a result of attempting to take-off with full nose-down elevator trim applied.

Recent tests have shown, however, that the force on the control column needed to rotate the aircraft under such out-of-trim conditions is much lower than that calculated at the time, and could be achieved by a single pilot. Therefore the above theory can now be largely discounted.

The cause of the Indian accident therefore remains undetermined, but the possibility clearly exists that for one reason or another the elevator lock was not successfully disengaged by the crew or became re-engaged after initial disengagement and that, subsequently, the throttle baulk was not effective in warning of this engaged condition.

2.2.4.3 *Incident to G-BEBA at Leeds – Bradford (UK) on 18 May 1977*

In this incident no fault was found in the aircraft after a very detailed examination following the take-off attempt. The aircraft was returned to service without any adjustments to the flying control or gust-lock systems being found necessary, and thereafter operated without any sign of a similar problem recurring and, for a considerable time, without need for adjustment of any part of the gust-lock system.

There appears to have been no mechanical reason why the elevator lock should not have disengaged once the gust-lock lever was positioned in the 'off' detent. Similarly, no fault was found on the aircraft such as would allow the carrying out of 'full and free' checks to cause the elevator lock to re-engage.

It cannot therefore be established what caused the failure to rotate during that incident; no tangible evidence has been found to link its cause to that of G-BEKF.

2.2.4.4 *Accident to HS-THG at Chiang Rai, Thailand, on 21 June 1980*

This accident being the subject of an investigation by the Thai authorities, it is inappropriate to comment on the basic facts given at Appendix 4.

2.2.4.5 *Summary – previous accidents and incidents*

With hindsight, there are indications that the accidents/incidents to LV-HHH and VT-DXO may have contained ingredients of the subject accident to G-BEKF. They are examples of the type of problem which, when brought to the attention of the design organisation might have alerted them to the hazard brought on by typical in service wear. It is most unfortunate that the cause of the incident to G-BEBA remains unresolved and that no comment can be made on the Thai accident, since the official report is not available.

2.2.5 *Design and certification aspects of the gust-lock system*

The HS 748 gust-lock system was designed to comply with Chapter D4-8 of the British Civil Airworthiness Requirements (BCARs) current at the time of initial type certification. This section stated in part that:

'the (gust) locking device shall be such that while it is engaged it will provide to the pilot unmistakable warning which it is impossible for him to ignore.'

The requirement was complied with to the satisfaction of the airworthiness authority at the time by providing an interlock which prevented throttle movement to the take-off power position when the gust-lock lever was in the 'on' detent and a telescopic gust-lock lever which stood obviously proud on the throttle console if it was positioned incorrectly between the 'on' and 'off' detents.

The system was in line with typical design philosophy at the time of original certification; however, since it does not provide a direct indication of gust-lock position, it cannot be relied upon to give positive warning of an unsafe lock position when a fault is present in the operating mechanism. In particular, it must be appreciated that the warning arrangements are an integral part of the operating system. Under certain fault conditions, not only can these warning arrangements be rendered unreliable but, in addition, the pre-take-off 'full and free' check may cause an undetected re-engagement of the elevator lock to take place. The particular fault which has been shown to cause this hazard can only be eliminated in service by applying very careful dimensional control to the gust-lock lever gate plate and gate-stop strip in addition to rigorous control of all other aspects of the maintenance of the system.

2.2.6 *Effectiveness of post-accident action*

Since the accident to G-BEKF, the manufacturer has made considerable efforts to prevent a repetition by requiring additional inspections as well as by introducing new tolerances and corresponding amendments to the aircraft's Maintenance Manual by way of Mandatory Service Bulletins. However, in the light of recent experience, it is questionable whether the checks and rectification actions called for in the current Bulletin are described sufficiently clearly and, in particular, whether the standards of workmanship and inspection required are not too demanding to be properly complied with by all HS 748 operators.

It is of particular significance that the HS 748 was designed as a rugged, 'DC-3 replacement' type aircraft, and that the majority of operators of the type consist of smaller overseas companies flying in widely varying conditions and often with limited engineering resources, over whose standards of maintenance the CAA and the manufacturer have little or no control. It must be concluded that, under these conditions, the rigorous control of all aspects of the maintenance of the gust-lock system which are demonstrably necessary for the aircraft's safety may not be achieved on a continuing basis by all HS 748 operators.

