INCIDENT

Aircraft Type and Registration:	Boeing 737-8K5, G-FDZR
No & Type of Engines:	2 CFM56-7B27/3 turbofan engines
Year of Manufacture:	2009
Date & Time (UTC):	25 November 2010 at 2052 hrs
Location:	Newcastle Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 8 Passengers - 189
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	13,950 hours (of which 950 were on type) Last 90 days - 170 hours Last 28 days - 60 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft stopped on the paved surface but with the nosewheel 10 ft beyond the marked runway end at the end of its landing rollout. The runway was reported to have a covering of 2 mm of wet snow, having been swept and inspected shortly before the incident. Towards the end of the landing run, deceleration of the aircraft had reduced despite the application of full manual braking. Two Safety Recommendations have been made.

History of the flight

The aircraft was being operating on a scheduled service from Arrecife, Lanzarote to Newcastle Airport UK. The co-pilot was pilot flying. On the outbound sector, the pilots discussed the fuel requirements for the return leg. Snow showers were forecast for the estimated arrival time at Newcastle so they elected, as a precaution, to carry an additional 1,100 kg of fuel for a diversion to Edinburgh as well as Manchester, the nominated diversion airport. The pilots used the C-Land application[1] to check the expected landing performance at Newcastle and found that, at their expected landing weight, they would be able to accept a wet runway and a slight tailwind. They also decided that if the runway had more than 3 mm of contaminant, this would mean that it was contaminated, which was not acceptable for their operation.

During the uneventful cruise segment of the return flight the pilots monitored the Newcastle weather,

Footnote

[1] A laptop computerised landing performance calculator.

which was changing rapidly with 13 METARs issued during a one hour period. The final METAR before the incident, issued at 2050 hrs, indicated a surface wind from 310° at 13 kt, visibility 4,500 m, light snow showers, scattered cloud at 400 ft, broken cumulonimbus cloud at 900 ft, temperature and dewpoint both -1°C and QNH 1009 mb.

All METARs broadcast by the Newcastle ATIS system between 1950 hrs and 2050 hrs declared the state of Runway 07 as "WET WET WET". At 1948 hrs the pilots contacted their Operations department, who informed them that snow clearing was in progress at Newcastle but that the airport was expected to be clear for their arrival. Using the C-land application the pilots calculated that the landing distance required for a wet runway was approximately 300 m less than the landing distance available (LDA). Shortly afterwards the co-pilot briefed the approach, stating that the runway was wet and slushy, that Flap 40 would be used for the approach and landing, and that he intended to use full reverse and Autobrake 3 on landing. He also stated his intention to "DISCONNECT EVERYTHING WHEN VISUAL AND GO TO THE END". The crew briefly discussed the possibility of using Maximum Autobrake for the landing but decided this was unnecessary.

At 2031 hrs, when the aircraft was established on the ILS localiser, ATC informed the crew that another aircraft that had just landed had reported "MEDIUM TO GOOD" braking action. ATC then passed a runway inspection report which stated "100% CONTAMINATION AND 3 TO 4 MILLIMETRES OF SNOW". At this point the crew discontinued the approach and positioned the aircraft towards the 'NT' non-directional beacon, intending to hold there until either the runway had been cleared sufficiently for them to make a second approach or it became necessary to divert to Edinburgh.

At 2040 hrs ATC informed the pilots that one clearing run had been completed and that the runway now had a covering of 2 mm of wet snow. Judging that the runway was no longer contaminated, the pilots updated the landing data for a wet runway using the C-Land application and carried out a second approach. The pilots estimated that the aircraft touched down abeam Taxiway F that is approximately 150 m beyond the ideal touchdown point. The co-pilot recalled that after landing he selected full reverse thrust. At 97 kt groundspeed he deselected the autobrake using manual braking[2], and selected idle reverse which was achieved by 60 kt. Idle reverse remained selected for the remainder of the landing run. When manual braking, the co-pilot reported that he felt the anti-skid system operating. Recorded data showed that he applied variable pressure of between 2,000 and 3,000 psi to the right main landing gear (MLG) brakes and approximately 500 psi to the left MLG brakes. The co-pilot did not recall applying asymmetric braking. The commander initially assessed the deceleration as normal. However, after annunciating "60 KT" in accordance with normal procedures, he became concerned about the length of the landing run. He made a non-standard "50 KT" call, applied manual braking and took control of the aircraft. The co-pilot relinquished control of the aircraft but continued to apply manual braking. The aircraft remained close to the centre-line of the runway throughout the landing run and stopped with its wheels on the paved surface and the nose of the aircraft 10 ft beyond the red runway end lights. The aircraft was not damaged and there were no injuries.

