Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Douglas DC 7C/F E1 - AWG
Report on the accident at Luton Airport, Bedfordshire, on 3 March 1974

LONDON
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1975

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Department of Trade
Accidents Investigation Branch
Shell Mex House
Strand
London WC2R ODP

19 August 1975

The Rt Honourable Peter Shore MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr G C Wilkinson, an Inspector of Accidents, on the circumstances of the accident to Douglas DC 7C/F E1 - AWG which occurred at Luton Airport on 3 March 1974.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 12/75
(EW/C477)

Aircraft:	Douglas DC 7C/F E1 - AWG	
Engines:	4 x Curtis-Wright 988 TC 18EA	
Registered Owner and Operator:	Aer Turas Teo, Irish Independent Airlines	
Crew:	Commander	– Uninjured
	First Officer	– Uninjured
	Flight Engineer	– Slightly injured
Supernumerary Crew:	One pilot	– Seriously injured
Passengers:		– Three injured
		– Three uninjured
Place of Accident:	Luton Airport, Bedfordshire 51^{o} 52′ N 00^{o} 22′ W	
Date and Time:	3 March 1974 at 00.08 hrs	
	All times in this report are in GMT	

Summary

Following a visual approach, at night, to Runway 08 at Luton Airport, reverse thrust was not achieved after touchdown. The brakes did not appear to the crew to be effective and all main wheel tyres burst when the emergency pneumatic brakes were selected 'on'. The aircraft overran the paved area, continued over a steep bank and came to rest in soft ground 90 metres beyond the end of the runway.

Serious injuries were sustained by a supernumerary crew member and some passengers who were not secured in their seats at the time of impact. The aircraft was damaged beyond economic repair; a small fire started which was quickly extinguished.

It is concluded that the accident occurred because of a failure to achieve reverse thrust after touchdown and an inadvertent application of forward thrust during the landing roll. The resulting overrun was aggravated by the operation of the emergency pneumatic brakes which resulted in the bursting of all four mainwheel tyres with consequent loss of braking capability.

1. Investigation

1.1 History of the flight

The aircraft was operating a charter flight from Dublin to Luton, loaded with newspapers and equipment necessary for the conveyance of horses back to Dublin. The passengers were six grooms who were intended to accompany the horses on the return flight.

During the uneventful flight from Dublin to the Luton area the pilot received a surface wind forecast for Luton of 300°/06 knots. At midnight contact was established with Luton Approach on 129.55 MHz. The pilot was given the Luton landing conditions as: 'QNH 1013.5, CAVOK, (ceiling and visibility OK) surface wind practically calm' and asked if he would accept radar positioning for a visual approach to runway 08, to which he agreed. The radar positioning was terminated at 00.04 hrs when the aircraft was cleared to Luton tower frequency with 'Six track miles to run' and the runway in sight. When the pilot contacted Luton Tower on 120.2 MHz at 00.05 hrs, he was cleared to land on runway 08 and given the surface wind as 300 degrees 04 knots. He acknowledged this last transmission and there was no further communication with the aircraft.

The evidence indicates that the approach path and speed were normal. The commander did not notice the Indicated Air Speed (IAS) immediately before touchdown but recalled that the initial approach was made at approximately 130 knots IAS reducing to the target threshold speed of 115 knots as the flaps extended.

The flight recorder readout showed that the aircraft touched down at an IAS of 105 knots. The commander was of the opinion that, despite a tendency to float, the aircraft touched down at the correct distance down the runway, and, as soon as it had done so, he called for reverse thrust immediately the aircraft was on the runway. On receiving the commander's order, the engineer selected reverse thrust on numbers 2 and 3 engines followed by numbers 1 and 4 whilst monitoring the engine instruments. The commander was familiar with this method of selecting reverse which was the technique normally used in the company. The flight engineer did not see the blue warning lights illuminate to indicate that the propellers were moving into reverse pitch, he therefore selected Nos 1 and 4 propellers to forward pitch, with throttles closed, in case the reason for the malfunction was an electrical overload due to operation of all four feathering/reversing pumps at low engine rpm. The commander had also noticed that the blue lights had not illuminated and, seeing that Nos 1 and 4 propellers were selected to forward pitch, called 'reverse all engines'. In response to his order the engineer made the required selection and all four throttle levers were seen to be in the reverse quadrant by the operating crew, although no blue lights were noted. Evidence from the crew, external witnesses and the flight recorder, indicated that the aircraft was not decelerating during this period and that no reverse thrust was achieved. (see Appendix).

