Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Boeing 727 Series 46 G-BAEF
Report on the accident at Luton Airport, Bedfordshire, on 21 June 1974

LONDON
HER MAJESTY'S STATIONERY OFFICE
1975

List of Aircraft Accident Reports issued by AIB in 1975

No.	*Short title*	*Date of publication*
1/75	Beechcraft 95-B55 (BARON) G-AZZJ at Cholesbury cum St. Leonards, Bucks January 1974	May 1975
2/75	Westland Sea King MK 41 89-61 at Yeovil Airfield, Somerset January 1974	May 1975
3/75	Piper PA-23 Series 250 (Aztec) G-AYDE and BAC 111 Type 518 G-AXMJ at Luton Airport, Beds April 1974	June 1975
4/75	Boeing 707-436 G-APFH at Heraklion Airport, Crete June 1974	June 1975
5/75	Rollason Druine D31 (Turbulent) G-APLZ at Grange Farm, Latchingdon, Maldon, Essex April 1974	June 1975
6/75	Bell 206A Jet Ranger G-AXAY at Inkpen Hill Hungerford, Berkshire March 1974	July 1975
7/75	Iberia DC9 EC-B11 and Spantax Coronado EC-BJC in the Nantes area, France March 1973	June 1975
8/75	Cessna 150C G-ASHF at Swanage Bay, Dorset June 1973	August 1975
9/75	Piper PA25-235 G-ASVX and Phantom FGR2 XV493 at Fordham Fen, Norfolk August 1974	September 1975
10/75	Piper Twin Comanche PA 30 G-ATYR at Saulmore Bay, near North Connel aerodrome, Argyll October 1974	*(forthcoming)*
11/75	Vickers Vanguard 952, G-AXOP at Hochwald/Solothurn, Switzerland April 1973	September 1975
12/75	Douglas DC 7C/L E1-AWG at Luton Airport, Beds March 1974	*(forthcoming)*

ISBN 0 11 511430 0

Department of Trade
Accidents Investigation Branch
Shell Mex House
Strand
London WC2R 0DP

5 August 1975

The Rt Honourable Peter Shore MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr R D Westlake, an Inspector of Accidents, on the circumstances of the accident to Boeing 727 Series 46 G-BAEF which occurred at Luton Airport, Bedfordshire on 21 June 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. 13/75
(EW/C493)

Aircraft:	Boeing 727 Series 46 G-BAEF
Engines:	3 Pratt and Whitney JT8D-7A
Owner and Operator:	Dan-Air Services Limited
Crew:	8 – Uninjured
Passengers:	126 – Uninjured
Place of Accident:	Luton Airport, Bedfordshire 51° 52′N 00° 23′W
Date and Time:	21 June 1974 at 0656 hrs All times in this report are GMT

Summary

During its take-off from Runway 26 at Luton Airport the aircraft did not leave the ground until very near the end of the runway. After taking off it struck the centre section of the Instrument Landing System (ILS) localiser aerial array, sited beyond the end of the runway, and a number of the approach lights of Runway 08. Although the aircraft suffered damage it climbed away successfully and later made a normal landing at Gatwick Airport.

The report concludes that the accident resulted from the cumulative effect of three factors, each of which could well have been individually acceptable. These factors were the erosion of the take-off run available, the delay in starting rotation and the very slow rate of rotation. This latter factor resulted in the aircraft descending slightly below the runway elevation in the valley west of the airport.

1. Investigation

1.1 History of the flight

The aircraft was making an international non-scheduled air transport flight from Luton to Corfu with 126 passengers and 8 crew. Prior to boarding the aircraft the commander and first officer visited the Pilot's Self Briefing Room where they collected their meteorological brief for the flight. They both checked the latest actual weather conditions for Luton, given on a television display in the briefing room, but subsequently neither could remember the actual figures. The first officer recalls that he noted the weather was good. The commander noticed that the surface temperature was +16°C, from which he estimated that the maximum permissible take-off weight for Runway 26 with zero wind would be about 161,000 lb. From this figure and the available traffic load weight, which he obtained from Dan Air's Traffic Office, he calculated the maximum fuel uplift, which was 46,000 lb. According to the Operations Manual the maximum permissible take-off weight for Runway 26 at Luton with zero wind, temperature +16°C, flap 15 was 160,200 lb. The equivalent figure for Runway 08 would have been 161,800 lb.

After boarding the aircraft the commander told the first officer that he was to make the take-off. The flight engineer extracted the take-off data from the tables in the Operations Manual, taking into account existing conditions, and the take-off data card was made up as follows:

> Engine Pressure Ratio (EPR) = 1.95 (all engines); V_1 and V_R = 132 Knots; V_2 = 147 Knots; Flap setting = 15°; Stabilizer trim = 6.3 units nose-up.
> NOTE: The EPR settings for engines 1 and 3 should have read 1.98.