The pilots judged that it would be impossible to taxi the aircraft from this position, so completed the shutdown

Footnote

2 The manufacturer refers to operation of the brakes using the brake pedals as *'manual braking'*.

checks and disembarked the passengers when suitable steps and transport were made available to take them to the terminal. Both pilots independently walked on the runway back towards the Runway 25 displaced threshold and assessed the surface as very icy.

Airport information

Runway 07 at Newcastle has a LDA of 2,209 m and a width of 45 m. A copy of the aerodrome chart is shown in Figure 1.

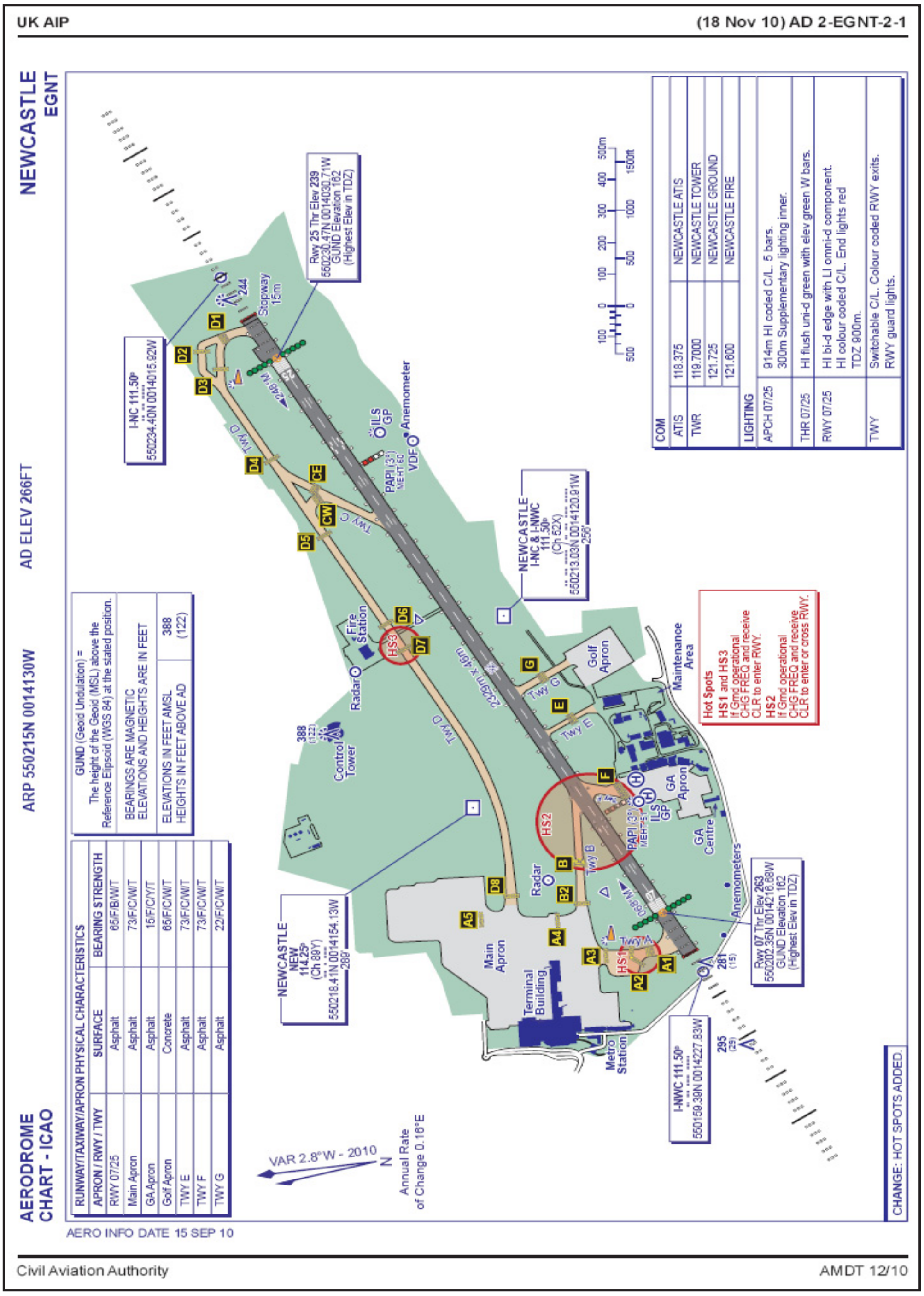

Figure 1

Newcastle Airport layout

After the aircraft had discontinued its approach the runway was swept by the airport sweeper vehicles, the Airport Operations Unit (AOU) operative following the runway sweepers to assess the runway surface visually. The AOU log shows:

