Department of Trade

ACCIDENTS INVESTIGATION BRANCH

HS 748-2 G-AZSU report on the accident at Sumburgh Airport, Shetland Islands on 10 January 1977

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

19 October 1977

The Rt Honourable Edmund Dell MP
Secretary of State for Trade

Sir,

I have the honour to submit the report by Mr P J Bardon an Inspector of Accidents, on the circumstances of the accident to HS 748-2 G-AZSU which occurred at Sumburgh Airport, Shetland Islands on 10 January 1977.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 9/77
(EW/C585)

Operator:		Dan Air Services Ltd
Aircraft:	*Type:*	HS 748-2
	Nationality:	United Kingdom
	Registration:	G-AZSU
Place of Accident:		Sumburgh Airport, Shetland Islands 59° 53'N 01° 18'W
Date of Accident:		10 January 1977

All times in this report are GMT

Synopsis

The accident was notified to the Department of Trade by the Airport Manager, Sumburgh Airport on the day of the accident. The Accidents Investigation Branch of the Department of Trade carried out an investigation with Operations, Engineering and Flight Recorder groups established under the Investigator-in-charge.

The aircraft was engaged on a non-scheduled transport passenger flight from Belfast to Sumburgh and after a normal approach and landing to the main instrument runway was unable to stop in the landing distance available. The aircraft was intentionally deviated from the paved surface to avoid running off the end of the runway into the sea and having done so the nose-wheel undercarriage leg collapsed. There was no fire and no injuries to the 54 occupants. The report concludes that the accident was caused by the aircraft landing on a slippery runway of insufficient length to accommodate these conditions.

The aircraft commander was provided with invalid information about the runway conditions and the braking action.

Recommendations are made with respect to the availability of friction meters, cabin emergency equipment, visual approach path guidance and the frequency of braking action reports.

1. Factual Information

1.1 History of the flight

The aircraft was operating Danair Flight No. 045, a non-scheduled service from Belfast to Sumburgh. Since the terminal weather forecasts for Sumburgh and Aberdeen were marginal, the aircraft carried sufficient fuel for a possible diversion to Glasgow or Prestwick. The aircraft took off from Belfast at 1624 hrs with a full load of 50 passengers. Whilst *en route* the aircraft was in radio contact with Aberdeen and it was learnt that the runway braking action there was below Company limits. At 1806 hrs, the aircraft reported to Sumburgh Approach that it was abeam Kirkwall and stated that it was in receipt of the 1750 hrs weather report, but requested the latest surface wind and runway state information. Sumburgh Approach replied as follows:

> 'SIERRA UNIFORM WILL DO THE SURFACE WIND IS INDICATING ZERO TWO ZERO AT ONE FOUR KNOTS AT THE MOMENT AND RUNWAY EH STATE IT'S BEEN PLOUGHED THERE WAS A LAYER OF WET SNOW ON THE SURFACE WHICH HAS NOW BEEN PLOUGHED LEAVING A DEPTH OF ABOUT A MILLIMETRE IN THE CENTRE AND UM THE MU METER IN FACT IS BROKEN SO WE CAN'T GIVE AN ACCURATE UM READING OF BRAKING ACTION HOWEVER MIKE X HAS JUST LANDED ABOUT EH TWENTY MINUTES AGO AND SAID THAT HE'D FOUND THE BRAKING ACTION MEDIUM AND EH HE HE LANDED JUST PAST THE THRESHOLD OF ZERO NINE AND STOPPED BEFORE THE TURN OFF DOWN TWO TWO'.

The aircraft acknowledged this message and was subsequently positioned by radar for an approach to Runway 27. At 1820 hrs the aircraft requested a wind check and was advised that it was from 010 degrees at 10 knots. The aircraft replied: 'AH ROGER THAT'S FINE FOR TWO SEVEN'.

At 1823 hrs the aircraft was cleared to land on Runway 27, the surface wind being reported as 360 degrees at 12 knots. The aircraft was given three further wind checks as it made its approach, all of which were from 360 degrees and varying between 10 and 13 knots.

