

Cessna 560 Citation, D-CAUW

AAIB Bulletin No: 9/2003	Ref: EW/G2003/05/04	Category: 1.1
Aircraft Type and Registration:	Cessna 560 Citation, D-CAUW	
No & Type of Engines:	2 Pratt & Whitney 535A turboprop engines	
Year of Manufacture:	2001	
Date & Time (UTC):	28 May 2003 at 1325 hrs	
Location:	Leeds Bradford International Airport, Leeds	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 2	Passengers - 8
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Nosewheel detached, radome damaged, dent in leading edge of right wing, bent main gear doors	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	59 years	
Commander's Flying Experience:	8,000 hours (of which 5,000 were on type)	
	Last 90 days - 70 hours	
	Last 28 days - 33 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft landed at Leeds Bradford Airport and overran the end of Runway 14 by a distance of approximately 525 feet (160 metres), the final 30 feet (10 metres) being onto an area of grass. The overrun was as a result of an approach conducted in excess of the recommended speed and, following a late touchdown, a delayed application of the wheel brakes.

History of flight

The aircraft was carrying out a charter flight from Hannover, Germany to Leeds Bradford Airport. There were eight passengers on board and the intention was for a return flight to take place later on the same day. The weather conditions recorded at 1320 hrs (5 minutes before the accident) were as follows: surface wind 240°/6 kt, varying in direction between 170° and 290°, visibility 16 kilometres, few cloud at 2,500 feet, temperature 18°C and QNH 1022 mb.

The aircraft arrived in the Leeds area from the south and was vectored towards the left-hand downwind position for an Instrument Landing System (ILS) approach to Runway 14. At this time the first officer was the pilot flying. As the aircraft neared the airfield, the commander established visual contact and requested a visual approach. The first officer was still the handling pilot but was being

given some guidance by the commander during the descent and subsequent turn onto final approach. At around five miles on the final approach the commander took over as handling pilot and the aircraft was passed a landing clearance by Air Traffic Control (ATC). At this stage the aircraft was established on the visual glidepath, 3.5° for this runway, in a clean configuration at an airspeed of 220 kt.

The aircraft continued descending on a 3.5° glidepath. At approximately 2 nm from the runway threshold an Enhanced Ground Proximity Warning System (EGPWS) Mode 4 "TOO LOW TERRAIN" alert was received. With the aircraft at 1.5 nm the speedbrake was extended and shortly after this, at a speed of 210 kt, 15° of flap was selected. Between 1.5 and 1.0 nm, ATC advised the crew that the landing gear was not down, to which the commander replied "WE KNOW". The landing gear was then selected down and, shortly afterwards, at a speed of 195 kt, full flap was selected. A second "TOO LOW TERRAIN" alert sounded twice but the repeat was interrupted by the autocallout "MINIMUMS" which occurred at 200 feet agl. Immediately afterwards there was one further "TOO LOW TERRAIN" aural alert and then a "SINK RATE SINK RATE" alert.

The aircraft began the landing flare in the region of the touchdown zone at a speed of 155 kt, floated for a considerable distance along the runway and then touched down beyond the runway mid-point at a speed of 121 kt. After touchdown the commander applied full reverse thrust but did not use the wheelbrakes immediately. Wheel braking commenced at around 1,900 feet (585 metres) from the end of the paved surface and continued until the aircraft started to run onto the grass. The aircraft left the paved area at a speed estimated to be 20 kt to 30 kt and came to rest in a nose-down attitude.

The tail of the aircraft was still in view from the visual control room and ATC activated the crash alarm. The Airport Fire Service deployed and were at the scene in two minutes. There were no injuries amongst the passengers or crew and they did not require assistance to vacate the aircraft.

Operational information

This aircraft required a minimum crew of two pilots and the company philosophy was to operate the aircraft using an integrated two pilot operation. One standard procedure required the handling pilot to ask the non-handling pilot to make selections of flaps and landing gear.

The flap settings available on the aircraft are: 7° for takeoff; 15° for takeoff and approach; and 35°, for landing. The normal sequence of selections for flap and landing gear on approach are: first, approach flap 15°; second, landing gear down; and finally land flap 35°. The Airplane Flight Manual (AFM) speed limits are: 200 kt for flaps 15°, 173 kt for flaps 35° and 250 kt for landing gear extension. The landing checklist requires the speedbrake to be stowed by 50 feet agl.