The Cockpit Voice Recorder (CVR) then recorded a number of orders by the commander to 'put them in the middle', these were instructions to the engineer to cancel the reverse thrust selections. The CVR also recorded two short periods of engine acceleration noise during the landing roll which, reference to the flight recorder readout showed were associated with the application of forward thrust. Signs of engine acceleration were also noted by external witnesses at a late stage in the landing roll. The commander assisted by the first officer applied the toe brakes, assessed them to be ineffective and, as the aircraft was still not decelerating, applied the emergency pneumatic brakes by turning the operating handle to 'on'. The commander did not notice any deceleration and, consequently, did not follow the procedure of selecting them alternatively to 'hold' and to 'on'. All four main wheels locked, the tyres burst and further retardation from the brakes was lost. Sparks and smoke were seen emanating from the area of the undercarriage when the aircraft approached the end of the runway. When it became apparent that the aircraft would overrun the runway the commander called to have the 'switches' put to 'OFF'. The flight engineer selected the ignition switches off before the aircraft left the end of the runway and ploughed across the overrun area. It was still travelling fast enough to follow a trajectory off the top of the bank at the end of the runway leaving no wheel marks down the slope. The aircraft stopped in soft ground 90 metres from the end of the runway at the foot of the bank having demolished part of the aerodrome fence and some of the approach lights.

When the aircraft had stopped the commander ordered an evacuation, his message being relayed to the cabin area by the flight engineer. All persons on board abandoned the aircraft without delay. As the flight engineer was leaving via the right hand side crew door, he noticed a small fire under the number 3 engine. He returned to the cockpit, pulled the firewall shut-off controls and discharged a fire extinguisher to all four engines. Largely as a result of this action there was no further fire, nevertheless the airport fire services were quickly on the scene and applied foam to inhibit any likelihood of a subsequent outbreak of fire. Some of the passengers had not been secured to their seats when the aircraft crashed even though the seat belt and no smoking signs were illuminated and as a result substained injuries, in one case serious. The supernumerary crew member, who was seated on the unsecured navigator's stool in the entrance to the cockpit and who had chosen not to use the seat provided, which was equipped with a lap strap, also sustained serious injuries.

The aircraft was substantially damaged.

1.2 Injuries to persons

Injuries	Crew	Supernumerary crew	Passengers	Others
Fatal	-	-	-	-
Non fatal	1	1	3	-
None	2	-	3	

1.3 Damage to aircraft

Damaged beyond economic repair.

1.4 Other damage

Some damage to airfield lighting and boundary fences.

1.5 Crew information

Commander	Aged 33 years.
Licence	Irish Airline Transport Pilot's Licence. (Endorsed for P1. DC7 Aircraft).
Instrument Rating and Certificate of Competency	Valid to 19 January 1975.

Last medical examination January 1974 (Valid to 1 May 1974). No restrictions.

Total flying hours	P1. 3,334.20 hours	P2. 1,503.25 hours.
Flying hours on type	P1. 1,185.55 hours	P2. 460.00 hours.

The Commander's technical training for the DC 7C, which included 17 hours 30 minutes simulator, was carried out in Holland in 1969 and was followed by first officer base training at Shannon. After completing 460 hours as a first officer on the type he was given command training which was followed by 123 hours in command under supervision before assuming independent command.

First Officer	Aged 30 years.
Licence	Irish Airline Transport Pilot's licence. (Endorsed for P2. DC7F Aircraft).
Instrument rating and Certificate of Competency	Valid to 8 February 1975.
Last medical examination	25 September 1973. Valid to 11 April 1974. No restrictions.
Total flying hours	P1. 1,537.15 hours P2. 1,606.05 hours.
Flying hours on type	P1. 144.55 hours P2. 343.15 hours.
Flight Engineer	Aged 33 years.
Licence	Irish Flight Engineer's Licence. (Endorsed for DC7F aircraft).
Certificate of Competency	10 February 1974 Valid to 10 February 1975.
Last medical examination	11 April 1973 Valid to 11 April 1974. No restrictions.
Total flying hours	380.17 hours all as flight engineer on DC7 type of aircraft.

The flight engineer was the Chief Engineer of Aer Turas Teo; who, in addition to his duties on the ground, also flew regularly as a flight engineer on DC7C aircraft.

1.6 Aircraft information

1.6.1 *Description: General*

E1-AWG was constructed in 1958 as a passenger carrying DC7C aircraft, manufacturer's number 45471, and was subsequently converted into a freighter before coming on to the Irish register on 9 November 1972. At the time of the accident it had a Certificate of Airworthiness in the 'Transport of Cargo I' category, valid until 20 December 1974.

The aircraft is powered by 4 Curtis-Wright 988 TC 18 EA turbo-compound air cooled radial engines driving Hamilton Standard 34E60 Hydromatic constant-speed reversible pitch four-bladed feathering propellers.

1.6.2 *Electrical system*

The electrical system is supplied by 4 engine driven generators and two 12 volt (v) 88 amp/hour (Ah) lead-acid batteries. The generators are connected to the main bus-bar via line-switch relays controlled by pilot and reverse current relays designed to ensure that generators were 'on line' when generating current at approximately bus-bar voltage, and 'off-line' at lower voltage to prevent any of them from drawing reverse current from the bus-bar.

