INCIDENT

Aircraft Type and Registration:	Bombardier DHC-8-402 (Q400), G-JEDW
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2004
Date & Time (UTC):	20 October 2005 at 0810 hrs
Location:	Leeds Bradford International Airport
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 60
Injuries:	Crew - None Passengers - None
Nature of Damage:	'Runway touched' sensor fairing abraded
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	4,150 hours (of which 200 were on type) Last 90 days - 126 hours Last 28 days - 42 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was conducting a practice CAT II ILS approach to Runway 32 at Leeds Bradford International Airport in VMC. Contrary to company standard operating procedures, the co-pilot flew the approach and the landing. At a height of approximately 80 ft, the co-pilot retarded both power levers, resulting in a high rate of descent. Both pilots applied power and the co-pilot flared positively in an attempt to reduce this rate of descent. In doing so, the aircraft was pitched-up to an angle sufficient to cause the underside of the rear fuselage to contact the ground. Damage was confined to the composite fairing covering the 'runway touched' sensor. There were no injuries. Although not a cause of the incident, the investigation revealed that the heading selectors for the commander and co-pilot operated independently, resulting in a temporary deviation from the ATC assigned heading. This was not noticed immediately by the non-handling commander. Two safety recommendations are made.

History of the flight

The crew reported for duty at Belfast City Airport (BHD) at 0515 hrs and checked in as normal. The co-pilot needed to complete six practice CAT II ILS (CAT II) approaches, before he could be issued with a company authorisation to fly approaches below CAT I weather minima. He had not practiced his full complement and asked the commander if he could practice a CAT II approach into their destination, Leeds Bradford Airport (LBA). The commander agreed.

The aircraft departed its stand at BHD at 0631 hrs and took off for LBA at 0640 hrs. The climb and cruise were uneventful. Analysis of the cockpit voice recorder (CVR) indicated that the pilots briefed for their arrival shortly before commencing the descent towards LBA. The co-pilot briefed the commander, who was not a training captain, for a practice CAT II approach to Runway 32 at LBA, referring as he did so to an 'aide memoire' in the quick reference handbook (QRH). This is provided by the operator to ensure that crews are familiar with the standard calls and considerations appropriate to this type of approach. He noted, however, that whereas the standard procedure was for the commander to land the aircraft from such an approach, the co-pilot would land the aircraft himself on this occasion.

The LBA approach controller instructed the aircraft to turn onto a heading of 070° for base leg and subsequently onto a heading of 350°, in order to intercept the Runway 32 localiser. Both pilots set new headings on their respective heading selectors in response to these instructions. The commander, having observed the aircraft make a left turn as expected, saw that it was going to fly through the localiser and realised that the aircraft was in fact established on a heading of 035°, which the co-pilot had set using his selector. When so alerted by the commander, the co-pilot immediately set the correct heading of 350°. The approach controller asked if the crew were able to position the aircraft back onto the localiser without radar assistance, and the commander replied that they could.

The aircraft was flown with the autopilot engaged until shortly before touchdown. Having intercepted the localiser, and subsequently the glide slope, the aircraft maintained a stable final approach. Having configured the aircraft for a standard CAT II approach, with landing gear down and 15° of flap (FLAP 15) set, the co-pilot called for FLAP 35, the normal configuration for a visual landing. The commander reminded him that a CAT II approach and landing was flown with FLAP 15 set. The co-pilot agreed, and the flaps remained at this setting. The co-pilot adjusted the power levers to approximately 17% torque in order to achieve and maintain a V_{REF} of 120 kt.

At a height of approximately 650 ft agl, the commander switched off both bleed air selectors, thus completing the before landing checks. During a standard CAT II approach the co-pilot should call "100 above" followed by "Decide" at decision height (DH), which is usually 100 ft agl. On this occasion, however, these calls were not made and the co-pilot remained at the controls in accordance with the briefing he had given. At approximately 80 ft agl, the commander called "disconnect", prompting the co-pilot to disconnect the autopilot. Almost simultaneously, the co-pilot retarded both power levers. Shortly afterwards the commander said "DON'T PULL THE POWER BACK…YOU PULLED ALL THE POWER BACK…." The co-pilot flared the aircraft positively in an attempt to reduce the developing high rate of descent, and both pilots advanced the power levers, but the aircraft touched down heavily and the tail touched the runway.

