AIRCRAFT ACCIDENT REPORT 4/81

DEPARTMENT OF TRADE

Report on the accident to Vickers Viscount 735 G-BFYZ at Kirkwall Airport, Orkney Islands, on 25 October 1979

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15 June 1981

The Rt Honourable John Biffen MP
Secretary of State for Trade

Sir

I have the honour to submit the report by Mr J S Owen, an Inspector of Accidents, on the circumstances of the accident to Vickers Viscount 735 G–BFYZ which occurred at Kirkwall Airport, Orkney Islands, on 25 October 1979.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch

Aircraft Accident Report No 4/81
(EW/C678)

Registered Owner and Operator:		Alidair Ltd
Aircraft:	*Type:*	Vickers Viscount
	Model:	735
	Nationality:	United Kingdom
	Registration:	G–BFYZ
Place of Accident:		Kirkwall Airport, Orkney Islands Latitude 58° 57′N Longitude 02° 54′ W
Date and Time of Accident:		25 October 1979 at 1520 hrs All times in this report are GMT

Synopsis

The accident was notified by Air Traffic Control (ATC) Kirkwall at 1606 hrs on 25 October 1979 and the investigation commenced at Kirkwall the following day.

Following a flight from Glasgow to Kirkwall the commander carried out a Very High Frequency Omni Range (VOR) instrument cloud break procedure onto runway 25 in poor weather and a strong gusting cross-wind. During an attempt to correct a mis-alignment with the runway at a low height No 4 propeller struck the runway as the aircraft touched down and it then ran off the right hand side of the runway. It continued along the grass, parallel with the paving, until it encountered the edge of an intersecting runway when the nose landing gear collapsed. This resulted in substantial damage to the aircraft but none of the occupants were injured.

The report concludes that the accident was caused by the commander failing to take over-shoot action at an early stage in the approach to land when it became apparent that the approach was unstabilised and the windscreen wiper was unreliable.

1. Factual Information

1.1 History of the flight

The aircraft was engaged on a non-scheduled passenger flight from Glasgow to Kirkwall and was being operated by the same flight crew that had flown the previous service from Kirkwall to Glasgow. Both pilots were qualified captains and for the return flight to Kirkwall they had changed their roles and seat positions. The commander on the return flight, who was also the handling pilot, occupied the left hand seat with the other captain performing normal co-pilot's duties from the right seat.

The aircraft departed from Glasgow at 1426 hrs and the ensuing airways flight was uneventful. At 1458 hrs it was instructed by Scottish Airways Control to descend from Flight Level (FL) 150 (15,000 feet) to FL 70 (7,000 feet) and to maintain FL 70 at Wick. Shortly before 1504 hrs it was cleared to descend to FL 50 and to continue with Kirkwall on 118.3 MHz.

During the descent from FL 150 the 'Descent' check list was read out by the co-pilot; this check included an approach and landing briefing which was given by the commander although at this stage the latest weather report for landing conditions at Kirkwall had not been obtained. Kirkwall Airport has two published instrument (cloud break) VOR procedures serving runways 28 and 25 respectively. The commander reviewed the let-down procedure for runway 28 and considered the company's operating weather minima appropriate to this procedure and that for a circling approach onto another runway once visual flight conditions were established. The weather minima for a VOR procedure for runway 28 at Kirkwall were 430 feet decision height (dh) with 1,500 metres visibility and that 1,000 feet dh with 3 km visibility were required for a circling approach. Whilst studying the instrument approach chart for the runway 28 VOR procedure the commander commented that extra time would be necessary to compensate for the anticipated headwind on the outbound leg of the procedure turn. He also noted that the 75 MHz fan marker beacon on the final approach path was 4 nm from the runway threshold and indicated that it would take about 2 minutes to reach the runway.

After the remainder of the descent check was completed the co-pilot made radio contact with Kirkwall tower whilst the commander was pre-occupied with radio beacon selection and identification. At 1504 hrs the co-pilot obtained the following weather report: Surface wind 150° at 35 knots, occasional gusts to 40 knots, visibility 4.2 km in rain, cloud 2 oktas at 600 feet, 5 oktas at 1,000 feet and 7 oktas at 1,500 feet; temperature plus 10° C, 'the runway is all wet with a slight amount of standing water at the intersection'. This report was noted by the co-pilot on his navigation log but he omitted to copy the reference to a slight amount of standing water at the intersection. He then informed the commander of the prevailing weather conditions, in the light of which the commander decided to carry out the let-down procedure for an approach to runway 25 because of the tail-wind component on runway 28. He informed the co-pilot of his intentions but he did not revise the briefing he previously gave for the runway 28 procedure. As the aircraft approached Kirkwall and before commencing the