> *'2025-2037 100% contamination, 1-2 mm wet snow. Snow all thirds'*

The ATCO log book shows:

> *'2040 Surface Inspection, contamination down to 1-2mm wet snow'*

The AOU operative recalls that he inspected the runway visually from his vehicle and estimated the contamination. He considered that the wet snow was in patches and commented that he had not experienced any problems with tyre grip while driving on the runway. The Airport Fire and Rescue Services watch manager, who attended the incident, reported that the runway condition was such that the black runway surface was clearly visible and that he had not had any tyre grip problems with his vehicle whilst driving the full length of the runway to attend the incident.

Appendix 3D of Civil Aviation Publication (CAP) 168, '*Licensing of Airfields*' details the method that should be used to assess and report the depth of snow or slush on a runway as follows:

> *'Depth of Snow or Slush*
>
> *A Standard Depth Gauge should be used to measure the depth of snow, slush or associated standing water on runways. Readings should be taken at approximately 300 m intervals between 5 and 10 m on each side of the centreline, avoiding the effects of rutting. Depth information shall be given in millimetres representing the mean of readings obtained for each third of the total runway length.'*

A Standard Depth Gauge is a mechanical device that consists of a tube that is stood vertically on the runway surface through the contaminant, and a coaxial disc that is lowered onto the top surface of the contaminant. The operator reads the depth of contaminant on a scale marked on the device. CAP 168 states that measurements should be taken every 300 m along a runway, between 5 and 10 m each side of its centreline. The operator of the device would need to disembark any vehicle 18 times to measure and fully assess the 2,329 m of Runway 07 at Newcastle.

Recorded information

The aircraft was fitted with a solid state flight data recorder (FDR) and cockpit voice recorder (CVR); both recorders captured the landing incident. Power to the CVR was removed promptly after the aircraft was shut down, preserving recordings relevant to the investigation.

The aircraft touched down at 2052:28 hrs at a recorded computed airspeed (CAS) of 140 kt and groundspeed of approximately 147 kt[3]. On touchdown, the ground spoilers deployed and both autobrake and reverse thrust were activated. Recorded brake pressure increased according to the autobrake command and aircraft longitudinal deceleration was between 0.26 and 0.21g. Fourteen seconds after touchdown, at a groundspeed of approximately 97 kt, the throttles were retarded to the idle reverse position and the autobrake disengaged.

Footnote

[3] Groundspeed was only recorded every four seconds.

Upon autobrake disengagement, manual braking was applied, initially significantly more on the right pedal than the left. At a recorded groundspeed of approximately 30 kt, maximum brake pressure was commanded to both sets of MLG brakes. Pressure applied to each brake could not be determined because commanded brake pressure was recorded upstream of antiskid regulation.

After the reduction in reverse thrust, there was a notable decrease in the aircraft deceleration to an average of 0.12g over the final 30 seconds of the landing. Application of full manual braking appeared not to change the deceleration except in the final two seconds, when deceleration peaked at 0.34g.