According to the evidence of both pilots, the aircraft was established on the final approach at about 700 feet at an airspeed of 110 knots. After the selection of landing flap at between 300 and 400 feet, the speed was allowed to decay towards the target threshold speed of 94 knots, whilst still maintaining a 3 degree glide slope as given by the Visual Approach Slope Indicator System (VASIS). The precise point of touch-down could not be established but it is thought to have been adjacent to the upwind pair of VASIS and alongside the intersection with Runway 22/04. The touch-down itself was smooth according to the evidence of one of the stewardesses and also from the flight data recorder. Ground fine pitch was selected and obtained. After touch-down, the commander, who was the handling pilot, applied intermittent braking and he noted that whilst this was effective, there was no significant loss of forward speed. He then applied full braking for the remainder of the landing run. As the aircraft crossed the intersection of Runway 33/15, it was apparent that the aircraft was not decelerating normally and that it would not be possible to stop within the runway distance remaining. He therefore decided to turn the aircraft off the paved surface to the left so as to avoid overrunning the end of the runway into the sea. The nose-wheel steering was found to be ineffective, so the commander applied full left rudder and full left brake and succeeded in steering the aircraft off the runway at a speed since estimated to have been between 30 to 40 knots. Shortly after the aircraft had left the runway, the nose landing gear assembly collapsed and the aircraft came to rest at 90 degrees to the runway heading, about 60 feet from the runway edge and 50 feet beyond the threshold of 09. There was no fire. The aircraft's engines were shut down and the batteries were turned off. The airport emergency services, which had

been on 'weather' stand-by, were on the scene within a few minutes. There was a short delay in the evacuation due to an initial lack of lighting. However, all the occupants left the aircraft shortly afterwards through the forward main door in an orderly manner as soon as the emergency lighting was switched on, and no one was hurt.

The accident occurred during the hours of darkness at 1828 hrs.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal	–	–	–
Serious	–	–	–
None	4	50	

1.3 Damage to aircraft

The aircraft suffered substantial damage to the nose landing gear, forward bulkhead, and both propellers.

1.4 Other damage

Two runway lights indicating the displaced threshold of Runway 09 were destroyed.

1.5 Personnel information

1.5.1 (a) *Commander*

Age:	35 years.
Licence:	Airline Transport Pilot's Licence.
Aircraft ratings:	PA 23, Nord 262, BAC 1-11, HS 748.
Instrument rating:	Valid to 13 December 1977.
Medical certificate:	Last medical examination 22 November 1976, with no restrictions.
Last competency check:	13 November 1976.
Last route check:	13 November 1976.
Flying experience:	
Total pilot hours:	5,173 (4,024 as pilot in command).
Total pilot hours on HS 748:	2,541 (755 as pilot in command).
Total flying in last 28 days:	78 hours, all on HS 748.
Previous landings at Sumburgh:	23, of which 7 were at night.
Rest period:	Two days stand-by plus 12 hours prior to date of accident.

(b) *First Officer* — Age 23 years.

Licence:	Commercial Pilot's Licence.
Aircraft ratings:	HS 748 (Group 1).
Instrument rating:	Valid to 26 May 1977.
Medical certificate:	Last medical examination 3 February 1976. Restricted: holder to wear glasses to correct for distant vision.
Last competency check:	17 October 1976.
Last route check:	14 May 1976.
Flying experience	
Total pilot hours:	669 (315 as pilot in command).
Total pilot hours on HS 748:	433 (156 as pilot in command under supervision).
Total flying hours in last 28 days:	79, (31 as pilot in command under supervision).
Previous landings at Sumburgh:	144 of which 25 were at night.
Rest period:	Two days stand-by plus 12 hours prior to date of accident.

(c) *Duty period*

The crew had been on duty since 0715 hrs on 10 January 1977, and the accident happened while completing a four sector duty period between Sumburgh and Belfast. They had been detailed to fly together as a crew on this route for a specific period.

1.6 Aircraft information

1.6.1 Details of aircraft

HS 748-2:	G-AZSU.
Manufacturer:	Hawker Siddeley Ltd.
Date of manufacture:	1967 Serial No. 1612.
Certificate of Airworthiness:	Valid until 14 April 1977.
Certificate of maintenance:	20 November 1976.
Total airframe hours:	16,649.
Maximum permissable landing weight:	19,504 kg.

Estimated landing weight at time of accident:	18,300 kg.
Centre of gravity range:	66.0 inches to 79.8 inches aft of datum.
Centre of gravity at the time of accident:	77.325 inches aft of datum.
Main wheel base track:	24 feet 9 inches.
Type of fuel:	Jet A-1.

The aircraft was certificated in the Transport Category (Passenger).