In addition, an equaliser bus-bar is provided to ensure that the load is equally shared between generators. The equaliser bus detects any differential voltage between adjacent generators and adjusts the controlling currents to the carbon-pile voltage regulators of the appropriate generators to bring the system back into balance. Relays are provided to isolate any failed generator from the balance bus thus permitting the remaining generators to share the load equally. The system is additionally protected by over-voltage and reverse current circuit-breakers.

Each generator has its voltage regulator, pilot relay and differential relay grouped on a single generator control panel. All four of these panels are grouped close to the cabin roof, aft of the flight deck allowing for easy removal and replacement.

1.6.3 *Propeller reversing*

Propeller reversing is achieved by use of the four electrically driven hydraulic feathering pumps, powered by the main 28v bus-bar via two resettable circuit breaker switches, one for each symmetrical pair of propellers. Reversing is initiated by pulling the throttles back to the forward pitch idle position, moving the single reverse lever aft and down to release the mechanical reverse lock and then moving the throttles further aft into the reverse range. The reverse mechanical lock automatically returns to the forward or locked position when one or more throttles are moved beyond the forward pitch idle position. Moving the throttles aft through the forward pitch idle position energises the reversing circuits by means of throttle operated switches which in turn energise reverse solenoid valves in each constant speed unit and the propeller feathering pump motors. The time taken for the normal cycle from forward pitch idle into reverse is approximately 4 seconds. During the reversing cycle, when the blade angle decreases to 22½°, a switch on No. 3 blade of each propeller closes, illuminating one blue light for each propeller, located on the top face of the central pedestal which indicates that the propellers are moving into reverse pitch. After the throttles are moved back through the forward pitch idle position further movement of the throttle levers aft progressively increases engine power. The operations manual contains a warning which states, in part, that 'Pausing in the reverse idle position should be avoided to prevent the possibility of engine stall and to ensure adequate generator output'.

No information has been made available by the manufacturer concerning the effect of accelerating the engines by movement of the throttle levers into the reverse quadrant before the propeller blades have completed moving into the reverse range.

1.6.4 *Emergency pneumatic wheel brake system*

Air pressure for emergency brake operation which is supplied from a cylinder installed in the nose-wheel well is controlled by a three position handle located beneath the glare shield, in front of the captain's seat. The selectable positions of the handle are 'OFF' (lockwired) 'HOLD' and 'ON'.

Movement of the handle to the 'ON' position causes compressed air to flow to a shuttle valve which closes the hydraulic line and opens the air line to the brake units. Movement of the handle to the 'HOLD' position shuts off the air supply but traps the air already in the line. Movement to the 'OFF' position releases this air. Emergency pneumatic brake reservoir pressure is indicated by a gauge on the co-pilot's cockpit wall, the normal pressure being 2,000 psi.

1.6.5 *Maintenance*

At the time of the accident the aircraft had completed 27,838 hours flying. It had undergone a No. 8 inspection at Shannon Repair Services on 24 January 1974, at which time it had completed 27,746 hours flying. Following this inspection a maintenance release, valid for 120 days or 300 hours flying, had been issued by the aircraft's operator, Aer Turas Turanta.

Log book entries show that Nos 1, 2 and 3 voltage regulators were changed respectively on 27 October 1973, during the No. 8 inspection completed on 24 January 1974 and on the 14 May 1973.

No evidence has been found that the No. 4 voltage regulator was changed while the aircraft was on the Irish register.

The serial numbers quoted for respectively Nos 1 and 2 voltage regulators were found to be those of respectively Nos 4 and 2 generator control panels installed at the time of the accident.

The serial number quoted for the number 3 voltage regulator was not found on any aircraft component.

A history of recent brake maintenance (listed below) was derived variously from the airframe log-book, record cards and the aircraft technical log.

Date of change	Brake unit	Number of landings
21 July 1973	3	-
9 August 1973	3	318 max possible
31 August 1973	1	250
7 December 1973	2	104
11 December 1973	4	100

The serial number of the brake unit recorded as fitted in the number 3 position does not co-incide with that of any of the brake units installed on the aircraft. It is not, therefore, possible to establish with certainty the number of landings made by the number 3 brake unit prior to the accident.

Technical log entries show that the right-hand wheel brakes (No. 3 & 4) were found to be very 'spongy' after a flight, approximately 50 hours flying time before the accident. This defect was rectified, but the same units were found to be binding after a flight 24 hours flying time before the accident. This defect was also rectified.

Eighteen flying hours before the accident, the aircraft suffered a complete hydraulic failure when a pipe to a flap actuating jack developed a leak resulting in loss of most of the hydraulic fluid from the system. After rectification, the hydraulic system appeared to function correctly for the next three flights. On the fourth take-off, however, the nosewheel failed to retract. The technical log shows that, during rectification of this defect considerable air was bled from the hydraulic actuating jack of the nosewheel.