VOR procedure ATC asked 'which runway will you be landing on?', to which the commander replied: 'we are making an approach on 25'. At 1514 + 20 seconds the aircraft reported 'outbound' (on the VOR procedure) and 3 minutes 15 seconds later it reported 'inbound to runway 25', thus signifying the completion of the procedure turn onto the final approach path. Kirkwall tower acknowledged the call, cleared the aircraft to land and passed the latest surface wind velocity of 150° at 38 knots. On the completion of the procedure turn the aircraft was at 1,400 feet and displaced to the right of the required inbound track; the displacement was subsequently corrected and a low rate of descent was commenced during which the commander asked the co-pilot to 'get the map out'. This was about 78 seconds before touchdown. After passing the fan marker at approximately 1,000 feet the left hand windscreen wiper stopped functioning and the commander re-activated it by switching 'off' and re-selecting the control rheostat, during the course of which the aircraft started to drift to the right of the approach path. The co-pilot saw the runway threshold lights when the aircraft was at about 700 feet and at this point ATC reported that the surface wind was 150° 30 knots with the runway wet. Shortly afterwards the commander called for 40 degrees of flap and commented that he 'couldn't do a circle'. The co-pilot then asked 'opening up?' to which the commander replied 'no we're all right'. The commander attempted to correct the lateral displacement with a descending turn to the left but the aircraft arrived over the runway threshold to the left of the centre line and the commander then made a turn to the right at a low height. As the aircraft approached the runway threshold ATC reported the surface wind as 145° at 25 knots and, at the same time, the left windscreen wiper again stopped working.

The commander was confident that a landing could be made in the existing conditions but when the windscreen wiper malfunctioned again near the threshold he considered that an overshoot at such a late stage would have been unsafe. The air traffic controller saw the aircraft as it crossed the runway threshold and he thought it was caught by a gust of wind. At this time the surface wind was 150° at 30 knots.

The aircraft touched down initially on its starboard main landing wheels to the left of the centre line, drifting to the right, then No 4 propeller struck the runway. The aircraft bounced and about three seconds later it touched down again on its starboard wheels, striking the runway for the second time to the left of the centre line with No 4 propeller. The commander then called for full power, not knowing that the aircraft was damaged, the co-pilot however, did not apply any power because he was aware that damage had been sustained. The aircraft diverged to the right, it left the runway then ran parallel along the grass until it crossed the intersecting runway paving where the nose landing gear collapsed. The aircraft came to rest on water-logged grass near the right hand edge of runway 25 and the commander ordered an evacuation which was carried out without injury. There was no fire and the airport fire and rescue services arrived promptly.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Non fatal	0	0	0
None	4	47	–

1.3 Damage to Aircraft

Damage was substantial and beyond economical repair.

1.4 Other Damage

Part of the airport portable lighting equipment on runway 15/33 was damaged and the runway surface was gouged.

1.5 Crew Information

1.5.1 *Commander:* Male, aged 54 years.

Licence: Airline Transport Pilot's valid until 30 September 1988.

Aircraft Ratings; DHC1, PA23, Cessna 150/210, HS 104, HS 114, Bristol 170, Viscount.

Medical Certificate: Class One certificate valid until 30 November 1979
Limitations; holder to wear glasses which correct for near vision.

Instrument Rating, Competency Check, Certificate of Test and Survival check all valid.

Flying experience:

Total hours on all types:	14,485
Total hours in command:	13,894
Total hours on type:	3,601 (in command)
Total hours last 28 days:	40 (38 hrs on type)

Experience as training pilot: Instrument Rating Examiner (IRE) and Type Rating Examiner (TRE) on Viscount aircraft valid until 30/11/79.
Appointed IRE and TRE on 19 November 1976.

Duty time: 3 hours 50 minutes on the day of the accident.

Rest time: 16 hours 05 minutes.

The commander had experience of seven or eight VOR procedural approaches to runway 25 at Kirkwall under instrument conditions, two of which were necessarily flown to company weather minima.

1.5.2 *Co-pilot:* Male, aged 55 years.

Licence: Airline Transport Pilot's, valid until 17 September 1987

Aircraft Ratings: Auster variants, BN2, BN2A, DH114, C47, Dart Herald, Viscount.

Medical certificate: Class one certificate valid until 19 March 1980

Limitations: (i) As or with co-pilot only

(ii) Holder to wear glassses which correct for distant vision

Instrument Rating, Competency Check, Certificate of Test and Survival check all valid.

Flying experience:
Total hours on all types: 13,587
Total hours in command: 13,337
Total hours on type: 2,000
Total last 28 days: 42 (41 hours on type).

Duty time: 3 hours 50 minutes on the day of the accident.

Rest time: 16 hours 05 minutes.

The co-pilot had made four previous landings at Kirkwall; none of these were made under instrument conditions or using the full VOR procedure.

1.6 Aircraft information

Type: Viscount 735

Date of manufacture: 1955

Certificate of Airworthiness: Transport (passenger) category, valid until 5 December 1979.

Certificate of Maintenance: Last renewed 16 September 1979 at 25,476 hours and valid for 90 days or 400 flying hours.

Total aircraft hours: 25641

Total number of landings: 16275

Maximum weight authorised:	28,123 kg
Maximum landing weight:	24,721 kg
Weight at take-off:	26,089 kg
Weight at time of accident:	24,469 kg
Centre of gravity limits:	Forward limit varies from 369 ins aft of datum (AOD) at 19051 kg or less, to 380.3 ins AOD at 28,123 kg. Aft limit is 395 ins AOD for all flight conditions.
C.G. at time of accident:	389.6 ins AOD.
Type of fuel:	Jet A1 kerosene.