1.6.2. Landing performance

The landing distance required, as given by the aircraft's Flight Manual, for a weight of 18,300 kg was 990 metres in zero wind conditions, and on either a dry or a wet runway. This distance is 1.67 times the actual distance that was established during the performance certification trials of the aircraft. When the runway is either flooded or icy a further 30 per cent or 70 per cent respectively must be added. Therefore at the aircraft's landing weight a landing distance of 1,290 metres would have been required on a flooded surface and 1,690 metres on an icy surface. These landing distance requirements assume one engine inoperative and that the speed to 50 feet over the threshold does not exceed the Maximum Threshold speed, that is 15 knots above the Target Threshold speed. In the case of G-AZSU at the time of its approach to Sumburgh, the Maximum Threshold Speed was 109 knots.

1.7 Meteorological information

The observations made at Sumburgh before and after the accident were as follows:

1750 hrs:	Surface wind:	020/10 knots.
	Visibility:	6,000 metres.
	Weather:	Recent rain and snow.
	Cloud:	2 oktas stratus at 800 feet. 5 oktas cumulonimbus at 1,200 feet.
	Temperature:	+ 1° Celsius.
	Dew point:	– 1° Celsius.
	QFE:	999 millibars.
	QNH:	999 millibars.
1840 hrs:	Surface wind	030/13 knots.
	Visibility:	8,000 metres.
	Weather:	Nil
	Cloud:	4 oktas cumulonimbus at 1,200 feet.

Temperature:	+ 2° Celsius.
Dew point:	0° Celsius.
QFE:	999 millibars.
QNH:	999 millibars.

The final approach was made visually, and shortly before touch-down ATC informed the aircraft that the surface wind was 360°/10 knots. The anemograph recorded at 1828 hrs, the time of the accident, a wind from 010 degrees at 12 knots.

From an examination of the available charts and data, the Meteorological Office considers it 'very likely, in view of the meteorological conditions, that there might have been ice on the runway' at the time of the accident.

1.8 Aids to navigation

Sumburgh airport is equipped with surveillance radar and this was used to position the aircraft for its approach to Runway 27.

1.9 Communications

Normal RTF communications were established on the Sumburgh Approach frequency 123.15 MHz and the aircraft remained on that frequency until after landing.

1.10 Aerodrome and ground facilities

Sumburgh airport is situated near the southern end of the Shetland Islands and is operated by the Civil Aviation Authority. There are two operational runways, tarmac covered: 09/27 (1,084 by 46 metres) and 15/33 (1,426 by 46 metres). Runway 04/22 is disused. The elevation of the threshold of Runway 27 is 14 feet, falling away to 4 feet at the 15/33 intersection before rising to 18 feet at the end. The Landing Distance Available on Runway 27 according to the UK Air Pilot, is 1,026 metres. Night operations from Runway 15/33 are prohibited due to terrain clearance considerations. On Runway 27 there is one bar of high intensity approach lighting on the centre line and also VASIS set at 3 degrees. The VASIS are positioned 126 and 281 metres respectively from the threshold. The runway is lit by high intensity edge lighting and threshold lights.

It was not possible to measure the runway surface friction coefficient as the Mu-meter was unserviceable due to a failed tyre and no spares were available. The Tapley meter, with which the airport was also equipped, is considered to be unsuitable for use in snow or slush.

Runway 27/09 had been ploughed at approximately 1700 hrs following a heavy snow shower and the braking action was then assessed qualitatively by the Fire Service as being medium to poor. A thin deposit of slush to an estimated depth of 1 mm remained on the runway after ploughing. An HS 748 which landed on 09 at 1720 hrs completed its landing run by the 22/04 intersection and the pilot reported the braking action as medium. During the next hour the runway surface was kept under observation and it is stated that no appreciable change was detected.

The ploughing and the braking action assessment was confined to an area 10 metres either side of the centre line in accordance with the procedures stated in section 9, Chapter 4 of the Manual of Air Traffic Services Part 1.

There is contradictory evidence from witnesses who visited the scene of the accident shortly afterwards as to the state of the runway. Two witnesses stated that there was no sign of ice, snow or slush on the cleared portion of the runway. Others reported that the centre of the runway was slippery and that driving conditions were difficult. All were agreed, however, that there were deposits of snow and slush to a depth of about 2 inches along the uncleared edges of the runway though one witness stated that these deposits were frozen, whereas another stated they were not.