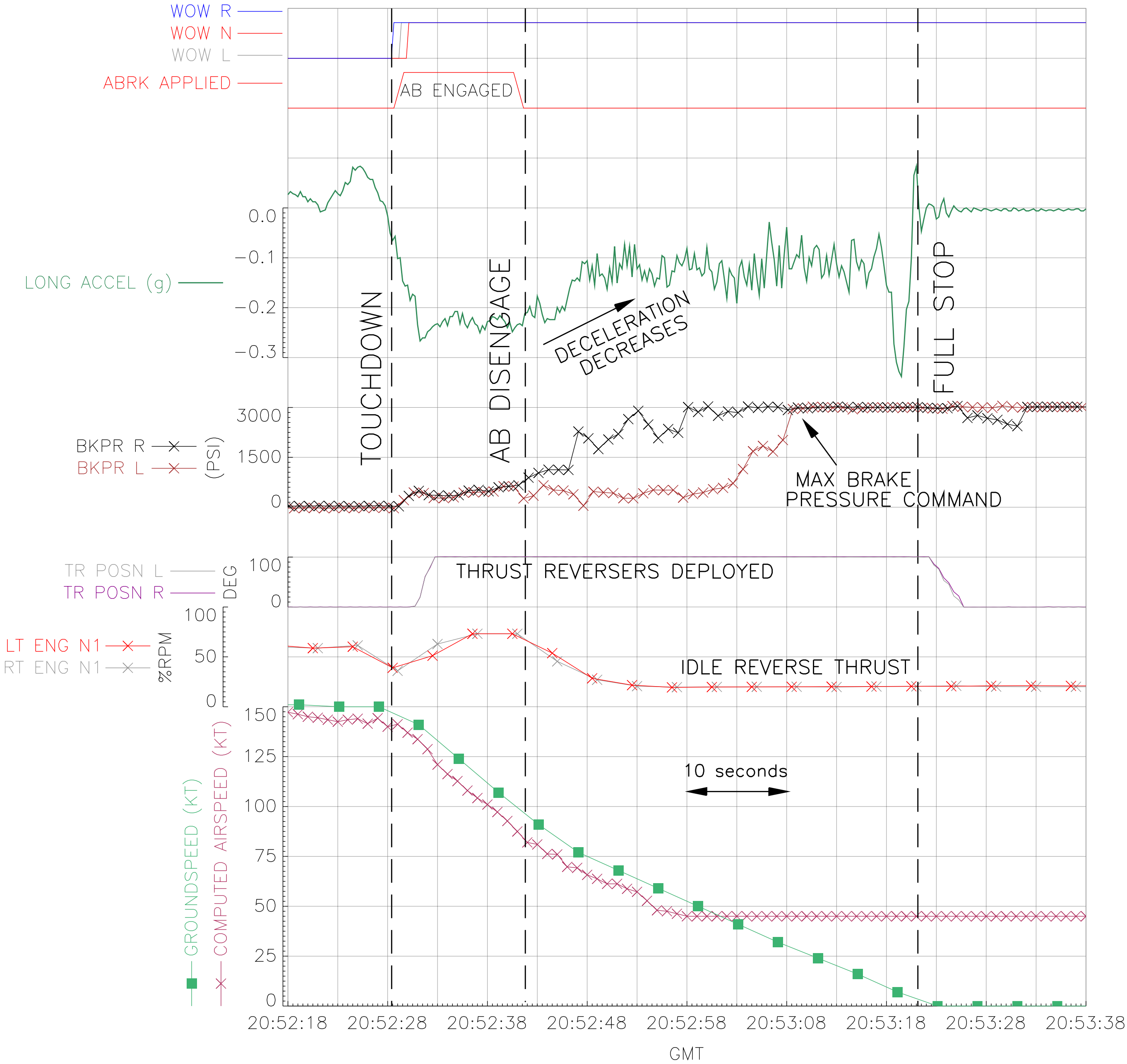

Figure 2

G-FDZR FDR parameters

Pilot in-flight assessment of landing distance

The crew used the C-Land application to calculate the landing distance required (LDR). The C-Land application requires an input of type and depth of contaminant in order to perform the calculation.

In the absence of the C-Land, the pilots can use the landing distance advisory information in the Quick Reference Handbook (QRH) to calculate the landing distance required. To do this the pilot must know the expected braking action on the runway. This information can come from three potential main sources; pilot reports, runway friction reports and runway surface description.

Braking action reports from pilots on previous landing aircraft can be used to assess braking action but these will be subjective and, if the previous landing aircraft is of a different type or weight, not directly applicable to the next aircraft to land.

Continuous Friction Measuring Equipment (CFME) should not be used to measure braking action when snow or slush are present on the runway.

The CAA NOTAL 2010/09 states:

> *'CAA policy is that Continuous Friction Measuring Equipment (CFME) should not be used when snow/slush conditions are present, as readings on wet snow and slush are unreliable from existing equipment; there is no correlation between CFME readings and aircraft braking performance.'*

In 2007 Boeing issued a Flight Operations Technical Bulletin (FOTB) 07-2 entitled *'Landing on Slippery Runways*' to all operators which advises:

> *'Runway mu values* ***can vary significantly*** *for the same contaminant condition due to measuring techniques, equipment calibration, the effects of contamination on the friction measuring device and the time passage since the measurement.* ***Do not*** *base landing distance assessments solely on runway mu friction reports. If mu is the only information provided, attempt to ascertain the depth and type of runway contaminants to make a better assessment of actual conditions.'*

Runway surface description can be used to assess braking action by using a Braking Action Correlation Table, published by the manufacturer, which provides estimated correlations between type and depth of contaminant and expected braking action. The QRH available to the crew contained this table.