Accordingly, it is strongly recommended that serious consideration be given to the re-design of the gust-lock system so as to ensure that positive operation of the locks is achieved at all times and that the possibility of the crew remaining uncertain or being misled as to the position of any lock is eliminated.

During the course of any re-design, particular attention should be paid to the special problems of incorporation and subsequent maintenance by typical overseas operators possessing limited engineering expertise and resources.

2.3 **Performance considerations**

Due to inaccuracies in the FDR, notably an apparent fault in the airspeed channel, it was not possible to make an exact evaluation of the aircraft take-off run. However, the following comments are considered to be valid:

All the indications are that the acceleration of the aircraft was normal until, approximately 5½ seconds after $V_R$ had been reached and at a speed in the region of 113 knots IAS, the throttles were closed. The brakes were applied about one second later, but the flight fine pitch stops were not withdrawn, with the result that maximum possible retardation was not achieved.

As the graphic representation of the take-off run and alternative procedures shows, any delay in abandoning the take-off beyond about 2½ seconds after $V_R$ would have resulted in the aircraft overrunning the perimeter road. Had GFP been selected in the accident case, in accordance with the prescribed abandonment procedure, the aircraft probably would have crossed the perimeter road some 10 knots slower than was actually the case, and first struck the sea not far from the shore line.

2.4 **Human factors**

It was not established who was the handling pilot for the take-off. According to company regulations, the commander should have fulfilled this role, because of the co-pilot's inexperience on the type, and there is some support for this assumption since the co-pilot made the final RTF calls. However, if this was the case, it is surprising that the commander had apparently switched the compass selector – which is normally selected to the handling pilot – to the co-pilot's instrument. It is, nevertheless, possible the commander intended that the co-pilot should assume control after take-off or that the switch was moved during the aircraft's evacuation or salvage.

Referring to the last two items of the checklist, there is some support for the hypothesis that the co-pilot may have pushed the gust-lock lever down into a 'false detent' position without moving it fully forward. He was inexperienced on the type and so might not have had the 'feel' of the required lever movement to the same extent as a more type-experienced pilot. Furthermore, his record was not one of absolute reliability, and there is just the possibility that he may still have been affected by the sleeping and tranquilliser tablets that he had taken previously. Although he had been warned by his family doctor not to take them whilst flying and, in fact, may not have taken them for at least 24 hours before the accident, expert medical opinion is that the tranquilliser Frisium taken alone or, more especially, together with the hypnotic Dalmane, may possibly have reduced his alertness. There is no positive evidence that he was so affected and his behaviour was reported as perfectly normal earlier in the day; nevertheless it is clear that in the opinion of both Civil Aviation and Royal Air Force medical experts, this pilot was unfit to fly at the time of the accident. That he had been taking these medicaments was not known either to his company or the CAA, both of which organisations had promulgated warnings to pilots on the possible dangers of medication and flying, and in particular concerning the taking of tranquilisers and sleeping tablets.*

There is no reason to believe that, when the checks were being carried out, the commander failed to monitor the actions of the co-pilot, as he was required to do, although the possibility cannot be ruled out that his attention was temporarily distracted. Furthermore, all HS 748 pilots are conditioned, and indeed entitled, to expect that, once the gust-lock lever is raised out of the 'engaged' detent and moved forward so as to disengage the control locks, it will only be possible to lower it again when it is far enough forward for all the locks to be fully disengaged. Therefore the average pilot might, with a quick glance, re-assure himself that because the lever is fully down it must necessarily be fully forward. This particularly applies to the co-pilot, whose normal angle of vision is such that he is looking down onto the lever from nearly above it rather than from the side (see photographs at plates 5 and 6). The commander is seated at a better angle to view the fore-and-aft position of the lever, but when the throttles are closed, as is usual whilst the checks on the flying controls are being carried out, his view of the lever could have been partially obscured if the lever was well back from the correct, 'off', detent position.