The flight engineer said that he mentioned to the commander that the loadsheet showed the aircraft was 125 lb overweight for a take-off on Runway 26 in zero wind. The commander apparently replied to the effect that there was some headwind component which would take care of this.

At 0622 hrs the first officer called the Tower on VHF and requested the airfield information. This was given as QNH 1021, apron QFE 1002, runway 26 and the temperature +16. At 0637 hrs the pilot was told that his proposed take-off time (slot) was 0654 hrs plus or minus 4 minutes and when asked if he could comply replied in the affirmative. At 0640 hrs another aircraft was told that the duty runway was 26, the wind calm and runway 08 available; the pilot of that aircraft chose to take-off on 08. At 0644 hrs the pilot of G-BAEF was asked how long he would be before starting, he replied that he was starting immediately and at 0649 hrs requested taxi clearance.

The aircraft was cleared to taxi to the holding point for Runway 26; in accordance with standard Air Traffic Control (ATC) practice this clearance did not include the surface wind. However the captain has stated that he understood a surface wind of 230°/08 knots was given at this time. While taxying the 'before take-off' check list was completed without any discrepancies being noted by the crew. Specifically the following items which have a bearing on engine thrust and aircraft take-off performance were completed:- pressurisation and anti-icing air were off, the anti-skid release indicators showed REL (brakes released) and the aircraft was in the appropriate configuration of 15° flaps and leading edge devices extended (green light on).

The aircraft was further cleared to backtrack down the active runway to the take-off position and while making a 180° turn in the dumb-bell at the end of the runway the crew received take-off clearance and were given the surface wind as 150°/less than 05 knots; this message was acknowledged. The final 'runway items' of the checklist were carried out during the turn and an immediate rolling take-off was started from a position which the captain later estimated was about 61 metres (200 feet) in from the beginning of the runway. Take-off commenced shortly after 0654 hrs, the aircraft being piloted by the first officer in the right-hand seat. An initial power setting of 1.4 EPR was made and after checking all engine indications as correct a take-off power setting of 1.95 EPR was applied.

Although at first the ground run appeared to outside observers to be normal, they noted that the nosewheel was not lifted until later than usual at a position on the runway just before or abeam of the runway visual range observation point for Runway 08 (approximately 1,850 metres (6,067 feet) from the beginning of Runway 26); the main wheels remained on the runway. The aircraft continued in a partially rotated attitude past the end of the runway and appeared to become airborne just at the end of the stopway, (there were no wheel marks on the grass beyond the end of the stopway). One observer said it seemed to him 'that the aircraft remained level while the runway dropped away from it'. The aircraft was then seen low in the valley to the west of the airport from which position it climbed away, slowly at first, but then normally, after attaining a fully rotated attitude.

Both the Air Traffic Aerodrome Control Officer and the fireman in the airport fire station watch room were convinced that the aircraft had struck the ILS localiser aerial, situated 168 metres (550 feet) past the runway end. Inspection of the aerial confirmed this and it was also found that a number of the approach lights of Runway 08 had been damaged. The pilot was initially informed by ATC shortly after 0658 hrs that the aircraft had probably struck the aerial; this was confirmed at 0704 hrs.

According to their statements after the accident, the take-off had appeared to be completely normal to both pilots. The commander said that the aircraft became airborne in the normal manner, at a position on the runway which caused him no concern and that there had been no indication to him that the aircraft was unduly low after it had been rotated. However, the first officer said that just prior to the 'V_1 rotate' call it did cross his mind that they were getting towards the end of the runway, whilst the flight engineer commented that he had thought the rotation was sluggish. At rotation the commander was mainly occupied with monitoring the instruments for speed and power. The first officer was looking outside the flight deck during the ground roll, apart from brief checks of the airspeed indicator, but at the rotate call he transferred his attention to the flight instruments. The flight engineer was chiefly concerned with monitoring the engine instruments. After the aircraft became airborne none of the crew realised that it had struck the localiser aerial and approach lights although some of the cabin staff heard a bang or unusual noise which they assumed was the landing gear retracting.

The first indication the crew had of any abnormality was after the landing gear had been selected up during the climb-out. It was then observed that the tail skid warning light was on, indicating that the tail skid was not in agreement with the position selected by the landing gear lever. A second problem was encountered when the flight engineer began to pressurise the aircraft and found that he could not do so in the normal manner; he attempted to bring the pressurisation under control and was finally successful.