1.11 Flight recorder

The aircraft was fitted with a Midas CMM/3B frequency modulated flight data recorder, the crash protected element of which was installed in the tail cone aft of the pressure bulkhead. The parameters recorded were as follows:

Altitude; indicated airspeed; pitch attitude; roll angle; normal acceleration (G); magnetic heading.

A clear record was obtained from the mandatory recorder, but the accuracy of the speed values obtained is considered to be no better than ± 5 knots, and then only when out of ground effect. A calibration of the equipment installed in the aircraft at the time of the accident was not available and could not be subsequently checked due to a fault that later developed in an electronic unit.

The significant values of airspeed that were obtained when all the available corrections had been applied are summarised as follows:

	Corrected reading	*Lowest possible value*
Approach speed after the selection of full flap	108 – 113 knots	103 knots
Speed through 50 feet	106 – 110 knots	101 knots (Vat + 7)
Speed on touch-down	93 – 97 knots	88 knots

The speeds through 50 feet and on touch-down are to some extent speculative as neither of these two events could be positively identified on the flight recorder trace. In particular, the touch-down point could not be determined from the G trace as there was no characteristic indication of this which suggests that the landing was smooth. The only indication of touch-down was that obtainable from the altitude and pitch attitude traces.

The rate of descent on the approach as the aircraft approached 50 feet was 9.5 feet per second and this corresponds to a 3 degree glide path, assuming a zero head wind component and using a derived true airspeed value.

The speed at which the aircraft ran off the edge of the runway could not be determined since the fine scale airspeed has a lower limit of 80 knots.

A cockpit voice recorder was not fitted to the aircraft nor was one required to be fitted.

1.12 Examination of the aircraft and accident site

The active portion of Runway 27 ended at the threshold of the reciprocal Runway 09, though the tarmac extended a further 190 feet. 300 feet beyond the runway end, on the

far side of a public road, there was a sharp, 10 feet drop over a sea wall to a rocky beach and the sea.

The aircraft had already been moved from the accident site prior to the arrival of the investigating personnel but it was evident from ground marks, which were covered by a light fall of fresh snow, that the aircraft had come to rest approximately 50 feet beyond the displaced threshold of 09 and 60 feet south of the runway edge facing a direction of 165° (M). The tracks could be traced back on to the runway, in a layer of frozen slush, to a distance of about 30 feet for each wheel and about 15 feet in from the runway's edge. These tracks indicated that, at that point, the aircraft had been travelling in a direction approximately 20° to the left of the runway heading and skidding to the right. When the runway subsequently cleared no rubbing or scalding marks were found on its surface.

The aircraft's nose landing gear had collapsed and both propellers had sustained tip damage. The nose leg had broken off shortly after the aircraft left the runway and as it passed through the row of 09 threshold lights, two were destroyed.

The starboard propeller was in ground fine pitch. The port propeller was in the feathered position but the tip damage indicates that at the time of impact it had been at some finer pitch condition. Both HP cock levers were found selected to the feather position and the flight fine pitch stop lever had been withdrawn. Both throttles were closed. The flap lever was set to full flap, though the flaps themselves had been retracted manually before the aircraft was moved.

All the tyres appeared to be in good condition with ample tread depth but some exhibited damage which could be attributed to the accident. The only tyres to show less than the specified pressure were the starboard nose-wheel tyre and the starboard main outer tyre, the two most vulnerable in a skid to the right. The tyres showed no evidence of heavy rubbing or scalding.

The brakes and their hydraulic system were intact and it was possible, therefore, once new engines had been installed, to test the system in its pre-crash condition (the engine driven hydraulic pumps were unaffected by the engine change). The system was operated successfully and full main and brake pressures were achieved. The low pressure warning lights functioned correctly and a successful preliminary check was made on the operation of the anti-skid units. When the hydraulic system was bled the fluid was seen to be clean with some fine aeration.

A subsequent detailed examination of the brakes and their associated anti-skid units and flow modulators was carried out by the manufacturers but no defects that could have affected brake performance were found.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

There was no fire, but as a precautionary measure, the commander operated the engine fire extinguishers after the aircraft came to rest.