1.6.6 *Aircraft loading*

Maximum authorised landing weight - 53,670 kgs. Estimated aircraft weight at time of accident - 48,808 kgs.

Permitted CG range - 14.4 per cent MAC to 32.5 per cent MAC.

Estimated CG at time of accident - 22.1 per cent MAC.

1.7 Meteorological information

Weather at the time of the accident was recorded as:

Surface wind	300°/04 knots
Visibility	12 Kilometres
Cloud	1/8 cirrus 25,000 feet
Air temperature	+ 20°C
Weather	Nil

The runway was dry. The accident occurred at night, with the moon half full.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Satisfactory communications had been maintained between the aircraft and London and Luton air traffic control. Communications are not considered to have been a factor in the accident.

1.10 Aerodrome and ground facilities

Runway 08/26 at Luton airport was 2,160 metres long x 46 metres wide and, with the exception of 441 metres of tarmac at the eastern end, had a concrete surface. The runway surface braking co-efficient was measured as 0.77-0.82. The elevation of the landing threshold of runway 08 was 514 feet above mean sea level (amsl). However the centre part of the runway was level with an elevation of 525 feet amsl up to 500 metres before end of the runway, where the threshold elevation was 504 feet amsl. There was, therefore, a downwards slope for the last 500 metres of the landing run with a gradient of approximately 1 in 66.

With the exception of 4 runway lights, 1 taxi way light and 1 obstruction light, all the airfield lighting was switched on and functioning correctly during the approach and landing. The alignment of the three-bar Visual Approach Slope Indicators (VASI) on runway 08 was checked on 18 April 1974 when small errors of 14, 9 and 6 minutes of arc respectively were discovered on three of the units.

There was a level area of soft ground extending for 50 metres beyond the upwind end of the runway terminating in a steep downward slope of approximately 5 metres. Beyond this slope there was soft ground, which sloped gently down to the aerodrome boundary, upon which the approach lights to runway 26 were located. One of which was demolished in the accident.

1.11 Flight recorders

1.11.1 *Flight data recorder*

The UCDD Flight Data Recorder (FDR) fitted to the aircraft survived the accident and the recorded information was recovered satisfactorily. Although provision was made for recording Indicated airspeed, pressure altitude, magnetic heading and normal acceleration against a common time basis, examination of the foil showed that the heading information had not been satisfactorily retained. Other recorded parameters were not affected and it is possible that the fault originated in the aircraft system supplying the heading input to the recorder.

Measurements for the read-out of other parameters were made at horizontally displaced points on the pressure altitude and indicated airspeed traces equal to nominal time intervals of 1½ seconds for the entire period from 30 seconds immediately prior to touchdown to the end of the recording, and at 3 second intervals for the preceding 1 minute period. Specific readings at intermediate points on the traces were also made where significant divergencies were apparent. Measurements were also made of the normal acceleration trace to establish mean levels before and after touchdown and at input points of significantly high level between the times of touchdown and the aircraft coming to rest. The measurements thus achieved were converted to true parameter values for the FDR using the most recent calibration data supplied by the operator which was dated 14 May 1973. The touchdown point on the runway was used as the indicated height datum. No corrections have been applied to the tabulated data to take account of position error within the pitotstatic system. These converted values were used in the preparation of the Appendix to this report.

1.11.2 *Cockpit voice recorder*

A Fairchild Type A 100 CVR was installed in the aircraft and a recording from this equipment was recovered after the accident. Transcribed information derived from the CVR recording was used, together with the flight recorder data, in the preparation of the Appendix.

1.12 Wreckage

1.12.1 *Examination at the accident site*

The aircraft came to rest 115 metres beyond the end of runway 08 and 15 metres to the left of the extended runway centre-line.

The damage included a circumferential split in the fuselage extending from the aft overwing emergency escape hatch on the starboard side over the top of the fuselage to a point close to floor level on the other side of the aircraft. Most of the frames in the fuselage underside were buckled and/or fractured where the aircraft had come into contact with the ground. The flaps were found in the fully extended position and had been severely damaged on contact with the ground.

The main undercarriage units had both broken away from the aircraft following failure of the radius arms and of the four pivot lugs attached to the main spars. The starboard main undercarriage unit came to rest beneath the starboard tailplane after it had struck the underside of the latter, doing considerable damage. The nosewheel assembly and a large section of the pressure floor above the nosewheel bay had broken away and had entered the forward freighthold. All four main wheel tyres had burst after having been worn away at one point on the circumference.

No. 3 engine and the forward part of its nacelle had become detached downwards just aft of the fire-wall, and the forward section of the No. 3 engine crank-shaft and its front bearing support casing had also failed in downward bending. The propellers were all close to the low-pitch position (of the forward pitch range) and each had at least two blades either bent or broken off. Considerable local damage had occurred to the leading edges of the remaining blades.