The commander stated that the touchdown, though hard, was not markedly different to some others he had experienced on the Q400 aircraft. He did, however, notice that the red master warning light and the TOUCHED RUNWAY warning caption were illuminated. The aircraft was taxied to a parking stand, the engines were shut down and the passengers disembarked without further incident.

The cabin crew reported that, although the landing had seemed hard, particularly so to the cabin crew member seated in the rear of the aircraft, they had not been aware

that the fuselage had come into contact with the runway. They had difficulty opening the left rear passenger door although no such difficulty had been encountered prior to departure from BHD. The passengers appeared unaware of the incident.

Aircraft information

The DHC-8-Q400 is a stretched derivative of the DHC-8 family of high wing twin turboprop powered aircraft. The Q400 is considerably longer, heavier and more powerful than its predecessors, with performance approaching that of some jet aircraft. Airflow over the wings produced by the wash from the large propellers, provides significant lift at low speeds. This can be affected if power is reduced prior to touchdown. Consequently, the usual landing technique is to maintain some power until the main wheels make contact with the runway.

The power levers fitted to the Q400 are not mechanically linked to the engines, but instead operate through full authority digital engine control (FADEC) units. The sensitivity of torque to power lever movement increases as the levers are retarded, such that at low torque settings, very small changes in lever angle result in relatively large changes in torque. At 17% torque, which typically is sufficient to maintain a stable approach with FLAP 15 set, the power levers will be very sensitive, and pilots reportedly acknowledge difficulty in correctly setting such values.

Heading selections on G-JEDW can be made on either of two rotary selectors mounted on the central flight guidance control panel (FGCP). Heading selections made using the left selector are shown on the left horizontal situation indicator (HSI)[1] and those made on the right selector are shown on the right HSI. In heading mode, if the left HSI is selected as the master, the autopilot will follow the heading bug on the commander's instrument but, if the right HSI is selected as the master, the autopilot will follow the heading bug on the co-pilot's instruments. The two are totally independent. Consequently, heading selections made by one pilot can only be monitored by the other pilot if he looks across to the heading displayed on the opposite HSI.

Engineering inspection

The operator, which did not have its own engineers based at LBA, requested a local maintenance organisation to inspect the aircraft for structural damage. An engineer attached to this organisation reported that the 'touched runway' sensor fairing was abraded but that no other damage was apparent. He reported that the rear passenger door could not be opened from outside but, because the door could be opened without difficulty from inside the cabin, he judged this to be the result of a fault with the external handle, rather than damage to the door or its aperture. The rear service door, on the right side of the fuselage opposite the rear passenger door, was not opened and consequently was not assessed for comparison.

Later on the day of the incident, the operator dispatched two of its own engineers and another flight crew to LBA who, upon its release from the AAIB, flew the aircraft to its maintenance base without incident.

Additional information

The co-pilot's intention to carry out a practice CAT II approach meant that he would not only fly the approach, using instruments, but land the aircraft, visually, using FLAP 15. However, he had little experience of this particular task. Under current provisions, the operator has stated that there is insufficient time available in the

Footnote

[1] Compass and radio navigation indicator presented on the left and right electronic flight instruments.

simulator to include such an exercise in the course of training for low visibility operations.

Flight Recorders

General

The aircraft was equipped with a flight data recorder (FDR), capable of recording the last 25 hours of flight data, and a cockpit voice recorder (CVR) that was capable of recording the last two hours of audio data from the flight deck environment. Both the FDR and CVR were removed from the aircraft and successfully replayed at the AAIB. The entire incident flight was recovered from the FDR and both the approach and landing phases had been recorded on the CVR.

The aircraft was also equipped with a quick access recorder (QAR) which was utilised by the operator to support its flight data monitoring (FDM) program. The QAR data was successfully replayed but was not utilised by the AAIB as it recorded the same data as that recorded by the FDR.

