ACCIDENT

Aircraft Type and Registration:	Bombardier Challenger 604, D-ABCD
No & Type of Engines:	2 General Electric CF34-3B turbofan engines
Year of Manufacture:	2003
Date & Time (UTC):	5 February 2006 at 1233 hrs
Location:	London Luton Airport
Type of Flight:	Non-scheduled Commercial Air Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to landing gear and airport approach lighting
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	41 years
Commander's Flying Experience:	9,041 hours (of which 688 were on type) Last 90 days - 102 hours Last 28 days - 41 hours
Information Source:	AAIB Field Investigation

Synopsis

On short final approach to Runway 26 the engine thrust increased to 64% N_1[1] (engine fan speed) and was not reduced before touchdown. Following a prolonged float, the aircraft touched down approximately 800 metres from the stop end of the runway, and ran off the paved surface. No evidence was found to indicate that any technical defect relevant to the approach or landing phase of flight was present before the aircraft left the paved surface. However, the investigation identified human factors that may account for the accident.

History of the flight

The crew began their duty at Luton Airport at 0600 hrs. Following normal preparation they flew the aircraft empty to Geneva, where they boarded one passenger before departing to return to Luton. The weather forecast for their return indicated the possibility of low visibility on arrival, and additional fuel had been loaded. The planned landing weight (37,449 lbs) was close to the maximum permitted by the structural limit (38,000 lbs).

The flight towards Luton was uneventful and the visibility was good by the time the aircraft made its approach. The surface wind was from 350° at 11 kt. The commander flew an ILS approach to Runway 26 using the autopilot and autothrottle. The approach speed was 137 kt, which was five knots above the value calculated

Footnote

1 N_1 is engine fan speed, a measure of engine thrust. The idle N_1 setting on this engine is approximately 30%.

for V_{REF} at the landing weight. At about 300 ft above the threshold elevation, the commander disconnected the autopilot. Later, he recalled having disconnected the autothrottle closer to 60 ft. The engine thrust increased to 64% N_1 by the time the aircraft passed through 40 ft above the runway. The commander began to flare the aircraft at the normal point, with both hands on the control column. The aircraft floated along the runway in a manner which both crew members described as most unusual. The aircraft touched down approximately 800 metres before the stop end of the runway and the co-pilot selected the spoilers UP. After a short delay the commander selected reverse thrust and began aggressive braking. Both pilots stated afterwards that, when the aircraft touched down, they considered that there was sufficient runway remaining to stop.

The landing roll continued with the aircraft decelerating normally until it ran off the end of the runway, into soft ground, at about 35 kt. The nose and right main landing gear, running through soft earth approximately up to the depth of the axles, struck the vertical faces of concrete lighting bases upon which two Runway 08 approach lights were mounted. This caused damage to the approach lights and the aircraft landing gear. The aircraft came to rest and the flight crew identified that there was no immediate threat to their safety and carried out normal shutdown checks.

The flight attendant and passenger, both seated in forward-facing passenger seats, were unaware of the incident until the aircraft was almost at a standstill, when the flight attendant noticed that the emergency exit lights had illuminated. With the aircraft at rest, both saw that there was grass, not runway, outside the aircraft, and concluded that the aircraft had left the runway surface. The flight attendant assessed that there was no immediate threat to safety and reassured the passenger.

The Aerodrome Controller (callsign Luton Tower) observed the late touchdown and, when he recognised that the aircraft was not going to stop on the runway, activated the crash alarm. The airport fire service responded rapidly and reached the aircraft soon after it came to rest. Neither fire fighting nor rescue was necessary.

Flight crew

The crew consisted of two pilots and one flight attendant. The pilot in the left seat was an experienced freelance Type Rating Examiner, employed from time to time by the company, and was tasked with providing instruction and familiarisation to the right seat pilot, who was being trained to carry out supervision of new captains. The left seat pilot was over 60 years of age, and the operator had a policy which required aircraft commanders to be under this age, so the right seat pilot was nominated as commander. In the two months prior to the accident flight, the left seat pilot had operated 15 flights for the operator, nine in the left seat and six in the right. The left seat pilot stated that, until the accident, he had been impressed with the right seat pilot's ability, noting that he was particularly "circumspect" and that he gave very full briefings.