1.15 Survival aspects

When the aircraft came to rest, all the cabin lights went out after the batteries had been turned off by the pilots. The senior cabin staff crew member, who was positioned at the

rear of the cabin, remained unaware that there was an emergency situation until she saw the other stewardess moving down the aisle towards her with a torch. The senior stewardess did not operate the emergency (Phoenix) lights at the rear of the aircraft, nor did she have a torch available to her until handed one by the second stewardess. In the meantime, the first officer had entered the cabin and switched on the Phoenix lights above the two emergency exits, which he then opened. He instructed the passengers to remain seated and then left the aircraft through the forward main door to assess the situation outside. By this stage, the senior stewardess had opened the rear door and extended the air stairs. The first officer shouted to her from outside that the stairs should not be used (as the lowest step was about 5 feet from the ground) and that the emergency exits should also not be used as the top surface of the wing was slippery. This was the first intimation that the senior stewardess had had that the aircraft was to be evacuated. She then shouted to the passengers to leave their hand baggage and evacuate the aircraft by the forward door. The commander was by this time standing by the door and he supervised the disembarkation of the passengers, which was orderly and unflurried. The emergency services, which had been on special alert because of the weather conditions, were on the scene promptly.

1.16 Tests and research

Nil.

1.17 Additional information

Extract from the Company's Operations Manual.

The Company's Operations Manual gives guidance to pilots as regards braking action, an extract of which is as follows:

> 'When braking action is reported as variable in stages over the length of the runway i.e. first third – POOR, second third – MEDIUM, last third – MEDIUM, the following instructions apply: No take off or landing is allowed if the last third stage is reported as Braking Action – POOR.
>
> Pilots must ensure that the landing distance required is less than the landing distance available which has been reported as having a suitable braking action.
>
> No take off or landing is allowed from runways where the overall braking action is reported as POOR.
>
> Whenever braking action is reported in the MEDIUM to MEDIUM/POOR range, pilots should exercise their discretion. IF IN DOUBT – DON'T GO.
>
> The maximum cross wind component for take off or landing when braking action is reported as MEDIUM/POOR is ..... HS 748 15 knots.
>
> *Very Slippery Surface*
>
> A surface will be very slippery if:
>
> (a) It is covered with untreated ice.
>
> (b) It is covered with untreated, densely compacted snow.
>
> (c) It is covered with a uniform layer of slush.
>
> (d) It has a considerable amount of standing water which may give rise to conditions conducive to aquaplaning.

In each case, if braking action is reported as POOR, take off or landing is prohibited.

For those contaminated surfaces where braking action is reported as MEDIUM/POOR or better ..... no take off or landing will be made if the total depth of snow exceeds 8 cm (actual) or, in the case of wet snow/slush or water, the depth exceeds 15 mm (actual or water equivalent depth).'

1.18 New investigative techniques

Nil.

2. Analysis

2.1 The landing

It could not be established precisely where the aircraft touched-down, but on balance, the most likely position appears to have been at the intersection with the 04/22 Runway and adjacent to the upwind pair of VASIS, that is, approximately 280 metres in from the threshold. This position is approximately in the centre of the VASIS touch-down zone, and this would seem to confirm that the aircraft made a correct approach on the 3 degree glide slope, and the flight data recorder read out supports this.

It proved impossible to determine accurately the aircraft's speed over the threshold or on touch-down due to the difficulty of identifying on the flight recorder traces where and when these two events occurred. Also, because of difficulties experienced with the calibration of the equipment, the airspeed values obtained are considered to be accurate only to within ± 5 knots. Taking these factors into account, it is concluded that the speed over the threshold was probably a few knots higher than the target threshold speed of 94 knots but less than the maximum threshold speed of 109 knots allowed for in the scheduled performance and from which the landing distance requirement of 990 metres on a wet or dry surface was derived. It is concluded therefore, that the accident could not have been due to an approach that was made either too high or too fast.

According to the evidence from the flight data recorder and also one of the stewardesses, the touch-down was smooth. There was thus a slight risk of aquaplaning in the circumstances, but there was none of the characteristic evidence of this having occurred from an examination of either the tyres or the runway surface.

A factor that may have affected the aircraft's point of touch-down was that, according to the anemograph reading at about the time of the accident, the wind was from 010 degrees at 12 knots, that is a tail wind component of 2 knots. The commander would have been quite unaware of this as throughout the final approach the wind was reported to him as coming from 360 degrees. His decision to land on Runway 27 was therefore perfectly reasonable and there would have been no advantage, as he saw it, in carrying out a circling approach on to Runway 09. He could not have made his initial approach to 09, as the only instrument approach is to Runway 27.