1.12.2 *Runway examination*

Examination of the runway revealed four distinct rubber tyre marks extending for a distance of 700 metres and terminating in four mainwheel tracks across the grass at the end of the runway. There was evidence of tyre bursts present on all four marks approximately 530 metres from the end of the runway. The track of the nosewheel was also visible on the grass at the end of the runway.

No ground markings from the aircraft were visible down the slope beyond the end of the runway, the first indication beyond the bottom of the slope being two deep holes made by the main landing gear units approximately 90 metres from the end of the paved runway.

1.12.3 *Aircraft instruments*

The extensive damage to the aircraft prevented complete functional testing of any of the instrument systems being undertaken. The location of the aircraft required its removal in sections from the site before a detailed examination could begin. The pitot static system was subsequently pressure tested in a series of sections. It was found to be within the manufacturer's leak specification over all parts except for a small number of sections damaged in the accident.

Both air speed indicators (ASI) were removed and calibrated. No. 2 instrument was found to be within specification but No. 1 was found, after initial pressurization up to its full scale value, to have developed a zero error of approximately 90 knots. This instrument was therefore subjected to a detailed strip examination. It was found that a push-rod, normally placed between the aneroid capsule and a calibrated spring, was not in its correct position. The pushrod was replaced in its correct position and the instrument recalibrated. It was then found to have a fairly constant error of 50 knots but its linearity was almost within specification.

It is considered that the push-rod had been shaken out of position as a result of impact forces and subsequent pressurization on the calibration rig had caused the unrestrained capsule to deform permanently. There was no evidence to suggest that the instrument was unserviceable before the accident.

1.12.4 *Brakes*

Examination of the brake units of the aircraft revealed that a number of the component discs were worn below the manufacturers' reject thickness. All the discs in the rotating assemblies of brake units 1 and 2 were at or below the reject thickness. In addition, all but three of the stationary discs on No. 2 brake unit were worn below their reject thickness. Nevertheless, in the opinion of the brake manufacturers, the brake units installed on the aircraft at the time of the accident would still have been capable of stopping the aircraft within the certification distance, provided that full hydraulic pressure was available, (see 1.16.1).

The hydraulic brake system was examined and revealed no evidence of pre-crash failure. Due to the considerable disruption of the sytem it was not possible to establish whether air bubbles were present in the fluid before the accident. A sample of fluid from the main hydraulic reservoir was analysed and found to be within specification.

The emergency pneumatic brake control was found to be in the 'on' position and it was established that pneumatic pressure was being applied to the brake units at the time the main undercarriage became detached.

1.12.5 *Electrical propeller controls*

Continuity and insulation tests were conducted throughout the electrical system controlling the reverse pitch operation of the propellers, with the throttle levers set in various positions representing both forward and reverse thrust selections.

Correct continuity was found to exist from the bus-bar side of the reverse control circuit breakers through each system to a relay ('D' relay) with the appropriate throttle lever in the reverse quadrant. No continuity existed through any system with the relevant throttle in the forward range. There was no evidence of insulation failure between adjacent reverse switches or between any of the circuits and earth. The two reverse control circuit brakers were found to be 'made'.

Four switches ('F' switches) on all four systems were in the open position and the switches of the latched relays (D switches) which control the feathering pump relays were found to be still closed in systems 2, 3 and 4 and open in system 1. This indicated that at the time power supplies were isolated from the reverse system – the reverse cycle had begun on propellers 2, 3 and 4.

1.12.6 *Propeller reverse functions*

The electric feathering pumps were rig tested and found to be all working within specification. No evidence was found of failure in the reverse circuits, switches motors or pumps that was not consistent with the damage caused by the final impact.

The reverse pitch warning systems were examined and no signs of pre-crash failure were found. Although the rigging of the throttle cable and lever systems could not be functionally checked owing to the severe damage to the underside of the control pedestal, it was established that all four reverse safety switches and the four reverse operating switches functioned when the throttle levers were set to the appropriate positions.

1.12.7 *Generating system and batteries*

The four engine driven generators were removed and rig tested with their associated control panels. The generators were found to be functioning within specification but the control panels were all found to be badly out of adjustment and not capable of performing correctly.

Three of the voltage regulators had resistances considerably higher than the maximum value under the conditions detailed in the manufacturers' test specification. Two of these regulators were unstable under specification tests. The control panel containing the remaining regulator was found to have all the controlling relays set incorrectly. Examination of the three defective regulators revealed that the carbon pile adjustment locking seals were not intact. The regulator defects had the effect of altering the voltage values necessary to open or close the relevant relays. It is considered that the performance of the whole electrical generating system as examined would have been severely degraded, particularly at low generator rpm and, under conditions of heavy electrical loading, the system would not have been able to maintain the nominal bus-bar voltage without considerable assistance from the batteries.