The right seat pilot was nominated as commander and 'pilot flying' on both of the day's flights. He was an experienced pilot employed full-time by the operator, and was already qualified to carry out supervision of new co-pilots. In the month before the accident, the right seat pilot had operated eleven flights, of which one was as 'pilot flying' in the right seat, two were as 'pilot not flying' in the right seat, and the others were in the left seat. Prior to that, he flew only in the left seat.

The two pilots had not previously flown together.

Landing technique

When interviewed, both pilots explained that in executive flying, they believed that passengers expected very smooth landings, and that achieving a very smooth touchdown was an important part of their task. However, they both acknowledged that on comparatively short runways it was necessary to concentrate on achieving an accurate touchdown in the correct place, to ensure safety.

Landing performance is calculated on the assumption that the aircraft will touch down within the touchdown zone (the area of runway around the point where the glideslope intersects the runway surface). On the Luton runway, this zone is identified by runway markings at 150 metre intervals from the landing threshold to a maximum of 600 metres, by the positioning of the PAPIs and by the ILS glideslope.

The operator's Operations Manual did not include any stipulation that a missed approach should be executed in the event of a prolonged float during landing.

Aircraft examination

This Challenger 604, D-ABCD, was built in July 2003 as serial number 5565.

At Luton, the aircraft was found to have run off the western end of the stopway of Runway 26. It came to rest having travelled approximately 30 metres beyond the end of the paved surface, the wheels having sunk into, and made tracks through, the soft ground. Tracks on the paved surface indicated that the aircraft was turning slightly to the right whilst sliding towards its left as it passed onto the soft ground.

When first examined, the flaps were retracted and the aircraft appeared to have been shut down in the normal way. The track created by the right main landing gear intersected the edge of a concrete plinth supporting a landing light. It was noted that the nosewheel axle was bent.

The aircraft was defuelled, the data recorders were removed and the aircraft was winched back onto the paved surface before being towed to a maintenance facility on the airport.

Accumulated mud was hosed from the landing gears. Detailed examination confirmed that all tyres remained inflated and were free from flat spots on their treads. A tyre on the right main landing gear had sustained cuts to a sidewall, apparently as a result of rolling contact with a lighting plinth. Three brake units were found to be within wear limits whilst the fourth was worn to slightly below the minimum specified thickness.

After the accident it was found that some electrical interlocks were not operating correctly and this appeared to be due to damage sustained by the weight switches and wheel speed sensors as the wheels 'ploughed' through the unpaved surface beyond the stopway. Borescope examination of one engine revealed slight ingestion damage to the compressor. The time of occurrence of this damage could not be determined and it was decided that the engines should not be run before removal. Accordingly, the electric pumps were used to power the hydraulic systems; all were found to hold pressure correctly and the spoilers were found to function appropriately.

A pitot-static test set was utilised to calibrate the ADCs (air-data computers) and the flight-deck displays. All parameters were found to be within limits. Electrical tests on the autothrottle system revealed no evidence of defects and, after replacement of the engines, the system was reinstated successfully.

Flight recorders

The aircraft was fitted with a Solid State Memory Flight Data Recorder (FDR)[2] capable of recording a range of flight parameters into solid state memory when power was applied to the aircraft. The aircraft was also fitted with a Cockpit Voice Recorder (CVR)[3] which recorded crew speech and area microphone inputs into solid state memory (120 minutes of combined recordings and area microphone and 30 minutes of separate higher quality recordings), again when power was applied to the aircraft. Both recorders were downloaded at the AAIB and data and audio recordings were recovered for this overrun accident. The BFU (Bundesstelle für Flugunfalluntersuchung, the German accident investigation authority) also assisted in analysis of the CVR, providing a transcript and commenting upon the manner of the flight crew's operation.

Flight data recorder

A time-history of the relevant parameters during the accident is shown at Figure 1. The data presented at Figure 1 starts 45 seconds before touchdown, with the aircraft on the extended centreline to Runway 26, 0.8 nm from the threshold. The aircraft's height was 370 ft aal and airspeed was 138 kt (V_{REF} + 6), descending at about 720 feet/minute, with the trailing edge flaps at 45º and the landing gear down. The autopilot was ON before being disengaged seven seconds later as D-ABCD passed through 300 feet aal[4].