When it became apparent to the commander that the aircraft could not be stopped on the runway, he unhesitatingly made the difficult decision to steer off to one side whilst there was still time to do so. That this was the correct decision in the circumstances cannot be questioned as had the aircraft been allowed to continue down the runway, it would almost certainly have run off the end and dropped on to the beach, with the attendant risk of severe damage to the aircraft and possible injury to the occupants.

2.2 The evacuation

The evacuation of the aircraft was orderly and without injury to any of the occupants of the aircraft. This appears to have been due in large measure to the actions of the first officer, who, acting on the instructions of the commander to evacuate the aircraft, first entered the cabin and turned on the Phoenix lights above the emergency exits, which he then opened. He told the passengers to remain seated and then left the aircraft by the forward main door in order to assess the situation outside. This action undoubtedly prevented any attempt being made to use either the rear door or the overwing emergency exits, which, had they been used, could well have resulted in injury. The cabin staff do not appear to have responded to the emergency when the aircraft came to rest, particularly the senior stewardess, and part of the reason for this was most probably because the intentions of the commander that the aircraft was to be evacuated were not immediately conveyed to them by the first officer before he made his outside inspection. The initial

lack of lighting in the cabin was a serious matter. The senior stewardess at the rear of the cabin ought to have had a torch available to her and she also ought to have turned on the rear Phoenix lights. It is understood that the Company has since taken action to ensure that torches are available to all cabin crew members and that a modification to the emergency lighting system is also being considered.

The executive order to the passengers to evacuate the aircraft was given by the senior stewardess after she had spoken to the first officer, and to do so, she had to shout from the rear of the aircraft. This method of communication is quite likely to induce a state of panic, though fortunately it did not do so on this occasion. Had a loud hailer been available to the cabin staff it would have eased their task considerably and left no doubt in the passengers' minds as to who was issuing the evacuation instructions. Though the equipping of public transport aircraft with loud hailers is to become mandatory in the near future, the operator has decided to equip their HS 748 aircraft immediately, even though the requirement does not apply to this class of aircraft.

2.3 Runway surface state

As there is no evidence that the aircraft's braking system was other than fully serviceable and there were no indications of aquaplaning having occurred, it must follow that the aircraft's failure to stop on the runway can only have been due to the state of the runway itself. There is some conflict of evidence as to what that state was. The Fire Service report of 1 mm of slush on the runway has been explained by the airport authorities as being a nominal figure which is used to indicate that there are no significant deposits sufficient to require sweeping. It is concluded therefore that the most probable state of the runway at the time the aircraft landed was that apart from the residue of slush remaining after ploughing, the centre portion 10 metres either side of the centre was clear, although it is likely ice was present, according to the Meteorological Office's assessment.

2.4 Runway braking action report

It follows that if the presence of ice on the runway was very likely at the time G-AZSU was making its approach then it was equally likely that the braking action was poor. That being so, the landing distance required by the aircraft would have been some 600 metres more than that available.

The Fire Service's assessment that the braking action was medium to poor was made after the runway was ploughed at about 1700 hrs and was therefore superseded by the report of the aircraft that landed at 1720 hrs. It was this report that was passed to the commander of G-AZSU at 1806 hrs, though it was incorrectly stated in the RTF message that the aircraft referred to had landed 20 minutes before. It had in fact landed 46 minutes before, so that by the time that G-AZSU landed, the report was over an hour old. Though it has been stated that no change in the runway state had been detected in that time, it is considered that in the meteorological conditions prevailing, a further braking action assessment might have been called for by ATC, if only to confirm positively that there had been no change. In the event it is very likely that a significant change would have been detected. There would seem to be a case therefore, when the weather conditions are marginal, for more frequent braking action reports unless the traffic is continuous.

Though the report that the centre of the runway had been ploughed to a depth of 1 mm appears to have had a considerable influence on the commander's decision to land, it is considered that the report by the previous landing aircraft had the greatest influence, though it was made clear in the RTF message to the aircraft at 1806 hrs that an accurate reading of braking action could not be given. Nevertheless the message itself was sufficiently reassuring to the pilot that a safe landing could be made.