Within the EGPWS system there are several different modes which can generate a "TOO LOW TERRAIN" alert, these are Modes 4A, 4B, 4C and Terrain Clearance Floor (TCF). The conditions for the Mode 4A "TOO LOW TERRAIN" aural alert are for the aircraft to be below 1,000 feet Radio Altitude with the landing gear up and the airspeed above 190 kt. Mode 4B is active when the flap is not in a landing position and Mode 4C during a go-around. The TCF alert is generated as a function of the aircraft's radio altitude and distance from the airfield.

The aircraft's actual landing mass was about 14,000 lbs (6,535 kg), giving a landing approach speed, V_{APP} of 109 kt and a final threshold target speed V_{REF} , of 104 kt. The calculated landing distance required under the prevailing conditions, having achieved the V_{REF} at 50 feet, was 2,700 feet (823 metres).

To comply with regulatory requirements the declared distances at Leeds Bradford Airport are different from the paved runway dimensions. Although the main runway is 7,380 feet long (2,250 metres), the landing distance available (LDA) for Runway 14 is reduced to 5,912 feet (1,802 metres). The reduction is caused primarily by a displaced threshold due to high ground beneath the approach path but the runway also has a paved over-run of 450 feet (137 metres) included within the pavement surface.

There is information in the UK Air Pilot, (AIP), which was reproduced on the approach charts used by the crew, that a nuisance EGPWS alert may occur at 2 nm final for Runway 14. This is because there is a ridge of high terrain at this point. Runway 14 has an undulating profile, starting with a downslope at the touchdown zone which becomes an upslope and then flattens out before again becoming a downslope to the end. Once on the runway, in a Citation aircraft or similar, the stop end does not become visible to the pilot until there is around 1,300 feet (400 metres) of runway remaining.

The flight log produced by the company operations department at the planning stage contained the following landing information: actual landing distance required 2,733 feet, the distance including a safety factor of 1.6 was 4,537 feet, and runway length 7,300 feet, (presumed to refer to the longest available). The runway chart in use by the crew correctly depicted, on the plan view, the paved surface available as 7,380 feet (2,250 metres) and in the text showed the longest runway as Runway 32 with a take-off run of 7,180 feet. The LDAs for all runways were also shown on the charts.

Flight crew information

The aircraft commander was also the owner of the operating company. He had flown various models of Cessna Citation aircraft over a number of years and this particular aircraft since it was purchased by the company in 2001. The first officer had only recently been employed by the company and had achieved 40 hours on the aircraft type. Neither pilot had flown into Leeds Bradford Airport before.

The commander made a very frank report of the circumstances leading up to the accident. He commented that the fact that the runway length exceeded the required landing distance of the aircraft by a large margin led him to be overconfident, even though he was aware that the approach speed was too fast. He stated that he used full reverse but did not apply the brakes on touchdown to save brake wear. He had in mind that the runway was long (for this aircraft) and so he was very confident that he had plenty of runway available. It was only as he crested the rise of the runway and the far end became visible that he realised he had overestimated the runway remaining. He did not consider that the accident was necessarily as a direct result of the long landing but more the result of his lack of perception of the remaining runway length available. He considered that had he braked immediately upon landing, the aircraft would have had sufficient runway in which to stop.

Flight recorders

Cockpit Voice Recorder

The aircraft was fitted with a solid state Cockpit Voice Recorder (CVR) which recorded the last 30 minutes of flight crew speech and cockpit area microphone sounds on a 'high quality' continuous loop when electrical power was applied to the aircraft, and the last two hours of flight crew speech and cockpit area microphone sounds on an 'ordinary quality' continuous loop. The CVR data was clear and free from distortion.

Flight Data Recorder

The aircraft was fitted with a solid state Flight Data Recorder (FDR) which recorded 12 analogue flight data parameters and about 50 discrettes on a continuous 25 hour loop. All of the available flight data was recovered successfully.