The aircraft continued to descend towards Runway 26, with the engine N_1[5] parameters fluctuating between 50% and 63%, crossing the threshold at about 110 feet aal. At this point, the aircraft started to flare, pitching from -1.8º to 1.7º nose-up over seven seconds, while the thrust was increased to 64% N_1. Over the next 15 seconds the pitch attitude slowly decreased to zero at touchdown when the right main and nose landing gears contacted the runway first. The distance travelled over the runway before touchdown was calculated as 1,310 m. During this period the N_1 remained at 64% and the airspeed varied between 134 and 141 kt.

The spoilers deployed immediately at touchdown. All three main landing gear 'weight-on-wheels' switches then showed a slight 'bounce' and the right main landing gear 'bounced' momentarily again. The thrust reversers were deployed and the brakes were applied five seconds later, after the aircraft had travelled 400 m along the runway. The aircraft then travelled a further 450 m to the end of the runway, and 130 m beyond, over the runway's stopway and onto the grass (indicated by the fall in pitch attitude as the aircraft followed the ground as it sloped down from the runway), before coming to a stop. The time from touchdown to stopping was 20 seconds.

Cockpit voice recorder

Staff at the BFU analysed the cockpit voice recorder and provided a transcript. They reported that the recording showed an apparently high standard of flight crew operation with clear briefings and good co-operation in a professional, slightly formal, manner. AAIB analysis concurred with these opinions.

Footnote

[2] L3 F1000 FDR capable of recording at least 50 hours of data at 128 words per second data rate.

[3] L3 FA2100 CVR.

[4] Although autopilot status was available on the FDR, a parameter for autothrottle selection was not.

Footnote

[5] For clarity, only the N_1 for the right engine is shown but this is also representative of the left engine. Parameters for throttle lever angle were not available on the FDR but the thrust parameters (N_1) appear entirely consistent with normal operation of the thrust levers. There was no evidence of any defect before or after this event.