Research

During winter 2010-11, the CAA led a limited trial aimed at providing accurate and timely runway contamination information at four UK aerodromes. A wider trial is planned for 2011-12. The methodology/system to develop landing distance from this is not part of the trial. However, EASA is commissioning research into systems/equipment that could seek to link the two elements. Similarly, the FAA, through their Take-off And Landing Performance Assessment Rulemaking Committee (TALPA-ARC) trials, has been working to develop a system which does enable runway contamination information to be used to help to determine landing distance required. Both trials are ongoing.

Use of reverse thrust

FOTB 07-2 states that pilots should:

> *'Maintain reverse thrust as required, up to maximum, until the airspeed approaches 60 kt. At this point start reducing the reverse thrust so that the reverse thrust levers are moving down at a rate commensurate with the deceleration rate of the airplane. The thrust levers should be positioned to reverse idle by taxi speed, then to full down after the engines have decelerated to idle.*
>
> *'Note: If the stop is in question, maximum reverse thrust should be used until the stop is ensured.'*

In normal operation, pilots might not be accustomed to applying increased reverse thrust as the landing ground roll proceeds because during most landings it is applied and then reduced.

Contaminated runway definitions

EU-OPS-1.480 contains the following definition of a contaminated runway:

> *'A runway is considered to be contaminated when more than 25 % of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by the following:*
>
> *(i) surface water more than 3 mm (0,125 in) deep, or by slush, or loose snow, equivalent to more than 3 mm (0,125 in) of water;'*

UK AIP AD 1-1-4 para 15.2 contains a table in which the following statement is made:

> *'For JAR-OPS performance purposes, runways reported as DRY, DAMP or WET should be considered as NOT CONTAMINATED.'*

UK AIP AD 1-1 para 5.5.2 states:

> *'Aqua planing conditions should be assumed to exist whenever depths of water or slush exceeding approximately 3mm effect a significant portion of the available runway.'*

CAP 683 '*The Assessment of Runway Surface Friction Characteristics*' contains the following definition:

> *'A runway is termed contaminated when water deeper than 3 mm, or wet snow or slush is present over 25% or more of the assessed area.'*

CAP 168, Appendix 3D, - *'National Snow Plan including Procedures for Dealing with Winter Contamination of Aerodrome Surfaces*', refers to contaminated surfaces but without definition.

AIC 86/2007 (Pink 126) - 'Risks and factors associated with operations on runways affected by snow, slush or water', refers to contaminated runways but does not define them. It states, at paragraph 2.3:

> *'Depths greater than 3 mm of water, slush or wet snow, or 10 mm of dry snow, are likely to have a significant effect on the performance of aeroplanes.'*

AIC 14/2006 (Pink 91) '*Landing Performance of Large Transport Aeroplanes*' contains the following statement:

> *'5.1 JAR-OPS 1 defines a contaminated runway as one which is covered with ice, snow, slush, or more than 3 mm of standing water.'*

ICAO Annex 14, '*Aerodromes*', does not define contaminated runways.

Analysis

The aircraft touched down abeam Taxiway F, approximately 450 m from the Runway 07 threshold which is approximately 150 m beyond the optimum touchdown point. Landing beyond the optimum touchdown point adds to the calculated landing distance required.

The initial deceleration of the aircraft was similar to that expected with Autobrake 3 selected but deceleration of the aircraft reduced when idle reverse thrust was selected.

The pilot was aware that he was to use the full length of the runway and exit at the end. He reduced the reverse thrust to idle by 60 kt and it remained at idle until the aircraft came to a halt. The FOTB allows for full reverse to be maintained down to 60 kt and then for reverse thrust to be gradually reduced until reverse idle is achieved no later than taxi speed. It is likely that the earlier reduction of reverse thrust to idle contributed to the increased landing distance. The pilot could have reselected full reverse later in the landing run when a successful stop became in doubt but this might have been an unaccustomed pilot action because, in normal operation, pilots are used to applying reverse thrust and then reducing it as the landing ground roll proceeds.