Flight Data

All times quoted are whole minute UTC values. At 0756 hrs, as the aircraft descended through FL130, the crew discussed the approach and landing. During the discussion regarding autopilot disconnection, which would normally occur at 80 ft agl, the co-pilot said "... EIGHTY FOOT, NORMALLY YOU WOULD TAKE CONTROL THEN, BUT I AM GOING TO LAND IT…IS MY UNDERSTANDING", to which the commander replied "YEAH".

At 0809 hrs, the aircraft was level at FL036 on a heading of 069°. The autopilot was engaged with the heading and altitude modes active. A short time later ATC advised a left turn onto a heading of 350°, which was acknowledged by the commander. The autopilot selected heading was set to 035° and the aircraft commenced a left turn. Approximately 20 seconds later the aircraft rolled wings level onto a magnetic heading of 035°. Shortly after this the commander prompted the co-pilot to make the correct selection and the autopilot selected heading was changed to 350°. The aircraft started a further turn to the left and, at about this time, the autopilot heading mode disengaged and the localiser mode engaged. Approximately one minute later the landing gear was lowered and the flaps were extended, initially to 5º and then to 15º.

The aircraft continued the left turn and the localiser parameter indicated that the localiser deviation was reducing. However, as this reduced towards zero, the aircraft continued to turn to the left and the deviation started to increase. The aircraft then made a right turn followed by a small correcting left turn as localiser deviation reduced, this time, to zero. With the aircraft now at a height of approximately 2,500 ft, the autopilot altitude hold mode disengaged and the glideslope mode engaged.

Recorded parameters indicated that the aircraft continued to descend as it tracked both the ILS glideslope and localiser signals. At about 130 feet agl, the airspeed was approximately 120 kt and the left and right engine torques were approximately 16 % and 18 % respectively. At 75 ft agl, the autopilot disconnected. Almost coincident with this, both power levers were retarded slightly (Figure 1 Point A) and both the engine torques and airspeed started to reduce. Shortly afterwards the commander said "DON'T PULL THE POWER BACK… YOU PULLED ALL THE POWER BACK…."

Two seconds later, at 50 ft agl and 115 kt airspeed, the aircraft started to flare. By this time both engines had stabilised at about 5% torque. Two seconds later, at 25 ft agl, with the pitch attitude approximately 7.5º nose