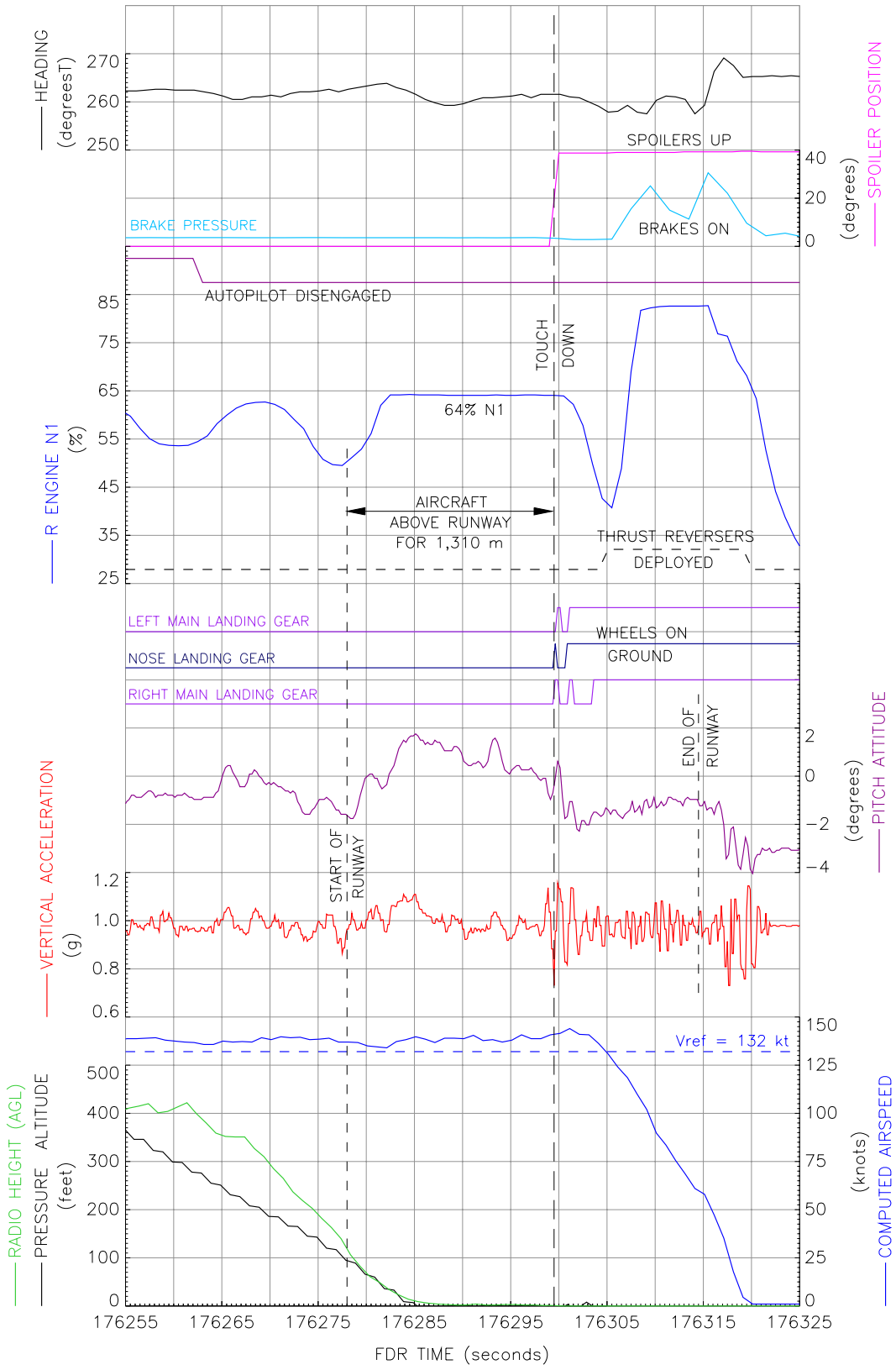

Figure 1

Salient FDR Parameters
(Accident to D-ABCD on 5 February 2006)

Autothrottle function

The autothrottle system fitted to the aircraft was an optional item, not fitted as standard equipment by the aircraft manufacturer although it was the only autothrottle system certificated on the type. The FDR did not record whether the autothrottle was engaged and no audio tone was triggered by disengagement. However, both pilots recalled that it had been disconnected "on short final" and, had it been engaged, it would have retarded the thrust levers to achieve a speed 10 kt below AFCS Airspeed Reference (speed bug) when the aircraft passed through 50 ft radio altitude. The commanded speed was 137 kt during the approach, and varied between 134 and 141 kt during the float.

The airport and landing performance

London Luton Airport is situated on the top of a hill, south-east of the town. The runway, orientated 08/26, is 2,160 metres long, and the Landing Distance Available (LDA) on Runway 26 is 2,075 metres. At the end of the Runway 26 LDA, a 60 metre stopway is provided. Although this stopway is the same width as the runway, it is not formally considered part of the LDA but is provided for use by aircraft executing a rejected takeoff.

The Landing Distance Required (LDR), given the conditions of the accident flight, was calculated. At a weight of 37,449 lbs and with a temperature of 4ºC, airport elevation of 526 ft and QNH of 1032 mb, the LDR was found to be 839 metres (2,755 ft).

Construction of the lighting plinths and relevant regulation

The elements of the approach lighting for Runway 08, which the aircraft struck during the overrun, were mounted on buried concrete plinths situated within the Runway Strip for Runway 26. The plinths were substantial and the lighting devices were bolted into the concrete, with appropriate wiring being fitted. The side faces of the plinths were vertical.

Civil Aviation Publication (CAP) 168 gives guidance and instruction on the design of aerodromes. The paragraphs of relevance to this investigation are reproduced below:

'4 Runway Strips

'4.1.1 A runway strip is an area enclosing a runway and any associated stopway. Its purpose is to:

'a) reduce the risk of damage to an aeroplane running off the runway by providing a graded area which meets specified longitudinal and transverse slopes, and bearing strength requirements…

'4.1.2 Ideally the whole of a runway strip should be clear of obstacles but in practice it is recognised that the strip facilitates the installation of visual, radio and radar aids, and some of these cannot perform their function if they are sited outside the runway strip.

'Equipment essential to an approach, landing or balked landing is permitted within the runway strip…

'Within the graded area of the runway strip constructions such as plinths, runway ends, paved taxiway edges, etc should be delethalised, that is, so constructed as to ***avoid presenting a buried vertical face*** *to aircraft wheels in soft ground conditions in any direction from which an aircraft is likely to approach. To eliminate a buried vertical surface, a slope should be provided which extends from the top of the construction to not less than 0.3 m below ground level. The slope should be no greater than 1:10.'*

It appeared that the lighting plinths had been in place for some years; inspections and audits of the aerodrome by the CAA had not revealed that the plinths did not meet the requirements of CAP168.