The aircraft climbed away to 1,500 feet where a power reduction to 1.7 EPR was made in order to comply with the noise abatement procedure. At 0657 hrs the aircraft reported passing 3,000 feet at which altitude speed was increased in stages to 200 knots during which the normal flap retraction schedule was carried out. The aircraft continued to accelerate and at 240 knots the first officer reported that excessive aileron was required to correct a heavy left-wing condition. The commander took over the controls and

found that 4 to 5 degrees of right-wing down aileron trim was required to keep the aircraft laterally level; the speed was maintained at 250 knots. It was at this time that the message from Luton Tower was received informing the crew that the aircraft had probably struck the localiser aerial.

In view of the aircraft's control characteristics and the message received from Luton Tower, the commander decided to discontinue the flight and land at Gatwick. On instructions from ATC fuel was dumped over the sea south of Worthing and after flying to Gatwick the aircraft made a low pass over the control tower with the landing gear extended in order that ATC personnel could check it visually. After the landing gear had been extended the lateral control problem with the aircraft disappeared and, on being informed that the landing gear appeared normal, a circuit and landing was made without further incident. The aircraft landed at 0758 hrs.

1.2 **Injuries to persons**

Injuries	Crew	Passengers	Others
Fatal	–	–	–
Non-fatal	–	–	–
None	8	126	

1.3 **Damage to aircraft**

Following the landing at Gatwick Airport the aircraft was examined for structural damage. Both main landing gear wing doors were extensively damaged, the tail skid was broken and a 3 to 4 feet gash had been made along the centre keel of the fuselage at the forward end of the rear cargo compartment. The wing doors, which are attached to the main landing gear legs and hinged at the top to fore and aft members of the main landing gear bay structure have each a total area of about 20 square feet. They are mechanically operated by the landing gear itself, remaining open when the landing gear is down and becoming flush with the underside of the fuselage when the landing gear is up. Both doors had been wrenched off their forward hinges and would have been partially hanging down after the landing gear was retracted, forming open scoops facing in the direction of flight.

The flying controls and all wing lift devices and spoilers were undamaged apart from a small puncture in the starboard inboard track fairing where a nut and piece of bolt from the ILS aerial were found lodged. This minor damage did not affect the operation of the controls when they were checked; they all operated in a satisfactory manner. Removal of the landing gear wheels and examination of the brake assemblies did not reveal any evidence of dragging brakes.

After the damaged landing gear doors had been removed and the damaged tail skid locked in place and faired off with speed tape the aircraft was flown, de-pressurised and with the landing gear down, to the operator's maintenance base at Lasham Airfield. On this flight, according to the aircraft commander, who was the operator's Boeing 727 fleet manager, the aircraft flew normally in all respects. In particular the take-off run and rotation to approximately 12^{O} was quite normal.

At Lasham checks were carried out on the following equipment:

Engine pressure ratio system
Attitude instrument system
Airspeed indicators
Altimeters
Engine bleed air and anti-ice systems
Ground spoilers

The results of the above checks did not reveal any significant defect which could have had any bearing on the accident.

1.4 **Other damage**

Damage was sustained by the following items near the take-off end of Runway 26 at Luton Airport:

No. 1 approach light of Runway 08 situated 61 metres (200 feet) beyond the end of the runway, ie at the end of the stopway and projecting about 1 foot above its surface.

Part of a wooden fence enclosing the ILS localiser protected area, situated 77 metres (252.5 feet) beyond the end of the runway.

An ILS field monitor aerial, situated 92 metres (302 feet) beyond the end of the runway.

The centre section of the ILS localiser aerial situated 167 metres (550 feet) beyond the end of the runway.

Other approach lights of Runway 08 including No. 4 situated 244 metres (800 feet) beyond the end of the runway and Nos. 8 and 9 situated 305 metres (1,000 feet) beyond the end of the runway.

The wooden fence, ILS monitor aerial and ILS localiser aerial were all frangible structures. The approach lights were also on frangible masts which were up to about 32 feet in height (8 and 9).

A drawing showing the damage is at Appendix 2.

1.5 **Crew information**

Commander:	Aged 51
Licence:	Airline Transport Pilot's Licence, valid until 8 May 1979.
Ratings:	Aircraft, Part 1; Comet IV, Boeing 707, BAC 1-11, Boeing 727. Instrument rating valid to 25 April 1975.
Last medical examination:	Assessed fit 26 February 1974, valid for six months.
Last competency check:	26 March 1974.
Last route check:	21 June 1973.
Total pilot hours:	15,818.
Total flying hours in command of Boeing 727 aircraft:	631.
Total flying hours in last 28 days:	54.
Rest period:	5 days prior to the accident flight.
Previous take-offs from Luton, Boeing 727:	3.