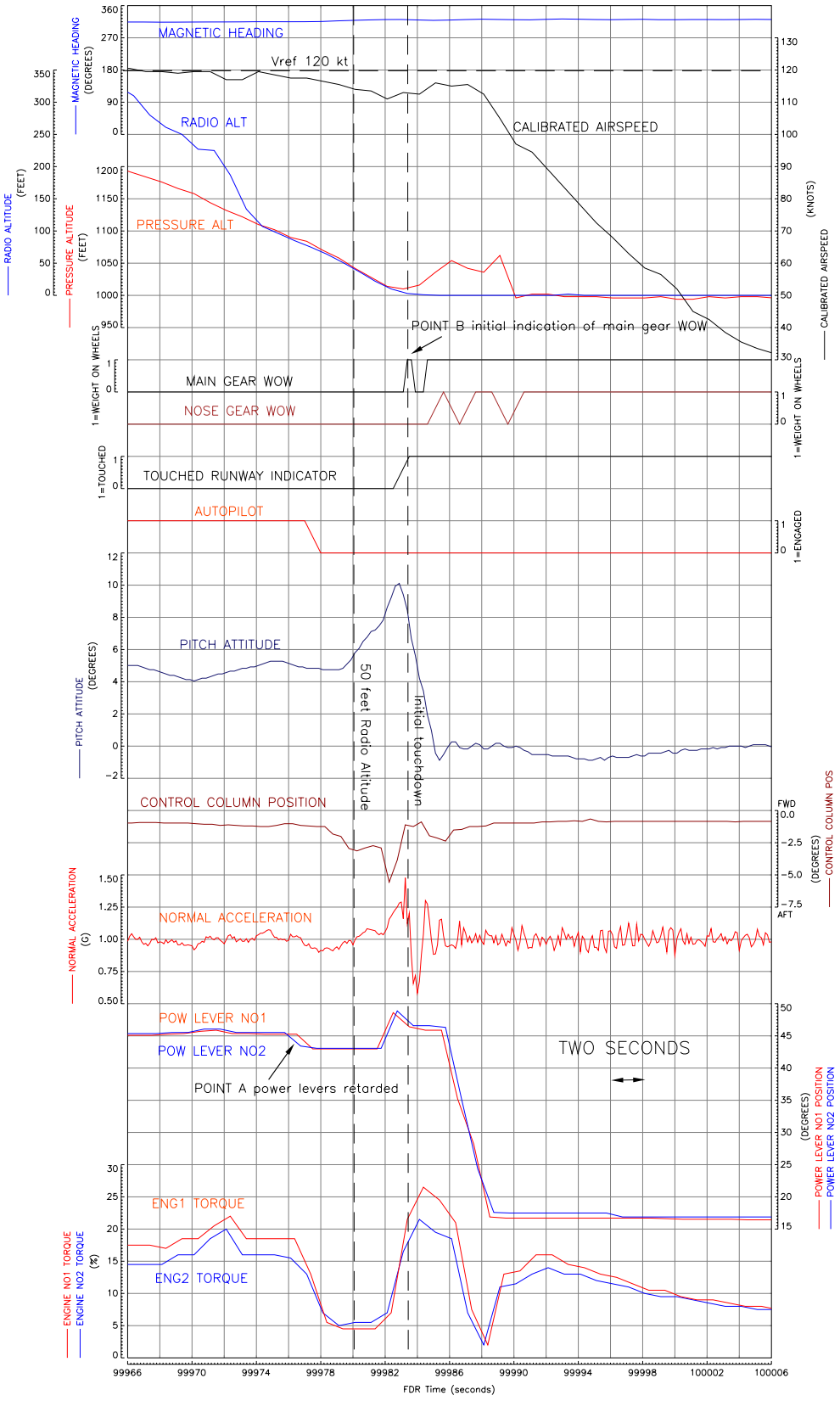

Figure 1

Salient FDR Parameters
Incident to G-JEDW on 20 October 2005

up and the airspeed at 113 kt, both power levers were advanced and the engine torque started to increase. The pitch attitude continued to increase to approximately 10º before reducing slightly to 9.4º, at which time a normal acceleration value of about 1.47g was recorded. This was coincident with the main gear weight on wheels parameter indicating that the aircraft had touched down (Figure 1 Point B). Almost simultaneously, the master and 'touched runway' warnings were recorded.

After the initial touchdown the aircraft momentarily became light before the main gear finally remained in a 'weight on wheels' condition. Shortly afterwards, the nose gear touched down and the aircraft oscillated in pitch slightly before settling, as evidenced by the pitch attitude and nose gear 'weight on wheels' parameters. The aircraft then began to decelerate. As it vacated the runway the crew advised ATC that they had a warning indicating that the aircraft tail may have touched the runway. The aircraft taxied to a stand where, at approximately 0820 hrs, the engines were shutdown.

Weight and balance

The maximum permissible landing mass for this aircraft was 28,009 kg. The fore and aft CG limits, which vary with aircraft mass, were approximately 18.5% and 33.5% MAC[2] respectively. Calculations made after the event indicated that the aircraft was operated within applicable limits at all times, with a landing mass of 25,245 kg and the CG located at approximately 27.5% MAC.

Discussion

Heading selection

The standard procedure when selecting the heading on this aircraft is for each pilot to operate the heading selector on his side of the FGCP, except when the aircraft is being flown manually. In this case the pilot not flying (PNF) should operate both heading selectors. In practice, the PNF often omits to set his own heading, because it plays no active role in the conduct of the flight and serves merely as an 'aide memoire'. In this instance, both headings were set, but the independent nature of the selections resulted in an incorrect heading selection being made by the PF that initially went unnoticed by the PNF. On this occasion the error was quickly resolved but, in the absence of additional cues (such as localiser deviation or positive radar supervision) it may not have been.