The two batteries in the aircraft were torn from their housings aft of the nosewheel bay during the accident. One battery casing was totally destroyed while the other was left with four intact cells from which most of the electrolyte had spilled. Examination of the plates of the demolished cells indicated that they had been in good condition before the impact. Electro-chemical tests conducted on the intact cells indicated that they were in good electrical condition but that at the time of spillage they were approximately half discharged.

Examination of the underside of the fuselage between the battery bay and the point where the batteries finally came to rest revealed no sign of arcing between the wreckage and the battery terminals that would account for the partial discharge of the batteries.

Inspection of the fuses on the main power cables from the bus-bar to the feathering pumps from the batteries to the bus-bar and from the bus-bar to all other fuse-protected items indicated that none had blown. Correct continuity existed between the bus-bar and the end of the battery cables where they reached the disrupted area above the batteries.

None of the generator reverse current circuit-breakers had tripped.

No circuit breakers other than the emergency hydraulic pump power circuit breaker were found tripped. All four over-voltage protectors were untripped.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

After the main tyres had burst during the latter part of the landing roll heat caused by friction between the wheels and runway surfaces resulted in a small residual fire in the lower part of No. 3 engine nacelle. This was extinguished by the engineer when he operated the aircraft fire extinguisher bottles before leaving the aircraft. Four appliances and twelve personnel from the Luton Airport Fire Brigade were on the scene within approximately two minutes of the accident occurring and, although there was no fire, 2,700 gallons of water and 162 gallons of foam were discharged over the wreckage to inhibit any possible outbreak.

Five appliances from the Luton County Borough Fire Brigade were also in attendance within eight minutes of the accident occurring but their services were not required.

1.15 Survival aspects

The supernumerary crew member and three of the passengers who were not secured in their seats were injured in the post impact deceleration. Seats equipped with lap-straps were available for all the passengers and the supernumerary crew member; in addition the 'Fasten Seat Belt' and 'No smoking' signs were illuminated. The accident was survivable.

1.16 Tests and research

1.16.1 *Component performance*

Since it was suspected that the battery/generator system on the aircraft may have been incapable of maintainting the bus-bar voltage in the 24v range under the conditions occurring during the landing run, tests were conducted on three of the feathering pump motors to establish their performance under conditions of varying input voltage and fixed output torque.

The manufacturers' specification tests call for operation of the motor at 24 volts and 2.5 lb ft torque and for a further test at 24 volts and 3.0 lb ft torque. Since the current consumption during the first test is required to not exceed 150A and the rated current value of the units is 150A, it was considered that this test was intended to be fairly representative of normal working conditions.

The second specification test, at 3.0 lb ft torque, required the current consumption of the motor not to exceed 175A, considerably in excess of the rated value, and it was therefore considered that this was intended by the manufacturers to be a test of serviceability under overload conditions.

For the purpose of further tests a value of 2.5 lb ft torque was used as being representative of pump motor torque under typical working conditions. Input voltages of respectively 28v, 24v, 18v and 15v were applied to each motor tested.

Since no data were readily available on the operating voltages of the reversing solenoids, the latched 'D' relays and the feathering pump operating relays, one of each type of component was removed and individually tested. The results were as follows:

Reversing Solenoids (Without oil pressure)	Voltage for valve to open	12v
	Voltage for valve to close	1v
Latched 'D' relay	Voltage to 'latch in'	14v
	Voltage to 'unlatch'	7v
Feathering Pump relay	Voltage to close	4v
	Voltage to open	1v

As both the CVR and the FDR had continued to function throughout the landing run a review was made of the inverter test specification in order to establish what minimum voltage was required so as to allow both CVR and FDR to function normally.

Under normal non-emergency condition the alternating current (AC) equipment in the aircraft was driven by rotary inverters supplied from the main bus-bar. The test specification for these units requires the output frequency to be maintained within tolerance under full load conditions down to an input voltage of 16v. In addition the frequency is required to remain within tolerance down to 9v input under no-load conditions. The inverters in this aircraft had all a low time since overhaul and should therefore have been in good condition.

One of the battery circuit current limiters, nominally rated at 500 A was subjected to a progressively increasing current and ruptured at 870A.

As no performance data were available for the specific type of battery installed in this aircraft, information was obtained from tests carried out on two types of British manufactured batteries of generally similar design.

With the two 12v 88Ah batteries installed in the aircraft, a demand of 800A would produce a voltage output of about 16v. Tests on the propeller feathering/reversing pumps showed that with an input of 16v the pump rpm achieved would be only about 50 per cent of the pump rpm expected at the normal working voltage of 24v to 26v. It is considered that the reduced pump speed would have the effect of approximately doubling the propeller reversing cycle time from the nominal 4 seconds to 8 seconds.