Analysis

No evidence was found to indicate that any technical defect relevant to the approach or landing phase of flight was present before the aircraft left the paved surface; in particular, the thrust parameters (N_1) appeared consistent with normal operation of the thrust levers**.** The one brake unit worn slightly below minimum limits was not considered to have affected braking performance. It was also possible that the unit was within dimensional limits when braking began on this occasion.

The flight proceeded normally until the last stages of the approach at Luton, and analysis of the cockpit voice recorder recording showed an apparently high standard of flight crew operation. This was also reflected in the recollection of the examiner, who stated that he was, until the accident, impressed with the right seat pilot's ability.

The approach was unremarkable, and well within the appropriate parameters, until the thrust increased to 64% N_1 and remained at this level until touchdown. The commander later recalled having disconnected the autothrottle close to 60 ft and the values of engine thrust (derived from the engine N_1 parameter) below 50 feet radio height appear inconsistent with the operation of the autothrottle system at this point.

It is concluded either that the commander selected a thrust lever angle which caused the engines to run at 64% N_1, in the last moments of the approach, or that he disconnected the autothrottle when the thrust levers were positioned to give approximately 64% N_1, and did not then retard them to the idle setting prior to the flare.

It is clear that although both pilots were aware of the unusual way in which the aircraft was floating along the runway, neither identified that this was caused by excess thrust. The right seat pilot had very little recent experience operating the aircraft from the right seat, having made only one flight as 'pilot flying' in the right seat in the two months prior to the accident, and it is considered that this lack of familiarity with the aircraft from the right seat is a likely factor in the accident. The brief delay between touchdown and the initiation of reverse thrust and braking may be explained by the short period between the first touchdown and the final touchdown of the right main landing gear; the commander may have been concerned to ensure that all three landing gear were firmly on the ground prior to braking.

The commander had placed both his hands on the control yoke for the flare and landing and it is possible that by doing this he was able to make smoother, more accurate, control inputs. Conversely, sensory feedback from the position of a hand on the thrust levers would provide a pilot with information about thrust lever position and movement.

The crew composition was unusual, as the commander, who had ultimate authority over the conduct of the flight, was nonetheless being 'trained' by a more experienced pilot and examiner. Neither pilot commented that he was conscious of this having affected their operation. However one factor, identified in earlier accident investigations, concerns the reluctance of a pilot who is not in command to dictate that a safety manoeuvre should be carried out. There can be an expectation that the commander, with overall authority, will be the one to dictate urgent safety actions, or to elect to continue a course of action which may be on the boundary of safe

operation. The right seat pilot, nominally the commander, may have felt that he was effectively under the tutelage of the examiner in the left seat and that, in the absence of instruction or comment to the contrary, the examiner was content with the way the flight was going. The examiner may have felt that the nominated commander, in the right seat, was responsible, and that it was not for him to 'interfere'. The crew composition may have provided a fertile ground for an error of omission of a critical action.

Safety actions

Discussions concerning the crew composition on the accident flight took place between the operator, the AAIB, and the Luftfahrt-Bundesamt (the German civil aviation authority). As a result, the operator's operations manual is to be amended to require that, when training or checking is taking place, the instructor or examiner must be the aircraft commander.

The design of the lighting plinths did not satisfy the criteria laid down in CAP168. This was discussed with members of the Civil Aviation Authority's Aerodrome Standards Department, and safety action is to be taken as a result.

The Civil Aviation Authority's Aerodrome Standards Department informed the AAIB that it intended to publish a Notice to Aerodrome Licence Holders (NOTAL) reminding them of the provisions of CAP 168 with regard to delethalisation of structures within Runway Strips, and intended to raise the topic at aerodrome audits. This NOTAL, 5/2006, was published in May 2006.

The aircraft operator has published a bulletin to flight crew pointing out that 'A safe landing may well be gentle. However, a soft landing is not necessarily a safe one!' and instructing flight crew that touchdown must be made within the touchdown zone.