The aircraft manufacturer has stated that each customer can specify heading selectors which are either 'independent' or 'coupled'. The electronic flight instrumentation system (EFIS) can be specified with speed, altitude and vertical speed information presented either in the form of tapes or dials, but coupled heading selectors are only available on those with a tape presentation. The operator chose initially to have its Q400 aircraft delivered with a dial presentation, in order to maintain commonality with its DHC-8-200 and -300 series aircraft, equipped with electro-mechanical instruments. When these earlier series aircraft were retired, the operator decided to take delivery of Q400s with a tape presentation, but with independent heading selectors, to maintain commonality with those already delivered. The operator is now in the process of reconfiguring the EFIS on all of its Q400s to a tape presentation and when this process is complete, it will remove the historical pretext for using independent heading selectors. However, the timescale for completion of this re-configuration is not established and it is of concern that aircraft with independent heading selection systems may still be in service for the

Footnote

[2] An expression of the longitudinal position of the aircraft's centre of gravity to the mean aerodynamic chord (MAC) of the wing.

foreseeable future. Therefore, the following safety recommendation is made:

Safety Recommendation 2006-049

It is recommended that the aircraft operator, Flybe, expedite the reconfiguring of the heading selector systems on their DHC-8-400 (Q400) aircraft that do not have coupled heading selectors, such that operation of either heading selector results in an identical selection being presented on both the commander's and co-pilot's flight instruments.

In June 1996, The Federal Aviation Administration (FAA) Human Factors Team (HFT) issued a report titled '*The Interfaces Between Flightcrews and Modern Flight Deck Systems*', which evaluated the interface between the flight crew and flight deck systems in the current generation of transport category aeroplanes. As a result, the HFT recommendations, and a number of related NTSB[3] recommendations, are being considered by a working group comprising representatives of the JAA[4], FAA and industry, which was formed to develop new airworthiness standards for flight guidance systems. The JAA responded by submitting a Notice of Proposed Amendment (NPA) to JAR 25[5], JAR NPA 25F-344, which aims to introduce a revised code for flight guidance systems that is harmonised with United States Federal Airworthiness Requirements (FARs). It includes the following text:

1. *'The function and direction of motion of each command reference control (e.g., heading select, vertical speed) must be readily apparent or plainly indicated on, or adjacent to, each control if necessary to prevent inappropriate use or confusion.*
2. *The flight guidance system functions, controls, indications, and alerts must be designed to minimise flight crew errors and confusion concerning the behaviour and operation of the flight guidance system'.*

Although these changes do not specifically preclude the use of independent heading selectors, the existing design of the FGCP on DHC-8-400 series aircraft would not meet the proposed criteria.

Standard operating procedures

The operator's Part B4 Dash 8 Q400 operating manual (B4) describes the procedure to be followed when carrying out a CAT II approach[6]. The issue current at the time of the incident stated:

'The F/O is pilot flying for the approach and, if necessary, for the go-around. In the case of a "visual" call, the Captain takes control and lands the aircraft.

Further:

At 100 feet above RA[7], the F/O calls "100 above". The Captain responds "Looking" and searches for visual references.

Footnotes

3 National Transportation Safety Board of the United States.

4 Joint Airworthiness Authorities, representing the civil aviation regulatory authorities of contracting European states.

5 Joint Airworthiness Requirements (JAR) 25 relates to certification of large aeroplanes.

Footnotes

6 The B4 refers to the commander as the "Captain" and the co-pilot as the "F/O" (First Officer)

7 RA, the decision height (DH) as set on the radio altimeter.

When the radio altimeter indicates the set DH, the F/O calls "Decide". The Captain responds "Visual" or "Go-around". If the call is "Go-around", the F/O immediately initiates a go-around. If the call is "Visual", the Captain takes control.

It also states that, after successful completion of the ground and simulator courses, pilots may carry out practice approaches to CAT II decision heights provided:

a) The reported cloud ceiling is not less than 500 ft and clear visual reference to the runway is established by 400 ft.

b) The RVR is not less than that required for CAT I operations.

Otherwise, the B4 does not differentiate between practice and actual CAT II approaches and it may be inferred that the procedure for each is identical. Indeed, a practice CAT II approach carried out in any other manner would not constitute practice of the required procedure and would not fulfil its purpose. However, the operator's General Manual (GM), which describes general procedures to be used on all aircraft types, states:

'The first officer may act as the operating pilot when the reported conditions are not worse than the Cat I minima.'