Co-pilot:	Aged 33.
Licence:	Airline Transport Pilot's Licence, valid until 17 January 1978.
Ratings:	Aircraft, Part 1; PA 23, PA 28, PA 30, DH 89, Auster variants, Comet variants, Boeing 727. Instrument rating valid to 24 May 1975.
Last medical examination:	Assessed fit 11 April 1974, valid for six months.
Last competency check:	25 April 1974.
Last route check:	17 March 1974.
Total pilot hours:	2,887.
Total flying hours in Boeing 727 aircraft:	653.
Total flying hours in last 28 days:	65.
Rest period:	22 hours 50 minutes.
Previous take-offs from Luton, Boeing 727:	15.
Flight Engineer:	Aged 43.
Licence:	Flight Engineer's Licence, valid until 13 May 1978.
Ratings:	Comet 4, Boeing 727.
Last medical examination:	Assessed fit 9 May 1974, valid for twelve months.
Last competency check:	25 April 1974.
Total hours as flight engineer:	2,700.
Total hours flight engineer Boeing 727 aircraft:	610.
Total flying hours in last 28 days:	71.
Rest period:	22 hours 50 minutes.

He had also flown approximately 8,000 hours as a flight navigator.

There were 5 female cabin staff all of whom had been checked and found competent in their knowledge of emergency procedures and cabin safety equipment.

1.6 **Aircraft information**

Boeing 727 G-BAEF was manufactured in 1966 and went into service with Japan Air Lines the same year. It was subsequently bought by Dan-Air Services Limited and commenced operating with them in April 1973. The records show it had been properly

maintained and that all mandatory modifications had been embodied. Its certificates of airworthiness and maintenance were valid and a Check C had been completed on 21 June 1974, the day of the accident flight; its total flying time was 17,835 hours.

According to the Operations Manual the Regulated Take-Off Weight (RTOW) for Runway 26 at Luton in zero wind, temperature +16°C and 15° flap was 160,200 lb. According to the loadsheet the aircraft's weight at take-off was 160,325 lb. Its centre of gravity limits for take-off were: forward = 11 per cent, aft = 34 per cent mean aerodynamic chord (MAC); the calculated centre of gravity at take-off was 20.3 per cent MAC requiring a stabilizer trim setting of 6.3 units nose up. Checks made following the accident showed that the calculated centre of gravity position was substantially correct but that the true take-off weight was probably 250 lb greater than the loadsheet figure. It was also determined from the Boeing 727 Flight Manual that the RTOW for the same runway and conditions was 161,000 lb. The aircraft's tanks at take-off contained 45,250 lb of Jet A1 aviation Kerosene.

1.7 Meteorological information

At Luton Airport meteorological information was available in the Pilot's Self Briefing Room where there was a self briefing display and where meteorological forecasts, prepared by London (Heathrow) Meteorological Office, could be collected. No forecaster was in attendance although pilots could telephone London (Heathrow) if they required additional information.

Local airfield meteorological observations were taken at 20 and 50 minutes past each hour by ATC officers (qualified meteorological observers) in the tower and transmitted, via a television system, to a screen in the self briefing room. At the time the two pilots visited the self briefing room the 0550 hrs observation would have been on display which was as follows:

Surface wind:	Calm.
Visibility:	2,800 metres.
Weather:	Mist.
Cloud:	Sky clear.
QNH:	1021.
QFE:	1002.
Temperature:	+15° Centigrade.
Runway in use:	26.

The 0650 hrs observation, approximately 4 minutes before take-off, gave the surface wind as 090°/03 knots and an observation taken immediately after the accident gave it as 150°/05 knots. A surface wind of 150°/ less than 05 knots was passed to the crew shortly before the aircraft commenced its take-off run. This wind information was obtained from an anemometer and a direction indicator situated on top of the control tower. Presentation of the information to the ATC officers was made by means of dial indicators; no recording system was fitted. Tests of the installation made shortly after the accident showed no apparent error of the direction indicator and, at a speed recording of 05 knots, the tower indicator was correct to within 1 knot.

A post-accident estimate of the weather at Luton at the time of the accident, made by the Meteorological Office, included the information that a weak east to south-easterly airstream covered central England. The surface wind over the area was variable in direction but predominantly between northeast and southeast with speed generally of 05 knots or less.

The accident occurred in daylight.

1.8 Aids to navigation

The effectiveness of the navigational aids was not a factor in this accident.

1.9 Communications

All communications were normal.