1.17.1 *Handling and performance*

According to the 'Normal Operation' section of the Operations Manual carried in the aircraft, ... 'Propeller reversing is the primary means of deceleration down to about

40-50 knots' .... Nevertheless, the landing performance charts in the same manual were based on the application of wheel brakes only without the use of propeller reverse. These charts indicate that the aircraft would have required a landing distance of approximately 1,737 metres for the conditions prevailing which was well within the 2,160 metres of the paved surface of runway 08 at Luton.

1.17.2 *Emergency pneumatic wheel brakes*

Operation of the emergency pneumatic brakes is covered in the Hydraulic Failure section of the Operations Manual which states, in part, ... 'Move the air brake lever to the 'HOLD' position, then quicky towards 'ON' and immediately back to 'HOLD'...... Any delay in the 'ON' position will result in locking the wheels and bursting the tyres, with subsequent loss of friction and braking action'.

Reference is also made to the operation of the emergency pneumatic brakes in the 'Systems and Equipment' section of the same manual. Following a description of the system in this section there is a cautionary note which states: 'When using the emergency air brake system the handle should be moved from 'ON' to 'HOLD' immediately braking action is felt ......'.

1.17.3 *Operations at Luton Airport*

Normal practice is followed at Luton by ATC in selecting the runway having the highest headwind component for take-off and landing. Under calm or cross-wind conditions runway 26 is the preferential and instrument runway and is most frequently used. However, when conditions permit; aircraft commanders may be given the choice of using runway 08 to facilitate their approach. Three landings had been made on runway 26 by large transport aircraft within the hour preceding the accident.

1.17.4 *Aircraft performance*

Flight test data supplied by the manufacturers indicates that, with the prevailing ambient conditions and given the aircraft configuration and performance as deduced from the FDR readout, the aircraft would have required a ground landing roll, without the use of reverse thrust, of 810 metres.

2. Analysis and Conclusions

2.1 Analysis

Under the conditions prevailing the aircraft should have stopped within the runway distance available using normal handling techniques. Despite shortcomings discovered in the wheel brake and electrical generation systems no evidence was found during the examination of the wreckage of any defect in either of these two systems, which would have prevented their being used satisfactorily for stopping the aircraft.

2.1.1 *Choice of landing direction*

Prior to landing, the commander had received the forecast surface wind, at Luton and, during his communications with London and Luton Air Traffic Control, had been asked if he would use runway 08; since use of this runway would facilitate a straight in approach. The commander was familiar with Luton airport and was aware that runway 08 had a definite downslope to the east. He was also aware of the penalties incurred in the aircraft's landing performance with a tailwind component. However runway 08 was, under the prevailing conditions, quite adequate in length for a safe landing to have been carried out and there is no evidence to indicate that if runway 26 had been used, the accident would have been prevented.

2.1.2 *Approach and touchdown*

From an examination of the FDR readout it is evident that the approach path followed and the airspeeds flown were quite normal. There is evidence of 'float' during the landing flare and 770 metres of runway were overflown before touchdown leaving 1,390 metres of paved runway surface available for stopping. However, the aircraft certification data indicate that 810 metres was required in order to stop using wheel brakes alone without reverse thrust.

It is possible that the slight (about 2 knots) tailwind component contributed to the relatively late touchdown achieved. The slight misalignment of VASI is not considered to have been significant.

2.1.3 *Failure to achieve propeller reverse*

Following touchdown the standard company propeller reversing drill was initiated apparently without immediate results and with no blue lights visible.

The condition of the aircraft electrical system was such that the main bus voltage would probably have been less than the nominal value at low engine rpm. On the DC7C selection of reverse pitch inevitably causes a heavy demand to be made on the aircraft's electrical system. The operator in this case was aware of the possibilities of an electrical overload and used a procedure which only required two propellers to be selected to reverse at a time in order to reduce the initial electrical load. During the landing run, propellers 2 and 3 were selected to reverse followed very shortly by propellers 1 and 4. The indications are that the heavy electrical demand could have caused the main bus voltage to fall to a low value, possibly 16v.

Whilst the degraded performance of the aircrafts electrical system would, most probably, have slowed down the rate at which the propeller blades changed pitch, it would not account for the non-illumination of the blue lights which indicate that reverse has been successfully selected. Detailed examination of the propeller reversing system did not reveal any evidence that would provide a reason for the system failing to function correctly. If the two reverse control circuit breakers had 'tripped' then the power supply to the reversing pumps would have been interrupted and reverse pitch could not have been achieved. However, examination of the wreckage showed that the circuit breakers were 'made'. Nevertheless, a lack of electrical power to the reverse pumps, for whatever reason, is the most plausible explanation for the inability of the crew to achieve reverse pitch.

The continued efforts to obtain reverse thrust without the blue lights being illuminated could only result in the application of forward thrust.