Recorded information

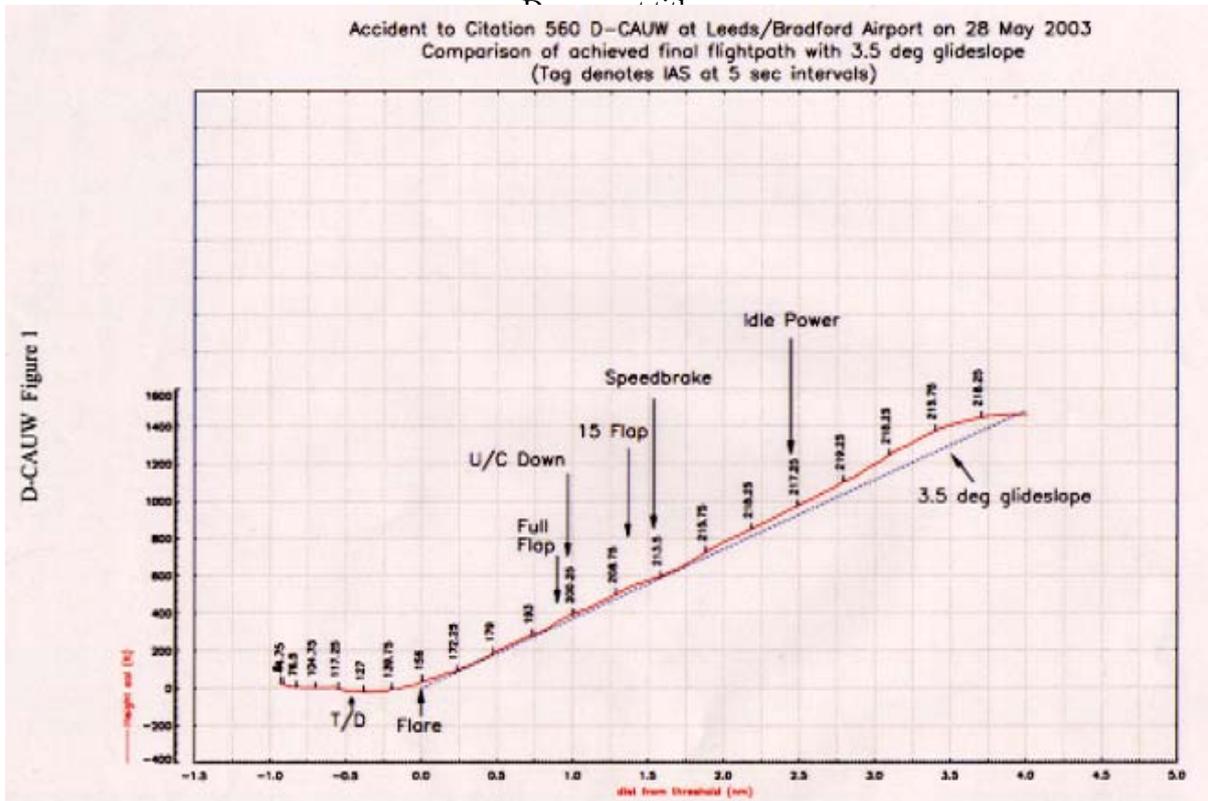
From the CVR it was evident that the first officer was the handling pilot until the aircraft was established on the runway heading prior to landing. There was no formal, verbal exchange of control but the commander took control at an unspecified stage during the final approach. The majority of the spoken communication was made by the commander to the first officer, with only an occasional comment made in reply. In the earlier stages of the approach, while the first officer was still the handling pilot, there were a number of prompts made to him by the commander to assist with establishing the aircraft on a visual final. Once the commander took over control there was very little

verbal communication between the two pilots. The majority of the ATC calls were also made by the commander.

Also recorded on the CVR were a number of EGPWS aural alerts which occurred during the approach. They are detailed in the table below with the associated reason, where it could be determined:

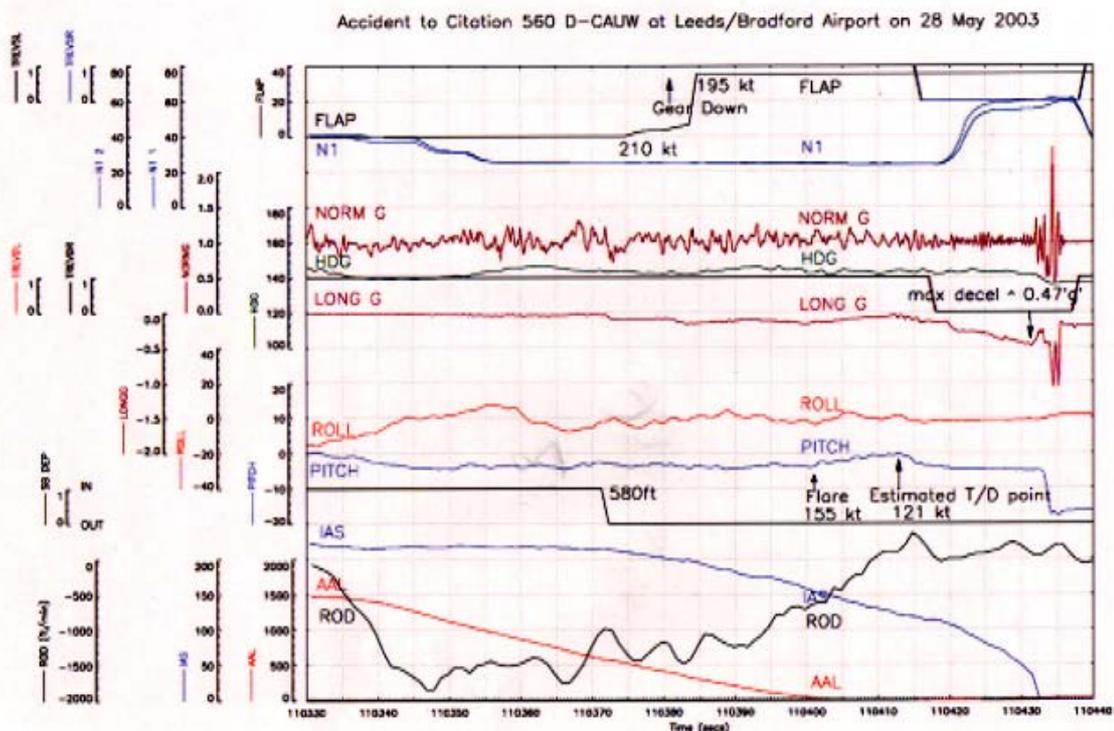
Approximate FDR Time (secs)	EGPWS Alert	Mode
110365	TOO LOW TERRAIN	Mode 4A Unsafe terrain clearance
110381	TOO LOW TERRAIN	Mode 4A Unsafe terrain clearance
110389	TOO LOW TERRAIN	Probable Mode 4A Unsafe terrain clearance
110391	SINK RA....	Mode 1 Excessive descent rate
110392	...MINIMUMS MINIMUMS	Mode 6
110393	TOO LOW TERRAIN	Reason undetermined
110395	SINK RATE SINK RATE	Mode 1 Excessive descent rate

D-CAUW Figure 1



The FDR data shows that for the final five miles of the approach, the aircraft maintained approximately the 3.5° glideslope. (See Figure 1.) The height above aerodrome level (aal) was derived from the barometric altitude (standard 1013 mb) recorded on the FDR. A time history of relevant flight data parameters is shown at Figure 2, from which the following information has been derived. Thrust was reduced to idle at 1,000 feet aal, 2.5 nm from the threshold. The speedbrakes were extended when the aircraft was at 580 feet aal and 1.5 nm from the threshold, and they remained extended throughout the remainder of the approach and landing. The airspeed was above 200 kt until the aircraft was at 400 feet aal and 1 nm from the threshold, with approach flap deployed. At 350 feet aal and 0.75 nm, further flap was selected, the landing gear was selected down and the speed reduced steadily to 195 kt by which speed full flap was achieved. Airspeed continued to reduce to reach 155 kt at the commencement of the flare. There was a protracted float along the runway for some 12 seconds with the speed reducing until touchdown, which occurred at an estimated speed of 121 kt. In the absence of any recorded weight on wheels parameter, the touchdown point was deduced from the observed change in pitch attitude.

D-CAUW Figure 2



Shortly after touchdown, reverse thrust was selected and the engine N_1 RPMs increased to 60%. The initial retarding deceleration was about 0.2 'g', which was consistent with data from previous landings where reverse thrust alone was used. The increase in deceleration above this figure, to a maximum value of about 0.47 'g' during the landing roll, probably indicates the point at which the wheelbrakes were applied.

Calculations based on the FDR data indicate that the aircraft floated for about 2,700 feet from the initiation of the flare at 155 kt until touchdown at 121 kt. They also show that the actual landing roll was about 2,700 feet, including the overrun onto the grass. Even if worst case errors in calculation of the landing roll are included, the data suggests that the landing roll could have been no more than 3,000 feet. This means that the aircraft must have touched down at or more than half way along Runway 14.

Aircraft examination

The Cessna Citation 560, also known as the Citation V Encore, is a light business jet with two turbofan engines. Retardation during landing is provided by a thrust reverse system, speedbrakes (upper and lower doors that deploy from the wing), and wheel brakes with an antiskid system which is operational at ground speeds above 12 kt.