1.10 Aerodrome and ground facilities

Luton Airport is situated 1.5 nm east of the town of Luton and is at an elevation of 525 feet. There is one concrete surfaced main runway 08/26 from which the aircraft took-off to the west. Runway 26 has a length of 2,160 metres (7,087 feet) with an additional 61 metres (200 feet) of concrete stopway at the end. There are no taxiways giving direct access to either end of the runway. This necessitates backtracking to the take-off positions followed by a 180° turn before take-off. At the time of the accident the runway surface was dry and the runway threshold and stopway lights were on 100 per cent. A plan of the airport is at Appendix 3.

The declared distances for Runway 26 were:

Take-off run available	– 2,160 metres (7,087 feet).
Emergency distance available	– 2,221 metres (7,287 feet).
Take-off distance available	– 3,240 metres (10,630 feet).

The overall gradient of the runway is 0.18 per cent up. However, for about the first 1,569 metres (5,147 feet) the gradient is 0.46 per cent up, the runway then slopes down to the end of the stopway, the gradient being 0.57 per cent down. From the end of the stopway the ground drops fairly steeply into a valley west of the airport. As a result of this the ground elevation at the end of the take-off distance available (TODA) is approximately 178 feet below the elevation at the end of the runway, which is the end of the take-off run available (TORA). See also 1.17.

1.11 Flight recorder

1.11.1 The aircraft was equipped with a United Controls Data Division engraved foil flight data recorder which recorded the following mandatory flight path parameters: pressure altitude (in this case to a datum of 1013.2 mbs), indicated airspeed, magnetic heading, normal acceleration and pitch attitude. The first four parameters were recorded on one side of the foil and the pitch attitude on the reverse side. The first two parameters were produced from transducers within the recorder, the remaining three were fed to the recorder from external sources. The protected recorder assembly was mounted on a shelf on the starboard side of the aircraft, just aft of the rear pressure bulkhead and was recovered undamaged; it had functioned correctly for the duration of the flight. A post accident calibration of the recorder showed that the altitude and airspeed parameters were within the manufacturer's tolerances and that the recording of the input signals of magnetic heading and pitch attitude were within specification; the recording of the normal acceleration signal was outside the manufactures tolerances.

1.11.2 *Accuracy of data*

The foil was read out under AIB supervision and measurements were made at intervals representing 1½ seconds real time from a point approximately 48 seconds before lift-off to a point 3 minutes after lift-off. Measurements were also made of specific engraved points on the airspeed and pitch traces over lengths where changes of parameters were too rapid and irregular for 1½ second readings to fully describe the local variation of values.

An assessment of the accuracy of this read-out is as follows:

(i) During calibration there were indications of non-repeatability of the recorder at air-speeds below 40 knots. Between 60 knots and lift-off there is considerable scatter of points probably due to airframe vibration during the take-off run. It is therefore considered that airspeed values below 40 knots are completely unreliable and that those between this speed and lift-off are only able to indicate the airspeed trend and are individually of unknown accuracy. It is considered that during the climb phase the airspeed results are accurate to within 1 knot of the CAS.

(ii) The indicated altitude values are considered correct to within 50 feet of the correct indicated pressure altitude values (ie uncorrected for position error affect).

(iii) Pitch attitude results cannot be guaranteed owing to the fact that the output from the artificial horizon synchro was not calibrated. It is considered unlikely, however, that they would be more than 2^{o} in error.

(iv) The normal acceleration results are considered to be only sufficiently accurate to indicate that no unusual positive or negative accelerations occurred.

(v) After corrections the time-bases of the various parameters are considered to have been located to within ½ second of their correct relative positions.

1.11.3 *Analysis of accident flight data*

An analysis of the read-out was made by the Airworthiness Division of the Civil Aviation Authority (CAA) and is at Appendix 1. Performance data appropriate to the aircraft's weight for both the 15^{o} and 5^{o} flap configurations and using 1.95 EPR's on all three engines were provided by the aircraft manufacturer and have been used as the basis for that analysis.

The analysis summary gives the following implications:

(a) A late and slow rotation delayed unstick and the stage at which a positive rate of climb was achieved.

(b) There are some indications of a slower rate of increase of air-speed than would be expected. This could be due to a shortfall in total engine thrust and/or a tailwind component occurring during the take-off run. (This is in addition to a small thrust shortfall that would already be expected from the stated use of 1.95 EPR on all engines, instead of the maximum permitted setting available).

(c) There is no reliable evidence to suggest that other than flaps 15^{o} was used during the take-off.

1.12 **Wreckage**

Not applicable to this accident. See 1.3 for damage sustained.

1.13 **Medical and pathological information**

No injuries were sustained in this accident.