1.7 Meteorological information

1.7.1 Pre-flight briefing

Before leaving Kirkwall on the day of the accident, the co-pilot for the return flight from Glasgow obtained a weather briefing, at the Kirkwall meteorological office, based on the 0900 hrs synoptic chart. At the time of the briefing (1200 hrs) a trough of low pressure lay just to the west of Glasgow and was moving east; it was expected to pass through Glasgow by 1200 hrs. After checking the landing forecasts the pilot enquired about the landing conditions expected at Kirkwall for the return flight from Glasgow; the Kirkwall forecast for the period 1300 hrs to 2100 hrs indicated a slight increase in wind speed as the trough approached and heavy rain was not expected until after the aircraft returned. Events showed that the rain arrived earlier than expected.

1.7.2 Kirkwall forecast

The forecast for Kirkwall, 1300 hrs to 2100 hrs was as follows:

Surface wind*:	150° at 27 knots, maximum 45 knots.
Visibility:	8 km.
Weather:	Haze.
Cloud:	4 oktas at 1,000 feet, 7 oktas at 1,500 feet.
tempo 1300 to 2100 hrs:	Visibility 4 km and cloud 6 oktas at 800 feet.

NOTE* Surface wind direction

Reported surface wind directions for take-off or landing are given in degrees Magnetic whereas wind directions except for take-off or landing are given in degrees True. The wind directions given in paragraphs 1.7.2, 1.7.3, 1.7.4, 1.7.5 and 1.17.6 are in degrees True, those given in paragraph 1.1 are Magnetic. The magnetic variation was 10° west.

1.7.3 **Actual weather conditions for Kirkwall**

Time	Surface wind*		Visibility	Cloud	Weather
1420	140/28 knots	Max 40 K min 12 K	6 km	3/8 @ 600 ft 5/8 @ 1,000 ft 7/8 @ 1,500 ft	rain
1450	140/30 knots	Max 42K min 18K	4.2 km	2/8 @ 600 ft 5/8 @ 1,000 ft 7/8 @ 1,500 ft	rain
1520	140/31 knots	Max 45K min 20 K	4.2 km	2/8 @ 600 ft 5/8 @ 900 ft 7/8 @ 1,500 ft	rain

Temperature was plus 10° C throughout this period.
The wind at 1,500 ft at Kirkwall was 150° to 160° at 45 to 50 knots. The accident occurred in daylight, 87 minutes before sunset.

1.7.4 The Anemograph record

The anemograph trace for Kirkwall aerodrome for the period 1400 to 1600 hrs indicated that the mean wind was 130° at 30 knots with a maximum gust of 45 knots and isolated momentary lulls of 13 and 18 knots. Approximately coincident with the time of the final approach there was a brief lull when the wind speed dropped to about 28 knots but then increased sharply to 42 knots. It should be noted that the anemometer head is located at the airport meteorological office on the south side of the aerodrome approximately 1,000 metres from the threshold of runway 25; instantaneous values of the wind velocity are also displayed on instruments in the air traffic control tower with the wind direction given in degrees magnetic.

1.7.5 Alternate aerodrome weather

At 1520 hrs the weather conditions at Aberdeen, the declared alternate on the flight plan, were: surface wind 140/16 knots, visibility 2.5 km, rain, cloud 3 oktas at 400 feet, 8 oktas at 500 feet, temperature +10° C. No significant change.

1.8 **Aids to navigation**

1.8.1 On the ground

The VOR beacon 'KWL' on frequency 108.6 MHz has no associated distance measuring facility. Non-precision instrument approaches for runways 28 and 25 are supplemented by 75 MHz fan marker beacons, the fan marker for runway 28 is 4.03 nm before the

threshold but because of the close proximity of the seashore the fan marker for runway 25 is only 1.74 nm from the threshold and is crossed at 520 feet amsl when inbound to the runway, from which height a normal 3° approach to the runway can be made. These navigational aids were working normally.

1.8.2 In the aircraft

The aircraft was adequately equipped with medium and very high frequency radio-navigational aids which were serviceable. There were sufficient maps and charts for *en route* navigation and instrument approaches; the VOR approach chart for runway 25 at Kirkwall is shown at Appendix 1.

NB The position of the fan marker for the runway 28 procedure has been superimposed on this chart for reference purposes only.

1.8.3 Visual aids

Apart from two 140 watt lead-in sodium lamps at the threshold, there are no approach or runway lighting aids for runway 25.

Visual Approach Slope Indicators (VASI) with standard ICAO red/white indications are available on runways 25, 10 and 28 only. The VASI system on runway 25 was checked subsequent to the accident and was serviceable.

1.9 Communications

Radio communications between the aircraft and Kirkwall ATC were normal and a transcript of recorded radio telephone (RTF) messages was prepared.

1.10 Aerodrome and ground facilities

Kirkwall airport (elevation 69 feet), is operated by the Civil Aviation Authority (CAA) and is not required to be licensed; however it is operated to normal aerodrome licensing standards and regularly inspected to ensure the standards are maintained. There are three tarmac runways (see Appendix 4) and the declared landing distances were:

Runway	Landing distance available	Slope
07	1183 m x 46 m	0.85 UP
25	1183 m "	0.85 DOWN
10	1310 m x 46 m	0.02 DOWN
28	1386 m "	0.02 UP
15	879 m x 46 m	0.97 UP
33	794 m "	0.97 DOWN

Because of the intersection with runway 15/33 and the down gradient from south to north, water from the vicinity of the southern part of runway 33 tends to run across RW 25.