2.5 Mu-meter serviceability

It is not a requirement that civil airfields in the United Kingdom be equipped with friction meters. However Sumburgh was equipped with a mu-meter at the time of the accident, though it was unserviceable due to a failed tyre. There were no spare tyres immediately available so nothing could be done to bring it into service at short notice. It is considered that at airfields such as Sumburgh, where weather conditions can be severe and subject to sudden changes, it is essential to a safe operation that provision be made to ensure that a serviceable friction meter is always available. This is fully appreciated by the authorities at Sumburgh who are keenly aware of the necessity to check the calibration of the mu-meter at frequent intervals and to ensure that those operating the equipment are properly trained, However for the mu-meter to be unserviceable solely because there were no spare tyres is unacceptable particularly as a high rate of tyre wear is inherent in its use. It is considered that an adequate stock of tyres should always be immediately available, and that even a stand-by mu-meter should be considered.

2.6 Visual approach aids

At an airfield such as Sumburgh, which has a relatively short instrument runway, there is a need for a good standard of touch-down accuracy. This would not seem to be provided by the VASI installation though this is not to suggest that this was a contributory factor to the accident. As can be seen from the diagram at Appendix B, VASI will deliver an aircraft that has made a correct approach anywhere within a touch-down zone some 275 metres in length. This is quite disproportionate to the total runway length available, particularly when it is borne in mind that the touch-down zone does not start until 225 metres in from the threshold. As has been concluded, G-AZSU made a correct approach and landed somewhere near the middle of the VASI touch-down zone. Thus some 280 metres of the 1,084 metre runway was behind the aircraft at that stage and of no use to it. Obviously, any system that can deliver an aircraft safely with consistent accuracy to a point closer to the threshold, and thus provide more roll-out distance, must be preferred. Such a system is the Precision Approach Path Indicator (PAPI), recently developed in the United Kingdom and now undergoing operational flight evaluation at Gatwick airport. Had PAPI been available at Sumburgh at the time of the accident, the aircraft would probably have touched-down at least 100 metres nearer to the threshold, which would have been a significant improvement on a runway of that length.

3. Conclusions

(a) *Findings*

(i) The aircraft had been properly certificated and maintained in accordance with an approved maintenance schedule and was free of defects at the time of the accident.

(ii) The pilots were properly qualified and competent to undertake the flight.

(iii) The aircraft made a normal approach on the glide slope at near the correct speed and landed in the middle of the normal touch-down zone.

(iv) The area 10 metres either side of the runway centre line was clear of significant deposits of snow and slush, though a very thin layer of slush remained after ploughing. It is very likely that this residue had started to freeze. The runway surface was therefore probably slippery and the braking action poor.

(v) It would not have been possible to bring the aircraft to rest within the runway distance remaining after touch-down in the prevailing conditions. The decision of the commander to steer the aircraft off to one side rather than risk over-running was commendable and prevented greater damage to the aircraft than it actually sustained and consequently possible injury to the occupants.

(vi) The braking action report by the previous landing aircraft was probably no longer valid at the time G-AZSU landed.

(vii) The aircraft was incorrectly informed by ATC that the previous landing aircraft, which had reported the braking action as medium had landed 20 minutes earlier. This influenced the commander of G-AZSU to continue his approach to land.

(viii) The commander's intentions that the aircraft was to be evacuated were not made clear to the cabin staff as promptly as they could have been. The evacuation of the aircraft was subject to a short delay due to an initial lack of lighting and the means of communication with the passengers were inadequate.

(ix) The touch-down zone associated with a VASIS approach is disproportionate to the length of Runway 27/09 at Sumburgh, though this was not a factor in the accident.

(b) *Cause*

The accident was caused by the aircraft landing on a runway of inadequate length in relation to the state of its surface, which was slippery. The commander of the aircraft had been provided with a braking action assessment and a report on the runway state that was probably invalid at the time he made his approach to land.

4. Safety Recommendations

It is recommended that:

4.1 At airports and aerodromes where mu-meters are held, two spare sets of tyres should be available and have previously been run in.

4.2 There is a review of the availability, the positioning and the use in public transport aircraft of this class of emergency lighting and passenger address systems when the aircraft's main electrical system has been de-energised following an accident.

4.3 Subject to the satisfactory completion of the current operational flight evaluation the installation of Precision Approach Path Indicators at Sumburgh and at other airfields in the United Kingdom with similar characteristics be considered.

4.4 When the braking action has been reported as less than good, and more than thirty minutes has elapsed since the previous aircraft report or measurement the braking action should be checked before passing details to an aircraft.

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