1.14 **Fire**

No fire occurred.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

Nil.

1.17 Additional aerodrome information

That area, commencing at the end of the runway (TORA), over which a Group A aeroplane can complete its initial climb from lift-off to the Flight Manual specified height, normally 35 feet, is known as 'clearway'. Obstructions must not penetrate the clearway plane, although frangible objects, including those essential to air navigation, penetrating the plane by not more than 3 feet may be permitted. Clearway plus runway combine to form the declared Take-off Distance Available (TODA). The length of clearway declared for any given runway may include a lesser length of declared stopway but must not exceed one half the declared take-off run available.

As applicable to the case of Runway 26 at Luton and, in accordance with the requirements of CAP 168 (Licensing of Aerodromes), because the final 591 metres (1,940 feet) of Runway 26 slopes downward, and because the ground in the clearway falls more than 30 feet below the end of the TORA, the clearway plane is a continuation of the last part of the runway, ie a slope of 0.57 per cent down. This plane continues with the same 0.57 per cent downslope for a distance of 610 metres (2,000 feet), this being the distance specified in CAP 168 as being necessary to ensure that an aeroplane may correct an initially adverse flight gradient. Beyond that point the clearway continues in the horizontal plane for a distance of 470 metres (1,543 feet). This composite clearway plane was penetrated by several frangible objects namely: the wooden fence, ILS monitor aerial and the ILS localiser aerial which penetrated the clearway plane by 0.66, 3.17 and 2.40 feet respectively; approach light No. 4 and approach lights 8 and 9 were 1.4 and 2.28 feet respectively below the clearway plane.

Note on frangibility

Frangible objects are defined as those which will retain their structural integrity and stiffness up to a desired maximum load. When subject to a load in excess of this maximum they will break into pieces whose configuration will present the minimum hazard to an aircraft.

2. Analysis and Conclusions

2.1 Analysis

2.1.1 General considerations

It is apparent from the flight recorder evidence and that of eye witnesses that the take-off rotation was initiated and achieved at a point much further along the runway than the scheduled position. From the damage sustained by the aircraft and by the ground installations at Luton Airport it is also apparent that the aircraft was dangerously low during its initial flight path after take-off.

This substandard performance was the result of an accumulation of factors which are considered individually in the following paragraphs. The majority of the relevant points arise from the analysis of the flight recorder data although it must be borne in mind that this analysis can only be as accurate as the data on which it is based and is therefore only correct to within the limits of the accuracy of the recorder and readout systems themselves. With this proviso it is considered that the results obtained are adequate for a reasonable assessment of the factors involved in this accident and are in agreement with eye witness evidence and the damage to the aircraft and airport installations.

2.1.2 Surface wind considerations

According to the Operations Manual the aircraft was slightly overweight for Runway 26 zero wind, but in any case it was below the RTOW of 161,000 lb derived from the Flight Manual. The commander was working to the Operations Manual RTOW (160,200 lb) but, because of a mistaken belief that the surface wind was 230°/08 knots, considered he was within the RTOW performance requirements for take-off on Runway 26 and accepted a taxi clearance to that runway. However the true significance of the wind should have become apparent when the aircraft was cleared for take-off and a surface wind of 150°/less than 05 knots (involving a slight tailwind component) was passed and acknowledged. Certainly at that point consideration should have been given to using Runway 08. Because of the slight beneficial headwind effect and because the overall slope was more favourable that runway would have allowed a higher RTOW. It is possible that the closeness of the take-off time limit 'slot' which expired at 0658 hrs, may have played some part in the decision to take-off on Runway 26. A change of runway would almost certainly have led to the 'slot' time being exceeded, which could well have resulted in further delay. There is no evidence that a surface wind of 230°/08 knots existed or was reported by Luton ATC, nor was it contained in any information provided to the crew by the Meteorological Office. On the contrary the meteorological situation indicates that a weak east to southeast airflow existed at surface levels. The wind observations just before and just after take-off (respectively 090°/03 knots and 150°/05 knots) were measured at the anemometer position on the Tower and may not therefore truly represent the wind on the runway but they do lend support to the 06 knot tailwind suggested in the flight recorder analysis.

2.1.3 Aircraft performance

Evidence on the rate of acceleration achieved by the aircraft during the take-off ground roll was obtained from the flight recorder read-out. One of two main possibilities considered in the CAA analysis of the data is that there could have been a loss of thrust or some unexpected drag during the take-off. (See figure 5 and text). However it is also relevant to note that the apparent lack of acceleration (up to 5 per cent) is within the limits of accuracy of the recording and read-out systems. The other possibility indicated by the analysis is that a line which could be drawn through the scattered airspeed points would be equivalent to the predicted Boeing airspeed/time line as affected by the onset

of a 06 knot tailwind during the take-off run. In that case there would be no implication of reduced thrust or unexpected drag.