MU meter equipment for measuring runway braking action is available on the airport when required. A report on braking action was not requested by G–BFYZ nor was it given.

1.11 Flight recorders

1.11.1 Data recorder

The aircraft was equipped with a Plessey PV 710 digital flight data recorder (FDR), which recorded the following parameters against elapsed time:

Indicated airspeed (IAS)	Normal acceleration ('g')
Pressure height	Flaps position
Magnetic heading	

The retrieved data was corrected to the following estimated degrees of accuracy:

Height ± 50 feet	heading ± 2 degrees
Airspeed ± 5 knots	normal acceleration ± 0.05 g

These accuracies are absolute, but incremental accuracy is likely to be better than given; however, during transition from free air into ground effect and during manoeuvres such as the landing flare and any high side-slip conditions, the above accuracies are likely to be degraded because of unknown position error effects coming into operation.

Presentation of the data

A corrected readout for 90 seconds prior to the first touchdown is shown in Appendix 2. Over the same period of time the aircraft's track over the ground was calculated from the data obtained with wind vector corrections derived from information provided by the Meteorological Office; this track plot (Appendix 3), also includes the ground run portion following first and second touchdowns. The plot of the final 90 seconds of airborne data and the period following the first touchdown was synchronised with the information contained on the ATC recording and the cockpit voice recorder.

1.11.2 Cockpit voice recorder (CVR)

The aircraft was fitted with a Fairchild A100 four channel cockpit voice recorder which records cockpit area sounds and information received through both pilots' headset microphones which are always 'live' regardless of their switched modes. The

recording, which covered the last 30 minutes of flight deck activities prior to shutdown, included ATC messages. The CVR and FDR were synchronised using the second touchdown point as a datum and the CVR speed during playback was adjusted exactly to the aircraft's power supply frequency of 400 Hz. FDR/CVR synchronisation was also confirmed at a point on the final flight path 20 seconds from first touchdown and at the point where the nose landing gear collapsed. The estimated degree of accuracy for CVR/FDR synchronisation at the second touchdown is within one second. The CVR information seen on Appendix 3 is not the actual phraseology used excepting for the events shown after the second touchdown point; the information given is only intended to indicate matters of significance and their chronological sequence.

1.11.3 Interpretation of the data

Prior to the events shown on Appendices 3 and 4 the aircraft had completed the procedure turn on to the final approach to runway 25 at an altitude of 1,400 feet above the runway threshold elevation; it had initially overhot the 245° inbound track to the VOR beacon which it then closed from right to left.

The track plot shows that it passed through the approach centre line and whilst tracking to its left it commenced a descent when between 2.8 and 3 nautical miles from the runway threshold. A rate of descent of about 920 feet per minute (fpm) was maintained until after passing to the south of the fan marker at 1,000 feet. At this point the commander remarked that they should be lower than they were. Shortly after passing the fan marker the rate of descent slowed up for about five or six seconds before increasing to 1800 fpm which was thereafter maintained; the reduction in the descent rate coincided with the commander's remark that his windscreen wiper had malfunctioned. The aircraft drifted to the right of the approach track and the extended centre line of the runway and, at about 700 feet when 30 seconds from touchdown, the co-pilot saw the runway threshold lights (these appeared ahead, downwards, but to the right of the aircraft's nose because of the large angle of drift). At 25 seconds from touchdown the commander called for 40° of flaps as the aircraft passed through 550 feet, maintaining its 1800 fpm descent rate; as the flaps extended the airspeed decayed from 140 knots and a flap extension of 40° was achieved 15 seconds from touchdown. At this point there was a descending turn to the left through 30° which was immediately reversed into a right turn of about 5.2° per second as the aircraft crossed the runway threshold at about 118 knots. As it approached the threshold the rate of descent was also reduced fairly sharply as the aircraft was flared for the landing, this manoeuvre showed a positive increment of 0.25g.

The first touchdown is identified by an 0.8g increment whilst turning to the right through 235° and the stall warning horn can be heard intermittently; the aircraft appeared to bounce or 'skip', remaining airborne for about 4 to 5 seconds during which time the flaps travelled from 40° to 47°. The second touchdown sequence is characterised by the sound of a propeller strike recorded on the cockpit area microphone which was coincident with a positive 0.26g increment on the acceleration trace, then one second later there was a positive 0.7g increment which is identified with the landing gear contacting the runway. This was immediately followed by the commander calling for overshoot power to which the co-pilot replied 'I can't its gone'

and then 'no way' as the flaps returned at 40°. The total elapsed time from first touchdown to the instant the nose gear collapsed was approximately 14 seconds.