One argument against the hypothesis concerning the re-engagement of the elevator lock, is that it presupposes that the aileron and rudder controls are checked for 'full and free' movement virtually simultaneously. It is the normal practice for the commander to exercise the rudder whilst the co-pilot checks the ailerons and elevator. However, a HS 748 co-pilot does not normally check the ailerons at exactly the same time that the commander is checking the rudder, because he will almost certainly cause the aileron control handwheel to strike the commander's upraised knee. It is entirely possible to envisage circumstances, however, in which the commander might decide to carry out all three control checks himself, in which case he could, without difficulty, check the rudder and ailerons simultaneously without contacting his knee in the process. Alternatively, if he had designated the co-pilot as the handling pilot, he might easily have allowed the latter to do all three 'full and free' checks himself, in which case the same argument applies.

* *Dan-Air Operations Manual General Part 1 Section 6 and CAA Aeronautical Information Circular (AIC) 14/1974 (now superseded by AIC 1/1980) refer.*

If it is assumed that the 'full and free' checks were completed, then, because the control column is normally left in the forward position and, during the take-off run, is held there by the handling pilot, the latter would very probably not have noticed that the elevator was not free until he attempted to pull back on the control column at or close to $V_R$. The flight simulator experiment in pilot response times demonstrated that the average reaction time in somewhat idealised circumstances, without a gust-lock lever and when recently briefed to expect emergencies, was just under 3 seconds. It has already been concluded that to stop the aircraft before the end of the perimeter road, the take-off would have had to have been abandoned within approximately 2½ seconds of reaching $V_R$.

Further evidence concerning pilot responses is provided by the opinion of the aviation psychologist quoted in paragraph 1.17.3.2 and the NTSB reports mentioned at paragraph 1.17.3.3. The crux of the matter is that an airline pilot is trained according to the discipline that the decision speed, $V_1$, is just what its name implies: if there is a serious malfunction before $V_1$, he stops, if it occurs after $V_1$, he is expected to continue and to deal with the problem in the air; abandoning the take-off is purely an option of last resort. Because the discipline is observed on every take-off the airline pilot can become completely steeped in it, and a considerable mental effort is required to reverse the decision process.

In the accident case therefore, it was not surprising that after $V_R$ had been reached and the elevator was found to be immovable, over 5 seconds passed before the decision was made to abandon the take-off. The crew would most probably have appreciated that if they remained on the ground an accident was almost inevitable. One could therefore well imagine the handling pilot making several desperate attempts to rectify the problem, for example, calling to the non-handling pilot to assist him, checking the elevator trim position, checking and possibly partially re-cyling and pushing fully forward the gust-lock lever. It seems credible that only when these measures failed would the crash into the sea be accepted as inevitable and the take-off be abandoned.

The fact that the brakes were probably applied about a second after the throttles were closed corresponds well with the results of the simulated locked elevator tests mentioned above. Although the brakes should, theoretically, be applied simultaneously with the throttles in an emergency stop, there is evidence that most pilots find difficulty in so doing.

It remains a matter of conjecture as to why the aircraft veered and subsequently skidded to the left shortly after the take-off had been abandoned and why GFP was never selected. The turn to the left is unlikely to have been deliberate, since the commander would have known that a right turn, if executed early enough, would have provided a less hazardous overrun path. Perhaps the most likely explanation is that both pilots were occupied until a late stage in attempting to free the locked elevator condition. Regarding the failure to select GFP, a possible explanation is that, if one or both throttles are left slightly forward, or bounce forward from the closed position, it may not be possible to withdraw the FFPS lever, due to the action of the FFPS lever/throttle interlock mechanism. This situation can and should of course be remedied by fully closing the throttles.

## 2.5 Survival aspects

### 2.5.1 *General*

The whole concept of modern public air transport operations is based on the premise that, during take-off, an aeroplane in trouble will either be able to stop on the runway or continue to climb away, albeit possibly at a lesser rate than normal. Certain margins are allowed for in case of an overrun accident; in the case of an airfield of Sumburgh's category the margin consists of an extra 150 metres of overrun area beyond the end of the runway, as explained in paragraph 1.10.

Statistics show that overrun accidents in which aircraft have failed to stop within the prescribed overrun area are rare. Nevertheless, when they do occur, they are liable to be severe, depending on the nature of the terrain or obstructions beyond. However, it would be unreasonable to expect an airport authority to cater fully for the exceptional circumstances of this particular accident, in which the take-off was not abandoned until some seconds after the maximum speed scheduled for a 'normal' abandonment. It could be argued, with some justification, that the temporary presence of a 'lip' or step at a point 20 metres from the far end of the RESA did not present a foreseeably unacceptable risk. The eroded area had previously been filled in a number of times by the Authority; however, there is no doubt that in the circumstances of the accident the step caused serious damage to, indeed 'endangered', the aircraft, contrary to the criteria set out in CAP 168. It must be pointed out that the criteria are not mandatory and that the CAA considered the obstruction as a temporary one and therefore not inconsistent with their policy of allowing concessions when the risks are not unacceptably high.