The post-accident check of the aircraft at Gatwick did not reveal anything which could have reduced its performance capability during the ground-roll and rotation phases of the take-off at Luton. This was further confirmed by checks after the aircraft had been flown to the operator's maintenance base at Lasham. The crew involved in the accident had no criticism to make of the aircraft, engine power, rate of acceleration or handling characteristics during the Luton take-off. The pre-take-off check list had been correctly completed including specifically all items relevant to engine and aircraft performance. The crew which took the aircraft from Gatwick to Lasham was equally satisfied with its take-off performance at Gatwick.

On the foregoing premises it is not considered that there was any significant loss of the aircraft's inherent performance capability which was a factor in this accident and it is considered reasonable to assume that there was a surface wind on the runway sufficient to give a tail component of the order of 06 knots, and thus extend the take-off ground roll.

2.1.4 Erosion of take-off run available

From paragraph 5.1.3 (ii) and (iii), of Appendix 1 it can be seen that the predicted ground roll distance to scheduled V_R (132 knots), with 1.95 EPR on all engines, would be 4,120 feet in still air and that this would become 4,580 feet assuming a 06 knot tailwind component. To this must be added a distance of between 200 and 300 feet lost in the 180^o pre-take-off turn at the beginning of the runway. Therefore it is considered that during this take-off the distance consumed from the beginning of the runway to scheduled V_R was 4,780 feet.

2.1.5 Delayed rotation

Although it proved impossible to determine the exact point of rotation from the flight recorder read-out, the most probable point would appear to be at 40 seconds; the speed at this time was 140 knots, that is to say 8 knots above the scheduled V_R. From the text following paragraph 5.1.3 (iii) of Appendix 1 this extra speed, allowing for a 06 knot tailwind, implies a further 700 feet producing a total of 5,480 feet to the start of rotation. Eyewitness observation suggest that it may well have been later than this (6,067 feet).

2.1.6 Slow rotation

In the text following paragraph 5.1.3 (iii) of Appendix 1 the rotation is assessed as being slow and averaging 1.3^o/second from start of rotation to lift-off. Table (ii) on the same page shows a predicted distance, with a 06 knot tailwind, of 2,070 feet from scheduled V_R to the estimated point of actual lift-off for 15^o flaps. 700 feet of this distance has already been accounted for because of the higher (8 knots) achieved V_R. The residual distance to the actual lift-off was therefore 1,370 feet and thus the total distance from the beginning of Runway 26 to actual lift-off was 6,850 feet. This runway together with the 200 feet of stopway has a total length of 7,287 feet.

The final 1,940 feet of Runway 26 and the further 200 feet of stopway have a down slope of 0.57 per cent. The aircraft had not been fully rotated at lift-off and was therefore probably flying approximately parallel to this slope after it left the ground, an assessment which is borne out by the fact that the aircraft struck the innermost approach light for Runway 08 which is positioned at the end of the stopway and projecting about 1 foot above the stopway surface. The ground beyond the stopway slopes down more steeply still and the eyewitness who stated that, it seemed to him, 'that the aircraft remained level whilst the runway dropped away from it' was undoubtedly correct in his impression.

The slow rate of rotation continued whilst the aircraft followed a flight path which eventually took it below the downsloping portion of the clearway plane to a point about 1,000 feet beyond the end of the runway. During this time it struck the localiser and some of the approach lights of Runway 08. It was not until about 13 seconds after the start of rotation that the aircraft was fully rotated to an attitude of about 13^{o}, sufficient to initiate a positive climb.

2.1.7 Flight path during climb out

It is impossible to assess the individual contributions which the slow rotation, the loss of ground effect because of fall away of the terrain and increased drag due to aircraft damage, played in the downward flight path during the few seconds after lift-off. Calculations relative to the subsequent climb out (see paragraph 5.2, of Appendix 1) suggest a drag increase equivalent to about a 5 per cent thrust loss. No precise calculations could be made to relate this to the damage to the landing gear doors but there can be little doubt that this was the cause. Both had been wrenched off their forward hinges and in the 'closed' position after landing gear retraction would have formed open scoops facing into the flight path.