1.12 Wreckage and impact information

1.12.1 Impact information

The initial touchdown, which occurred 87 metres into the paved surface of runway 25, was 10 metres left of the centre line; evidence of the touchdown was apparent from 15 slash marks by No 4 propeller and tyre tracks from the starboard main landing gear wheels. The orientation and spacing of these marks indicated that, at the time of the initial contact with the runway, the aircraft was banked approximately 9° to the right and was tracking approximately 240° (M) and was drifting slightly to the right. The starboard main wheels contacted the ground slightly before No 4 propeller blades. Subsequent to this initial contact with the runway the aircraft bounced and followed a curving path to the right before touching down for the second time some 225 metres beyond the first touchdown and 11 metres left of the centre line. The sequence of ground contact on the second touchdown was: No 4 propeller, followed by a starboard main wheel, a nose wheel and finally the port main wheels. During the second touchdown, No 4 propeller blades struck the runway surface a total of 32 times. The orientation and spacing of the ground marks indicated that the aircraft was banked approximately 10° to the right and was tracking 250° (M) still drifting sideways to the right.

Following the second touchdown the aircraft remained on the ground and its subsequent path could be traced from tyre marks which continued towards the right hand side of the runway before beginning to turn to the left. The aircraft ran off the right hand side of the runway at a point approximately 140 metres from where runways 15/33 intersect runway 25 and it travelled along the grass parallel with and adjacent to the edge of the runway. Whilst travelling over the grass it was yawed approximately 8.5° to the left of its track. As the aircraft encountered the paving of runways 15/33 the nose landing gear support structure collapsed. The paved surface of runway 15/33 is curved in plan view at the junction with runway 25 and consequently the port main landing gear wheels struck the step of the runway paving before the starboard wheels; the resulting weight transfer, together with the effects of the collapsed nose gear, caused propellers 1, 2 and 3 to make heavy contact with the intersecting runway surface. The loads transmitted to No 2 propeller at this time resulted in a fracture of its reduction gear casing and the complete propeller became detached from the engine. There was no evidence of a further strike by No 4 propeller at this stage but strikes by Nos 1 and 3 propellers continued across the breadth of the intersecting area, with evidence that No 3 propeller had stopped turning by the time the aircraft had reached the far side of the intersection. The No 4 propeller contacted the ground again to produce four light strokes on the paving as the aircraft crossed onto the grass beyond the intersection. Nos 1 and 4 propellers continued to rotate and contact the ground as the aircraft slid across the grass to a stop near the side of runway 25. A diagram of the first and second impact marks on the runway and the aircraft's subsequent track may be seen at Appendix 4.

1.12.2 *Wreckage*

On-site inspection revealed that the flying controls functioned normally, there were no abnormal settings or selections on the flight deck except for the fire extinguisher switches which had all been selected to 'First shot'. The flap selector lever was in the 40° detent and it was established that the flaps were at the 40° position when the aircraft came to rest. The left hand windscreen wiper control was set to 'On' with its speed selector close to the maximum speed setting and the corresponding windscreen spray switch was 'On'.

A detailed examination of the aircraft following its removal from site revealed no evidence of pre-crash defect with the exception of the left hand windscreen wiper. All fractures in the nose landing gear structure resulted from an overload applied to the nose leg in an aft direction with a small side component to the left. There was no evidence of pre-existing structural damage or weakness.

1.12.3 *Windscreen wiper mechanisms*

The windscreen wipers are self-contained units comprising an electrically driven hydraulic pump and a hydraulic actuator, which drives the wiper arm. Both units were checked. The co-pilot's unit functioned correctly but the captain's system would not operate until the wiper arm had been moved manually, after which it operated normally for a few cycles before reverting to an erratic sweep of the extreme lower edge of the windscreen. Examination of the defective unit in situ revealed that the electric motor was running and that the level of hydraulic fluid in the system was low. Following topping up to the correct hydraulic fluid level, the unit functioned correctly. The fluid level in the co-pilot's unit was normal. There were no signs of gross leakage from the captain's unit, but both units exhibited signs of slight general seepage.

During the months of September and October 1979, three separate unserviceabilities in the wiper mechanism on the captain's side had been recorded in the Technical Log. In each case the fault had been cured by topping up with hydraulic fluid. The company maintenance procedures are such that a recurrence of a defect of this type is permitted three times (ie total 4 defects) before a more detailed investigation and repair is required.

1.12.4 *No 4 Propeller and engine*

It was possible to identify the damage inflicted on the propeller blades at the time of the first contact with the runway and to identify the principal blade damage attributable to the second contact. It was not possible to establish with confidence the damage to the propeller operating mechanism attributable to the latter stages of the second touchdown and that attributable to the heavy contact with the turf beyond the runway intersection.

Because of the relatively small area of forward bending at the propeller tips which is identified with the first contact with the runway it is thought that had an overshoot been initiated after the first touch the propeller would have probably delivered

adequate power, but the serviceability of the propeller for an overshoot after the second touchdown could not be determined, however, the extent of the blade damage from the second series of strikes was more severe than the former and could have affected its propulsive capability.

Examination of No 4 engine revealed that the unit was not damaged sufficiently by the propeller strikes to have impaired its full power capability.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

There was no fire and the fuel tanks remained intact throughout the accident sequence.