When braking manually, the brake pressure applied by the pilot on the right MLG brakes varied between 2,000 and 3,000 psi and on the left MLG brakes between 0 and 600 psi. The co-pilot recalls feeling the antiskid system operating when he took over manual braking until the aircraft came to a halt. Later in the landing run, after idle reverse thrust was selected, residual reverse thrust and aerodynamic drag would have contributed little to deceleration of the aircraft. Recorded deceleration during that period was not consistent with the 'GOOD' braking action anticipated by the crew, suggesting that the runway surface was slippery. Runway conditions had been assessed visually immediately before the incident from a vehicle which was following the sweeping vehicles. The resulting report of surface conditions may not have been accurate.

The definition of contaminated runways in CAP 683 differs from the statement contained in AIC 86/2007. The former considers a runway as contaminated when any depth of slush or wet snow is present over the defined area, whereas the latter document requires a depth of 3 mm of wet snow or slush for there to be a significant effect on the performance of aircraft. The CAA stated that material contained across CAA documentation relating to contaminated runway operations is targeted at different audiences and therefore there are necessary differences in style and content. However, in the case of CAP 683 and AIC 86/2007, the difference in wording results in a contradiction. The inconsistencies concerning the definition of a contaminated runway surface, or the effects of contaminant when wet snow or slush is present, could cause pilots to assess incorrectly the contamination state of a runway. This incorrect assessment would lead to an incorrect calculation of LDR. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2011-087

It is recommended that the CAA publishes a single definition of Contaminated Runways.

The CAA stated that currently there is no common taxonomy regarding runway contamination, and the requirements published by ICAO and EASA (in

EU-OPS) differ. The ICAO Friction Task Force (FTF) is working to produce a taxonomy and the CAA is an active member of the task force.

CAP 168 states that the depth of snow or slush on a runway should be measured using a Standard Depth Gauge at predetermined intervals along the runway. It appears that this method was not used in this case. To complete a full and accurate assessment of Runway 07 would have required the operator to take 18 measurements along the runway, disembarking from any vehicle used on each occasion. This would have been a time-consuming process during which time the runway would be unavailable for aircraft movements and the condition of the contaminant might change sufficiently to render the results invalid, especially in the rapidly changing weather conditions.

Although the definitions of contaminated runways are not consistent, the majority of definitions imply that 3 mm of contaminant is the depth above which aircraft stopping performance may be significantly affected. When assessing contaminant depth of this magnitude using a Standard Depth Gauge, a measurement error of only 1 mm represents a 33% error.

In order to calculate landing performance the pilots normally use the C-Land application with the QRH providing an alternative method. In the absence of reliable direct reports of braking action, the pilots could use with the Braking Action Correlation Table in the QRH to complete their calculations. Both methods require type and depth of contaminant and, for either method to correctly calculate landing distance the pilots must accurately know the type and depth of contaminant.

Existing methods of contaminant depth measurement, as defined in CAP 168, may provide an inaccurate depth assessment of the contaminant because of the length of time required to complete it and because the depth measured is sensitive to small gauge reading errors. These combine to provide pilots with inaccurate information which may affect the accuracy of the LDR calculation. Therefore, the following recommendation is made:

Safety Recommendation 2011-088

It is recommended that the CAA develops a system of contaminant depth measurement that provides accurate and timely runway contamination information to enable pilots to determine the landing distance required.

Safety action

The aircraft operator has made internal recommendations to:

1. Review the guidance to pilots in company manuals regarding the use of auto and manual braking especially in relation to the possibility of inadvertent asymmetric manual braking in a crosswind.

2. Review the guidance to pilots in company manuals regarding landing in conditions where the braking action is not given but may be in doubt.

3. Review the guidance to pilots in company manuals regarding the "60 KNOT" call made by the non-handling pilot during the landing roll especially to clarify whether airspeed or groundspeed should be used for this call.

4, Initiate a survey to establish if a pattern of early disengagement of auto brake exists.

Conclusion

The aircraft entered the stopway of Runway 07 at Newcastle Airport because the braking action on the runway was less than the pilots had anticipated. It is possible that there was a significant difference between the actual and reported conditions because the depth and type of contaminant on the runway was assessed visually. Touchdown of the aircraft beyond the normal touchdown zone, and selection of idle reverse thrust before the aircraft was at taxi speed, may have contributed to an increased landing distance.