In this connection it is noteworthy that only the previous year CAP 168 had been subject to substantial revision, the principal effect of which was to provide 'criteria' in place of 'standards' and to allow dispensations at the discretion of the Authority from the standards previously required to be met by a licensed aerodrome. Although no doubt the present document conforms to ICAO standards and recommendations, the evident relaxation from the previous standards can only be seen as a retrograde move, and a reconsideration of the content of CAP 168 would seem highly desirable.

In difficult overrun situations such as Sumburgh, where the sea defences provide an apparently unavoidable extra hazard, it is recommended that the provision of some form of retardation device should be re-considered. It is understood that the CAA, as the Airport Authority, have taken measures to eliminate the step once and for all.

The primary factor which influenced the possibility of survival in this accident was the rapidity with which the forward part of the fuselage sank. Aircraft ditching characteristics are considered at the design stage, but only with respect to a comparatively controlled event. It is unrealistic to expect the design requirements to cater for the circumstances of an uncontrolled ditching in a nose-down and banked attitude, as in this event. There seems a reasonable probability that the aircraft would have remained afloat for a longer period if it had crossed the perimeter road and contacted the sea with wings level and undercarriage undamaged. The computer studies showed that, in this condition, the aircraft would have struck the sea in an approximately $5^{o}$ nose-down attitude; this assessment is subject to a considerable margin for error, and it has not been possible to determine whether or not the fuselage would have remained intact. However, had the port wing remained attached to the fuselage, the overall buoyancy of the aircraft must have been improved.

2.5.2 *Initial evacuation*

The impact with the sea caused the aircraft to break its back and the left wing to detach, with the result that it started to sink by the nose almost immediately. As the emergency exits were opened, more water poured into the sinking aircraft. Fortunately, it appears that all on board were properly strapped in, and no-one was incapacitated by the crash. However, the cabin filled with water very quickly, assuming a steep nose-down attitude, and there was a rush for the emergency exits verging on panic.

The stewardess's behaviour in attempting to calm the passengers and subsequently to marshal a number of them out of the rear door was exemplary and almost certainly helped to reduce the number of casualties. The fact that the passengers were all comparatively young, fit and used to the environment, must also have increased their chances of survival. As might be expected under these circumstances, those passengers nearest to the emergency exits were, in general, the most successful in escaping from the cabin.

It seems probable that the lack of a full demonstration of the donning and of the operation of lifejackets and the absence of individual safety leaflets did not affect the survival prospects of the seasoned passengers, and the procedure adopted complied with the Air Navigation Order. However, from the experience of this accident, it would seem prudent that on all public transport flights taking-off or landing directly over water, complete lifejacket demonstrations should be given, and individual safety leaflets provided.

A number of survivors complained of difficulty either in locating and extracting their lifejackets, or alternatively, in inflating them.

Investigation disclosed that the first problem was due partly to the fact that hand luggage placed under the seats in some cases impeded access to the lifejacket stowages, but was mainly due to the positioning and method of attachment of the stowage. The stowages were positioned well back under the seats and the method of attachment of each pouch was such that two hands were often needed to open it and extract the jacket. Furthermore, the seat pitch in the accident aircraft was sufficiently close to make it extremely difficult to reach the stowage properly without tipping forward the back of the seat in the row ahead. In the rush to evacuate the aircraft, and the short time available, this process was often impossible. It would seem that, were the lifejackets to be repositioned immediately under the front of each seat, their accessibility would be much improved, and any hand luggage could be pushed behind them. The alternative installation, which involves mounting the stowage fore-and-aft, instead of sideways, may produce an improvement, but cannot be regarded as a satisfactory long-term solution.

The post-accident investigation of the adult lifejackets themselves revealed no specific indication as to why several failed to inflate. The most probable explanation is considered to be that in the rush to inflate them and escape, passengers did not pull down firmly and sharply enough on the inflation toggle, a procedure which is essential. It is of note that although a number of passengers reported that they had inflated their lifejackets before leaving the aircraft, a practice never to be recommended in normal ditching circumstances, on this occasion they were fortunate in having no apparent difficulty in escaping.