1.15 Survival aspects

Retardation forces were low and no one was injured when the nose landing gear collapsed or during the subsequent evacuation. All persons on board were properly strapped in for the landing and there were no failures in the passenger seat attachments or seat belts. One of the two jump seats occupied by cabin staff suffered a failure of the single tubular link connecting the seat legs to the floor attachment point. This failure was produced by compression bending of the strut as a result of forward movement of the leg sections of the seat, probably caused by the feet and lower limbs of the occupant pressing against them during the deceleration phase. This particular seat design was peculiar to G–BFYZ only.

A stewardess tried to open the rear entrance door but although its release mechanism functioned she was unable to force it open against the pressure of wind on the port side. A few passengers left the aircraft via the over-wing exits but the majority went through the front entrance door which was opened by a male passenger and was held open by the co-pilot. Aircraft fire service personnel and vehicles had already been called to 'weather standby' because of the high gusting wind conditions before the aircraft made its approach, consequently their response to the emergency was instantaneous and they arrived at the aircraft in less than one minute.

All exit doors and emergency exits were checked for correct operation and were found to be in order.

1.16 Tests and research

None

1.17 Additional information

1.17.1 Statutory requirements for safe operation

Statutory requirements relating to the responsibilities of an operator or aircraft commander for the safe operation of a particular flight are covered under provisions of the Air Navigation Order (ANO) and the Air Navigation (General) Regulations (ANGRs). Article 6 of the ANO relates to the 'Air Operator's Certificate' (AOC) which is issued by the CAA to operators of aircraft registered in the United Kingdom, as an indication that they are considered competent to secure the safe operation of their aircraft. One of the General Conditions of the AOC required that every flight shall be conducted in accordance with the provisions of an Operations Manual and Instructions.

1.17.2 The Air Operators Certificate

Information is given in the CAA publication CAP 360 on the requirements to be met by holders of AOC. In Chapter 2 'Operations Manual' Section 5.3.5 it states:

'Crosswind limits for take-off and landing. It is not sufficient to repeat a statement entered in a Flight Manual that a particular crosswind component has been found acceptable; operators limitations shall be stated in unequivocal terms and account taken of the effects of gusts and surface conditions. Limits in excess of this figure mentioned in the Flight Manual normally will not be accepted'.

1.17.3 Flight Manual

The aircraft Flight Manual is part of the Certificate of Airworthiness and as such a commander must operate the aircraft in accordance with any instructions and within any limitations contained therein.

The Flight Manual of G–BFYZ stated in Section 4, 'Handling', that the maximum crosswind component in which the aircraft has been demonstrated to be controllable on take-off and landing is 27 knots; it should however, be noted that this is not a 'Limitation'. Following a request by Alidair in November 1977 to raise this figure to 30 knots for their existing fleet of 700 series Viscounts, the CAA Airworthiness Division agreed to the proposed increase if Alidair applied to the CAA Flight Manual Section for the appropriate amendment. This was done and amendment P/68 was incorporated in January 1978 in the existing Flight Manuals except that of G–BFYZ which did not enter service with Alidair until December 1978. The amendment in respect of this particular aircraft's Flight Manual had not been applied for at the time of the accident but this omission was a technicality since the CAA already agreed that the amendment to 30 knots could equally apply to all 700 series Viscounts operated by Alidair.

In February 1978 Alidair issued a Notice to Pilots which stated that the maximum crosswind component for the Viscount was increased to 30 knots for dry runways or when braking action is good, but the limits contained in the Operational Manual would remain unaltered.

1.17.4 Operations Manual

The following table and instructions were contained in the Alidair Operations Manual dated 1 October 1977, they deal with landing on contaminated runways.

'The main effect of runway contamination on landing is the reduction of braking ability. The Landing Distance Required graphs in the Flight Manual are applicable to a hard dry runway but are factored so as to be valid for a wet runway. However, if the runway is affected by snow, slush, standing water of at least 2 mm depth or ice, the Landing Distance Required must be increased in accordance with the reported braking action, as summarised below:

Runway conditions	Reported braking action	Restrictions required	Maximum crosswind component
Water	Good	No restrictions	27 knots
	Moderate	Increase landing distance required by 20%	20 knots
Snow and Ice	Poor	Increase landing distance required by 27%	10 knots

1.17.5 Crosswind limits and assessment of crosswind component

A Flight Safety Notice, issued by Alidair in October 1977, gave guidance to its pilots when assessing crosswinds and gust factor; it said:

> 'To assess more crosswind limit when gusting reported, using 50% of the gust factor added to steady wind velocity; eg surface wind 150/25 knots gusting to 35 knots, gust factor is 10 knots – 50% is 5 knots, therefore 25 + 5, wind assessed as 150/30 knots'.

There was no evidence that the crew considered the foregoing, other than having a 'mental picture' of the relationship of runway and wind direction.