Examination of the FDR readout shows that the decay in IAS is linear from 12 seconds before touchdown to 12 seconds after touchdown, with no indications that any reverse thrust had been applied during this period. Reference to the FDR readout indicates that the IAS remained sensibly constant for the period between 12 seconds and 19 seconds after touchdown. The most probable explanation for this is that during this time a degree of forward thrust was balanced by the application of some brake.

The first indication of any retardation effect appears some 20 seconds after touchdown lasting for approximately two seconds. As by this time only about 450m of runway lay ahead and as all four main wheel tyres had already burst an overrun became inevitable.

2.1.4 *Normal wheel braking*

No evidence was found during the examination of the wreckage of any significant malfunction of the brake hydraulic system although examination of the brake friction assemblies showed them to be worn to the extent that their efficiency may have been impaired. It is the considered opinion of the brake manufacturer, however, that they would have been able to stop the aircraft within the published distance, although there is a possibility that the efficiency of the hydraulic brakes may have been significantly reduced. It is reasonable to assume that, as they would have been used while the aircraft was taxying out they were considered by the crew to have been serviceable when the aircraft left Dublin.

The Operations manual states, that 'Reverse thrust should be used as the primary means of deceleration down to about 40-50 knots ......' It is therefore not surprising that the pilot does not appear to have used the hydraulic wheel brakes prior to the first burst of engine heard on the CVR 12 seconds after touchdown. The first main wheel tyre burst as the result of the selection of the pneumatic brakes to 'ON' 15 seconds after touchdown. Thus there was only three seconds available for the assessment of the efficiency of the hydraulic brakes before the pneumatic brakes were operated.

Under the prevailing conditions the evidence indicates that the pilot should have been able to stop the aircraft by the use of the hydraulic brakes alone, provided he had made the decision to abandon attempts to select reverse thrust and left the engines at idle power before 12 seconds had elapsed after touchdown. If the decision was made any later then an overrun would have been inevitable.

2.1.5 *Emergency pneumatic brakes*

The captain's decision to make use of the emergency brakes was sound and, as the marks on the runway indicated, they were effective in action. At about the time that they were applied the aircraft was still travelling at approximately 85 knots, with forward thrust being developed. These factors probably accounted for the commander's decision to operate the pneumatic brakes in the way that he did. With the selector lever maintained in the 'ON' position, the continuous supply of high pressure air to the brakes locked the wheels causing the tyres to burst, destroying all further braking capability for the final 500 metres of the runway and thus aggravating the overrun.

2.1.6 *Aircraft maintenance and documentation*

The standard of the aircraft maintenance and documentation, was poor and below that which is normally found on public transport aircraft.

2.1.7 *Crew training*

The training of the flight crews was considered to have been both comprehensive and thorough.

2.1.8 *Injuries to persons on board*

Some of the passengers left their seats during the landing run, and as a result were injured in the accident. Although no livestock was being carried during the flight, when interviewed afterwards these passengers indicated that it was their normal practice to vacate their seats after landing in order to attend to the race-horses which they normally accompany. The supernumerary crew member's injuries were also the result of lack of restraint as he was seated with his lap strap fastened in a seat which was not secured to the structure when the impact occurred. However, seats equipped with lap straps were available for all those injured and if they had been used it is considered that they would have emerged from the accident unscathed.

2.2 **Conclusions**

(a) *Findings*

(i) The aircraft was correctly loaded.

(ii) The crew were properly licensed and competent to carry out the flight.

(iii) The aircraft landed on runway 08 at Luton airport with a surface wind of 300°/04 knots.

(iv) The aircraft touched down at a speed of 105 knots IAS, 770 metres beyond the landing threshold of the runway.

(v) No effective reverse thrust was achieved on any of the propellers.

(iv) There was no evidence of pre-crash failures in the aircraft, its engines or equipment.

(vii) There was no evidence of pre-crash inaccuracy in either of the two ASI systems.

(viii) The generator control system was out of adjustment and the aircraft batteries were at a low state of charge.

(ix) The wheel brake friction units were worn to the extent that their efficiency may have been impaired.

(x) A degree of forward thrust was inadvertently applied for two short periods during the landing run.

(xi) The emergency pneumatic brakes were applied continuously locking the wheels and causing the tyres to burst 500 metres before the end of the runway.

(xii) The aircraft ran off the paved area of the runway, over a bank and came to rest in soft ground 90 metres beyond the end of the runway.

(xiii) Injuries were suffered by a supernumerary crew member and some passengers who were not secured in their seats at the time of impact.

(xiv) There were discrepancies in the company's records concerning replacement of certain components on the aircraft.

(b) *Cause*

The accident was caused by the aircraft overrunning the runway after a failure to achieve reverse thrust and the inadvertent application of forward thrust during the landing roll. Operation of the emergency pneumatic brakes resulted in the bursting of the main wheel tyres with consequent loss of braking capability.

G C Wilkinson
Inspector of Accidents

Accidents Investigation Branch
Department of Trade

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