### 2.5.3 *Miscellaneous rescue aspects*

2.5.3.1 It is evident that in general the emergency services reacted promptly and efficiently to the accident and there were a number of instances of considerable bravery during the rescue operation. Inevitably, after every major accident such as this, there were aspects which could be improved upon in the light of experience and these are discussed in subsequent sub-paragraphs.

2.5.3.2 There was no mention in the Airport Emergency Orders of specific procedures to be implemented in the event of an off-shore accident, although such accidents had been simulated and emergency procedures practised. The orders have since been revised, and procedures included. Although the responsibility for off-shore rescue belongs to the Department of Trade, Marine Division, (HM Coastguard), in circumstances such as these they cannot reach the accident site as quickly as those on the airport. It is therefore recommended that, in the case of airports with runways facing out to sea, the airport authorities concerned and the Home Office (through the Police) liaise with the Department of Trade, Marine Division (through HM Coastguard) so that procedures for rescue close off-shore may be agreed and promulgated.

2.5.3.3 The Sumburgh Airport Emergency Orders current at the date of the accident specified the (old) Virkie Terminal building as the emergency reception centre, whereas when the accident occurred those in charge designated an area in the newly opened, Wils Ness, terminal as the centre. This delayed the arrival of the local doctor, although not to a critical extent. The revised Emergency Orders have been up-dated in this respect.

2.5.3.4 Although very well intentioned, the presence of the two non-SAR helicopters caused considerable difficulty to survivors swimming in the rough seas on account of down-wash. The guidelines to be circulated by the BHAB should prevent a recurrence.

2.5.3.5 Had the emergency services on shore been equipped with some form of launching device for their lifelines, these might have been of considerable assistance in the rescue efforts. Although it is understood that there are drawbacks to such devices, it is recommended that a suitable device be developed, if necessary, and provided at coastal aerodromes.

2.5.3.6 The Zodiac dinghy available to the emergency services arrived too late to help survivors, in spite of the best efforts of its crew.

Although distinctly desirable, it would apparently be a very large undertaking indeed to provide (i) the required sheltered launching points for rescue vessels, near the extended centre-lines of the two runways which face the sea; the runways would necessarily be facing almost into wind when in use (ii) rescue vessels themselves, able to accommodate the maximum number of passengers arriving at or departing from Sumburgh on any one flight. In the circumstances it would appear that money and effort could be more usefully spent in attempting to prevent a serious overrun, as already discussed.

2.5.3.7 Survivors commented that on reaching the shore-line they had great difficulty in climbing over the protruding concrete blocks forming wave breakers. Since the Airport Authority has been advised that no attempt should be made to smooth the concrete blocks, the emphasis must again be on prevention of a recurrence of a similar overrun.

2.5.3.8 Those in charge of on-shore rescue operations had difficulty, at times, in making themselves heard, due to the proximity of the helicopters. It is therefore recommended that, as a potentially useful piece of equipment at the scene of a major accident, loud-hailers be included in the scale of emergency equipment provided at all aerodromes of Category VI and above.

## 2.6 The aerodrome licensing requirements

Sumburgh Airport is not required to be licensed because it is operated by the CAA, who are also responsible for the issue of aerodrome licences. Although it is understood that the CAA applies the same licensing and operating standards to its own aerodromes as it would require from operators of licensed aerodromes, this accident has demonstrated that it is highly desirable that it should be seen to be so doing, and a recommendation is made accordingly.

## 2.7 CVR requirements

Had a CVR been fitted to the accident aircraft, the inquiry would have been much assisted. It should have been possible to determine who was the handling pilot and to obtain a better appreciation of the manner in which the crew carried out their pre-take-off checks. More importantly, it might have provided a better insight into exactly what happened in the cockpit in the critical half-minute of the take-off run. In view of the great benefit to accident investigations and, therefore, flight safety, which experience has shown can be derived from CVR's, it is recommended they be fitted to all public transport category aircraft exceeding 11,400 kg maximum authorised weight.

# 3. Conclusions

(a) *Findings*

(i) The aircraft was correctly loaded and its documentation was in order.