1.17.6 Landing conditions at Kirkwall

According to ATC Kirkwall the depth of water at the intersection was less than one millimetre at the time of the approach and landing; the rest of the runway was merely wet with no significant water deposits. The reported surface winds passed to the aircraft are listed below together with the crosswind components assessed in accordance with paragraph 1.17.5 above and the calculated tailwind components for runway 25:

Time	Surface wind	X-wind comp.	Tailwind component
1504	150/35 gusting 40	37.5 kts	6.5 kts
1514	150/35	35 kts	6.5 kts
1517	150/38	38 kts	7 kts
1518	140/30	29 kts	10 kts
1519	150/30	30 kts	5 kts
1519 + 30	145/25	25 kts	4 kts

1.17.7 Landing distance requirements

Although the landing distance required for this flight should be calculated on the basis of the wind forecast for the destination at some time before departure from Glasgow, it is realistic to consider the landing distances required on a basis of the wind reported while the approach was being carried out.

In the conditions prevailing at 1504 hrs, the aircraft required a landing distance of 1127 metres for a landing on runway 25 if 47° of flap were used. If 40° of flap were used 1172 metres would have been required. The landing distance available was 1183 metres.

1.17.8 Co-pilot's duties

The duties of a co-pilot are contained in the Operations Manual Vol 1 Section 1; in respect of his in-flight duties the following are listed:

'8.3 **Responsibilities in Flight'.**

(a) Assisting in the safe and effective conduct of the flight.

(b) Properly carrying out all routine or emergency checks in accordance with the captain's orders.

(c) Keeping a record of the instrument readings of fuel being used and remaining.

(d) Maintaining an accurate navigation log.

(e) Maintaining radio contact with Air Traffic Control or other stations.

In addition to the foregoing, the co-pilot's duties during an instrument approach procedure are listed in paragaph 18.2 of the Operations Manual as follows:

'(d) P2; (a) He will throughout the approach, monitor and assess the accuracy of the aircraft's approach path, airspeed and rate of descent.

(b) Maintain a lookout throughout the approach phase to obtain visual contact with the approach lighting or runway (lights).

(c) Will advise P1 at 200 feet and 100 feet above critical height and, if no contact, before decision height.

On reaching decision height the P2 will say either:

(i) "Decision height – no contact" or

(ii) "Decision height – lights/runway left, right or ahead".'

1.17.9 Reporting of surface wind velocities

Annex 3 to the ICAO Convention (Meteorological Service for International Air Navigation) contains the following recommendations in Chapter 2:

'4.5.2 Recommendation ..... and for reports for landing the observations should be representative of the touchdown zone .....

4.5.3 Recommendation. Representative wind observation should be obtained by using one or more sensors appropriately placed according to local conditions, for example, separate sensors may be needed to obtain measurements representative of the lift-off and touchdown areas.'

2. Analysis

Both pilots were properly licensed, the aircraft was correctly loaded and with the exception of the left hand windscreen wiper there were no significant defects.

Prior to making the initial approach the commander reviewed the VOR let down procedure for runway 28 but later, on receipt of the latest weather report from Kirkwall, he decided to carry out the VOR procedure for runway 25 but failed to appreciate that the fan marker beacon was closer to the runway than it was on the other procedure for runway 28. Consequently the let down and approach pattern were incorrectly flown and the aircraft was too high when it passed the fan marker on the final approach. Before arriving overhead and prior to the commencement of the cloud break procedure, ATC queried the commander's intention as to which runway would be used for the landing. He decided that unless the cloud base and visibility permitted a circling approach onto runway 15, the landing would be made on runway 25. At the commencement of the final approach following the completion of the procedure turn, the commander asked the co-pilot to 'get the map out', presumably with a view to making a circling approach. Later, however, with the runway threshold lights in view, and realising that the conditions precluded a circling approach onto another runway the commander committed himself to a landing on runway 25.

Except for having a mental picture of wind direction relative to the runways considered, there is no evidence that either pilot made any attempt to quantify the crosswind component for a landing on runway 25 although the approach was made on the assumption that a landing on this runway might well be made. With the exception of the final wind report by ATC five seconds before touchdown, at which stage the commander had committed himself to a landing, the reported wind velocities were at approximately right angles to runway 25 and, together with the strength of the reported gusts at the commencement of the approach, were in excess of the demonstrated crosswind conditions given in the Flight Manual which set the upper limit to any assessment derived from the company's Operations Manual or supplementary instructions to pilots. It should be noted however, that the surface conditions reported by ATC did not necessarily represent the wind velocity in the touchdown area because of the recording sensor's distance from the runway threshold.

Although the surface wind reported by ATC about 5 seconds before touchdown was given as 25 knots, the evidence of the anemometer trace indicates that this was a brief and transitory lull at the point of measurement. From the evidence of the ATC controller and the flight crew it is possible that the aircraft was caught by a strong gust of wind at a critical moment as it arrived at the touchdown area.

Since landing performance is a dispatching requirement based on forecast landing conditions, there was no statutory requirement to review the landing distance required whilst airborne but it would, in many instances, be good airmanship to do so and holders of AOCs are required to present landing distance information for the use of their crews in easily interpreted tabular form. Such information was not available to

the crew in this instance because Kirkwall was not frequently used and, in the circumstances, it would have been necessary to refer to the Flight Manual performance graphs. However, it is no easy matter for either of the pilots to extract landing performance information from the Flight Manual, whilst performing their other duties, during an approach to land in bad weather. Nonetheless, the need to do so could be anticipated before the approach is commenced but in this instance the information was only available in the Flight Manual in an impractical form not easily interpreted in the air.