Elsewhere, it states that the operating pilot will signify his intention to continue the approach by calling "visual", implying that it is the operating pilot who will land the aircraft. However, it is not clear that this section of the GM refers to Dash 8 Q400 operations. The GM adds:

'...it is emphasised that the company operations manual Part B1[8] (sic) should be regarded as having precedence over this material whenever there may be differences'.

In summary, it appears that the operator did not intend co-pilots to practice landing from a CAT II approach, but sufficient ambiguity existed for flight crews to believe that it was acceptable for the co-pilot to do so under certain conditions. The aircraft was operated contrary to standard procedures but in accordance with a reasonable interpretation of them.

Training

Whereas most pilots will, from time to time, have flown down to, and landed from, a CAT I decision height of approximately 200 ft agl, the view from 100 ft agl is somewhat different. The touchdown threshold may be hidden by the aircraft's nose and the touchdown zone appears much closer. This may give the impression that the aircraft is above the normal approach path. It is conceivable, in this case, that because the co-pilot was relatively inexperienced, his instinctive reaction to these visual cues was to retard the power levers in order to regain what he perceived to be the correct approach path.

The sensitivity of the power levers at angles corresponding to approach torque makes setting the correct values very difficult. This phenomenon is highlighted in training; most pilots are able to achieve accuracy with practice. The co-pilot, who had recently completed his training on type, may not yet have been familiar with these characteristics, or the sudden reduction of lift resulting

Footnote

[8] Part B1 refers to the operation of another type of aircraft but the reference occurs within a part of the GM which is not obviously limited to discussion of that type.

from large power reductions prior to touchdown. Much of his previous experience was gained on types such as light singles and a procedure simulator representing a jet aircraft, on which neither of these factors was present or significant. Indeed, the operator has reported that pilots with many thousands of flight hours, whose most recent experience is on jet types, tend to reduce power too soon on landing when flying the Q400.

A further factor for less experienced pilots is that most visual approaches are flown using FLAP 35, whereas all CAT II approaches are flown using FLAP 15. Training is given in the use of both configurations for visual landings, and crews may elect to land using FLAP 15 on runways with an LDA of 1,800 m or greater. They are, nevertheless, unlikely to practice FLAP 15 landings in the course of normal line operations. On the incident flight, the co-pilot flew both the approach and the landing. He had first to fly the aircraft by sole reference to the flight instruments until 100 ft agl, and then acquire the runway visually before landing, using the flap setting with which he was least familiar.

Training records revealed that the co-pilot had experienced some difficulty achieving consistently acceptable approaches and landings, but that these issues had been quickly addressed by some additional line training.

In the event of the commander becoming incapacitated, the B4 provides that:

> *'If the Captain does not respond to the "Decide" call, the F/O takes control and lands or makes a go-around as appropriate. A landing should only be made if it is obvious that the landing criteria have been met at first glance.'*

In addition, the GM stipulates that:

> *'During training conducted in the simulator the co-pilot shall be familiarised with the duties assigned to him during a Cat II approach (instrument monitoring, call-outs etc)'.*

It follows, therefore, that co-pilots should receive training and practice in landing the aircraft from a CAT II approach to the appropriate weather minima, but there was no provision in the training syllabus for the co-pilot to do so. Furthermore, the operator has confirmed that under current provisions there is insufficient time available in the simulator to include such an exercise in the course of training for low visibility operations. It is therefore recommended that:

Safety Recommendation 2006-050

The Civil Aviation Authority should ensure that co-pilots of Bombardier DHC-8-400 series aircraft operated by Flybe, receive training and practice in landing the aircraft from a Category II ILS approach.

Follow up action

The operator has notified the AAIB that from January 2007, when additional simulator capacity becomes available, co-pilots of Bombardier DHC-8-400 series aircraft will receive training and practice in landing the aircraft from a Category II ILS approach.

The operator has also notified the AAIB that it is rewriting its general and type specific operating manuals, in order to remove ambiguities in the description of standard operating procedures highlighted by this investigation.