The aircraft was resting nose down on the grass approximately 12 metres beyond the end of the paved surface of Runway 14. The wheels had dug deep furrows into the soft ground and the nosewheel had dug in sufficiently to break free from the nose gear leg. The right wing had impacted the ILS monitoring antenna, knocking it over, and producing a small dent in the leading edge of the right wing. The radome suffered minor damage when it impacted the grass surface after the nosewheel separated. There was also some damage to the main gear doors. The speedbrakes were extended and the flaps were found set to the landing position of 35°. There were no skid marks on the end of the runway.

The aircraft had logged 755 hours and it had its last maintenance check on 28 January 2003. No faults were found on the aircraft that might have contributed to the accident.

Analysis

There were a number of indications to the crew that the approach was not stabilised. Firstly the speed was not reducing at a sufficient rate to enable timely flap selection and flap limit speeds were exceeded. Secondly, there were a number of EGPWS alerts; although the first one may have been as a result of local terrain, there was no response to any of the subsequent alerts. Thirdly, ATC felt it necessary to remind the crew about the landing gear on short final approach. Finally the speedbrakes remained extended throughout the landing whereas the checklist required them to be stowed by 50 feet. Some crew interaction or acknowledgement of these events would normally be expected but none was evident.

There are several factors which may explain the apparent lack of verbal communication and monitoring of the approach between the two pilots. The rushed nature of the approach and the late deployment of flap and landing gear together with the EGPWS alerts left little opportunity for standard operating calls or checklists. Also there was a very steep experience gradient between the two pilots; in particular the first officer had very few hours on type whereas the commander had thousands. Furthermore the commander was directly responsible for the employment of the first officer.

The commander believed that there was sufficient runway in which to stop even after the long touchdown. The actual landing roll calculated from the FDR data suggests that the aircraft stopped in the expected distance of 2,700 feet. In fact, the deceleration during the final part of the roll was relatively high as the aircraft went onto the soft grass otherwise the landing distance would have been longer. This and the increase in longitudinal 'g' confirm that braking did not begin at the time of touchdown but occurred later, at around the time the commander was able see the end of the runway.

Had he applied full brake pressure immediately on touchdown, the aircraft should have stopped on the paved surface but probably beyond the declared landing distance.

In most cases, in daylight, once the touchdown zone of a runway is behind an aircraft there is no direct indication to a pilot what remaining length is available other than what he can see ahead. However, the touchdown zone markings for the opposite runway, normally at around 1,000 feet remaining, can sometimes be an indication. In recognition of this problem, some aerodromes have adopted a system of marker boards displaying distance to go information. In the absence of marker boards and any familiarity with the airfield environment, a pilot may not be able to form a good judgement of remaining distance once past the touchdown zone, particularly where, as in this case, there is a significant slope. For this reason, even when there may be excess landing distance available, a landing at the touchdown zone is desirable.

There were several other factors which may have contributed to the accident. The glidepath for Runway 14 at Leeds is unusually steep at 3.5°, because of the ridge of high terrain two miles from the runway. This would make it more difficult to correct for an approach which started too high or too fast. To achieve the 3.5° angle of descent at an average groundspeed of 200 kt, as maintained between 5 nm and 1.5 nm, would require a rate of descent of around 1,250 feet per minute which would be unusually high at this stage of an approach. Again, because of the terrain, the Runway 14 landing threshold is displaced by 1,020 feet (311 metres) leaving an LDA of 5,912 feet, (1,802 metres), considerably shorter than the actual paved surface. The company flight plan did not reflect this as the only runway distance quoted therein was the longest available at 7,300 feet, although the correct information was available on the approach plates used by the crew. It is possible though that the 7,300 feet was the figure in the mind of the commander, leading him to believe the landing distance was longer than it actually was.

The first EGPWS alert at 110365 secs (FDR time) may have been triggered by the ridge of high terrain. Conditions for a Mode 4A "TOO LOW TERRAIN" alert at 110389 secs did not appear to have been met for two reasons. Firstly the alert occurred eight seconds after the landing gear was selected down, although the time taken to lock down is not recorded, and secondly the airspeed was 175 kt (190 kt or greater required). The same case applied for the "TOO LOW TERRAIN" alert at 110393 secs, where the landing gear was certainly down. Neither alert appeared to fulfil the conditions for any other Mode 4 alert or for the Terrain Clearance Floor function.