The company's crosswind limitations incorporated in the table of landing distance requirements with a contaminated runway, which is in the Operations Manual, were not applicable to the case in question because there was less than 2 mm of standing water on the runway surface and there was no indication that braking action was other than good. However, as a result of this accident the operator revised this instruction to include wet runways where depth of water has not been reported and takes into account whether or not it is raining at the time of touchdown.

During the final approach phase the aircraft was about 500 feet too high at the marker beacon but the commander realised this and attempted to retrieve the situation after being distracted by a malfunctioning windscreen wiper. This resulted in an unstabilised final approach during the visual phase which required a large correction to the left to regain the extended centre line whilst attempting to lose excessive height rapidly 15 seconds before touchdown. This situation in itself should have prompted the commander to discontinue the approach but he persisted in his attempt to land, even when his windscreen wiper again stopped working. An overshoot even at this late stage should have been within the capabilities of an experienced Viscount pilot who was also a type rating and an instrument rating examiner. This accident again illustrates the reluctance of a commander to discontinue the approach rather than attempt a last moment side-step manoeuvre when the aircraft is badly placed for a landing. In this latter respect attention is drawn to a previous Viscount accident at Bristol (Lulsgate) Airport which was reported in CAP 313, issued by the Accidents Investigation Branch in 1968.

In the accident at Kirkwall however, the co-pilot, a fully qualified captain, was aware of the deteriorating situation but took no positive steps to warn the commander during this final visual phase except to make the remark 'opening up?'. His reluctance to warn the commander was consistent with his mental attitude that it was the captain's responsibility. The Operations Manual required the co-pilot to 'assist in the safe and effective conduct of the flight'. It is considered that this instruction was insufficiently specific and the co-pilot's duties should have been more positively defined, particularly for the visual phase of the approach and landing. Whilst recognising that further elaboration on this instruction raises the question of how far a co-pilot should go to ensure that the aircraft is handled safely, the operator accepted that a 'grey area' did exist and, following the accident, took steps to review the instructions relating to co-pilot's monitoring responsibilities.

In the past there have been a number of serious accidents where the crew has comprised two or more pilots, each qualified in command of the type concerned. This has

happened with sufficient frequency as to throw doubt upon the assumption that such a crew is at least as efficient, and their aircraft operation as safe, as when the crew comprises a pilot-in-command and a subordinate co-pilot. Notwithstanding specific competency requirements which have to be observed when commanders are used as co-pilots, it may well be that a 'captain' who is carrying out the duties of a co-pilot could be less well practised and, indeed less effective than a regular co-pilot in a supporting role. The question arises as to whether this accident is yet another case. There appears to be a need for research to be conducted in order to establish whether a flight crew comprising two qualified aircraft commanders is less safe than a normal crew comprising captain and co-pilot. At Appendix 5 is a list of some accidents in which the flight crew comprised two or more qualified aircraft commanders.

The commander decided to continue with his attempt to land after the windscreen wiper malfunctioned for the second time when he was trying to re-position the aircraft over the runway after over-correcting the lateral displacement. As this was being done the aircraft touched down on its starboard main wheels drifting to the right and struck the runway with No 4 propeller. It bounced or skipped and was to all intents out of control, probably due to a heavy gust of wind coincident with the second touchdown which resulted in No 4 propeller again striking the runway fractionally before the right landing wheels made contact. The commander then called for go-around power but the co-pilot did not respond because he was aware that the aircraft had already sustained damage. Since neither pilot had any means of ascertaining the magnitude of the damage to the aircraft, it should in any case have been considered hazardous to continue the flight further.

The faulty windscreen wiper which malfunctioned at two critical periods during the final approach was contributory to the accident, but it cannot be regarded as the primary causal factor since the accident could have been prevented by timely action by the commander to discontinue the approach in both instances.

3. Conclusions

(a) *Findings*

1 The flight crew were correctly licensed and appropriately experienced.

2 The aircraft was correctly loaded and its documentation was in order.

3 With the exception of the faulty left hand windscreen wiper there were no significant defects in the aircraft.

4 The attempt to land was made in weather conditions of rain, low cloud and a strong gusty cross-wind.

5 The last reported wind before touchdown was within the prescribed cross-wind limits and the landing distance requirements were fulfilled.

6 The published cloud break procedure for runway 25 was carried out incorrectly in that the aircraft overflew the fan marker beacon approximately 500 feet too high.

7 The visual stage of the approach was unstabilised and the aircraft was poorly positioned for a landing as it approached the runway threshold.

8 The approach should have been discontinued when it was evident that the aircraft was unstabilised on its final approach before landing.

(b) *Cause*

The accident was caused by the commander failing to take overshoot action at an early stage in the approach to land when it became apparent that the approach was unstabilised and the windscreen wiper was unreliable.

4. Safety Recommendations

It is recommended that:

1 The Civil Aviation Authority initiate research to establish whether or not two qualified aircraft commanders, operating as a flight crew, are less safe than a normal crew comprising a captain and a co-pilot of subordinate rank or grade.

2 The siting of the anemometer at Kirkwall be examined with a view to providing the most realistic assessment of surface wind velocity.

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