This 5 per cent thrust loss/drag increase during climb out served to confirm the probability of a tailwind rather than a thrust loss/drag effect during the ground roll. If there had been such an effect during the ground roll then, unless it had been caused by brake-drag, something which was not borne out by post accident examination, the after take-off climb out could have been expected to show about a total of 10 per cent thrust loss/drag increase because of the additional drag of the landing gear doors. It is considered therefore that the change in the thrust/drag relationship at about time 197 seconds in Fig. 10 does represent a flap retraction from 15^{o} to 5^{o} and confirms the crew's use of 15^{o} flap for the take-off.

Consideration of the circumstances of the accident indicates that it was the result of the cumulative effect of three factors, namely the erosion of the take-off run available combined with the delayed and slow rotation. There was insufficient attention to pre-flight preparations, to power settings and to aircraft handling during the take-off sequence. In this connection a factor which could well have made a further contribution to the erosion of the take-off distance was the check setting to 1.4 EPR whilst rolling for take-off. This is an acceptable procedure where the runway length is more than adequate for the RTOW but in this case, where there was no such margin, it would have been good airmanship to have aligned the aircraft and made this check setting, or even set a higher EPR, against the brakes before starting the take-off roll.

2.1.8 Other considerations

The principle of limiting the approach installations to a specified height and of requiring them to have a degree of frangibility appear to have achieved their purpose in that the damage to the aircraft did not seriously affect its ability to continue flight.

The flight recorder analysis shows that there may have been a tailwind component as high as 06 knots. This had led to examination of the problem which exists with regard to maximum RTOW take-offs made in reported calm wind conditions. It is a matter for consideration whether a light tailwind component should be assumed to exist when a calm surface wind is forecast or reported. Reported headwind and tailwind components are factored by 50 per cent and 150 per cent respectively for take-off performance calculations whereas a zero wind is ignored and assumed to be correctly reported.

A further shortcoming which affected the take-off run available in this accident at Luton was the distance lost due to the absence of a taxiway to the beginning of the runway thus necessitating a 180^{o} turnround before take-off. Generally, take-off performance calculations are based on the published declared distances and there is no allowance for aircraft

ground manoeuvring. This also is a matter for consideration particularly as it relates to the published declared distances at airports where backtracking of the runway before take-off is necessary.

2.2 Conclusions

(a) *Findings*

(i) The documentation of the aircraft was in order and the flight crew members were properly licensed and adequately experienced for the flight.

(ii) The load had been properly distributed but the aircraft's take-off weight was probably 250 lb more than that shown on the load sheet.

(iii) Although the aircraft was slightly over the Operations Manual regulated take-off weight for Runway 26, zero wind, it was within the take-off weight permitted by the Flight Manual for the same conditions.

(iv) The aircraft was being flown by the first officer from the right hand seat.

(v) During take-off the aircraft hit the ILS localiser aerial situated 167 metres (550 feet) from the end of the runway; a fence, the ILS monitor aerial and a number of approach lights were also damaged.

(vi) The aircraft suffered damage to both main landing gear wing doors, the tail skid and centre keel of the fuselage at the forward end of the rear cargo compartment.

(vii) Prior to hitting the ILS localiser aerial there was no technical defect or malfunction of the aircraft, its engines, flying controls or services.

(viii) Take-off speeds were correctly extracted by the crew from their Operations Manual: V_1 V_R 132 knots, V_2 147 knots.

(ix) The commander mistakenly believed the surface wind was 230°/08 knots and did not take account of the reported wind of 150°/less than 05 knots passed to him and acknowledged just before take-off. It is probable that during the take-off the aircraft experienced a tail wind component of about 06 knots.

(x) Approximately 61 to 91 metres (200 to 300 feet) of the effective take-off run available was lost due to the aircraft having to make a 180° turn at the runway end after backtracking to the take-off position.

(xi) Engine thrust was check set at 1.4 EPR whilst rolling and the final take-off thrust for engines 1 and 3 was set .03 EPR too low.

(xii) The aircraft was not rotated until 8 knots above V_R, ie about 3 seconds late; the rate of rotation was slightly less than half the desired value and averaged only 1.0° per second from 0° to 13° aircraft nose up.

(xiii) The aircraft did not climb for a distance of about 1,000 feet after becoming airborne but instead followed a slightly downward flight path.

(b) *Cause*

The accident resulted from the cumulative effect of three factors viz:

(i) The erosion of the take-off run available,

(ii) the delay in starting rotation, and

(iii) the very slow rate of rotation.

Factors which contributed to (i) above were,

1. Loss of effective take-off run available due to positioning from a 180° turn for start of take-off.

2. Check setting to 1.4 EPR whilst rolling.

3. Incorrect setting of take-off thrust.

4. The effect of a probable 06 knot tail wind component.

R D WESTLAKE
Inspector of Accidents

Accidents Investigation Branch
Department of Trade

August 1975