(ii) The crew were properly licensed and sufficiently experienced to carry out the flight. However, the co-pilot had been taking medication of a type which indicated that he was temporarily unfit to fly and which could have affected his performance.

(iii) The aerodrome was not licensed, nor was it required to be.

(iv) The first part of the take-off run was normal, but subsequently the aircraft failed to rotate in pitch. It overran the end of the runway, crossed the overrun area, and came to rest in the sea, in a damaged state, some 50 metres off-shore.

(v) The failure to rotate was probably due to the re-engagement of the elevator gust-lock preventing movement of the elevators.

(vi) The re-engagement of the gust-lock probably occurred during the 'full and free' control check, after the gust-lock lever had been moved forward by one of the pilots to an angular position short of the 'controls unlocked' detent but with the telescopic section of the lever fully retracted.

(vii) The incorrect angular position of the lever remained undetected, since the safeguard against such positioning is the appearance of the fully extended telescopic section of the lever.

(viii) Premature lowering of the telescopic section of the gust-lock lever was made possible by insufficient interference between the gate-stop strip and the gate plate in the control console.

(ix) The lack of interference resulted from some non-standard repairs to these components. The repairs were probably carried out before the aircraft was returned to the British register.

(x) The components had originally been designed with insufficient interference to allow for reasonable in-service wear, bearing in mind that no wear limits were specified by the manufacturer.

(xi) The throttle interlock did not prevent take-off power from being achieved with the elevator gust-lock engaged because it was not designed to give protection against the gust-lock lever being left in an intermediate position.

(xii) It was not possible to determine which of the two pilots was the handling pilot.

(xiii) The pilots would probably have first become alerted to the locked elevator condition at, or close to, $V_R$. The subsequent delay of some 5½ seconds before an attempt was initiated to abandon the take-off cannot be considered excessive.

(xiv) In order to stop the aircraft within the overrun area, using maximum retardation, the take-off would have had to have been abandoned within about 2½ seconds of reaching $V_R$.

(xv) For reasons which are unclear, the pilots did not fully implement the designated abandonment procedure. However, had they done so, the aircraft would still have landed in the sea at a comparatively high speed, although closer to the shore.

(xvi) The aircraft sustained substantial damage when it struck the edge of the perimeter road, which constituted a danger to aircraft and thus did not conform to the criteria recommended in, though not demanded by, CAP 168.

(xvii) The emergency services mounted a valuable rescue effort.

(b) *Cause*

The accident was caused by the locked condition of the elevators which prevented the rotation of the aircraft into a flying attitude. It is likely that the elevator gust-lock became re-engaged during the pilots' pre-take-off check, and that this condition was not apparent to either pilot until the take-off was so far advanced that a successful abandonment within the overrun area could not reasonably have been made. The re-engagement of the gust-lock was made possible by the condition of the gust-lock lever gate plate and gate-stop strip.

# 4. Safety Recommendations

It is recommended that:

*4.1* Serious consideration be given to the re-design of the gust-lock system so as to ensure that positive operation of the gust-locks is achieved at all times and that the possibility of the crew being misled as to the position of any lock is eliminated.

*4.2* CVR's be fitted to all public transport category aircraft which exceed 11,400 kg maximum authorised weight.

*4.3* In the case of airports with runways facing out to sea, the airport authorities concerned and the Home Office (through the Police) liaise with the Department of Trade, Marine Division (through HM Coastguard) so that procedures for rescue close off-shore may be agreed and promulgated.

*4.4* Aerodromes operated by the CAA be licensed in accordance with the requirements for other aerodromes.

*4.5* The content of CAP 168, Licensing of Aerodromes, be reviewed in the interests of upgrading the safety margins contained therein.

*4.6* The CAA reconsider the possibility of the provision of some form of retardation device in or beyond overrun areas at critical aerodromes.

*4.7* Demonstrations of the method of donning and of the operation of life-jackets be required, and individual safety leaflets be provided, on all public transport flights which take-off or land directly over water.

*4.8* Consideration be given to re-positioning life-jacket stowages in HS 748 and other aircraft with similar stowage arrangements, so as to improve their accessibility.

*4.9* A suitable launching device for lifelines be developed and provided at coastal aerodromes.

*4.10* Where not already provided, loud hailers be included in the scale of emergency equipment at all aerodromes of Category VI and above.

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