
ACCIDENT

Aircraft Type and Registration:	Boeing 737-8AS, EI-DLR
No & Type of Engines:	2 CFM56-7B turbofan engines
Year of Manufacture:	2006
Date & Time (UTC):	13 November 2008 at 1920 hrs
Location:	Stand D 61, London Stansted Airport, Essex
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 164
Injuries:	Crew - None Passengers - None
Nature of Damage:	No 1 engine cowling damaged, tow bar attachment broken
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	14,000 hours (of which 2,500 were on type) Last 90 days - 270 hours Last 28 days - 23 hours
Information Source:	AAIB Field Investigation

Synopsis

A cross-bleed engine start procedure was initiated prior to the completion of the aircraft pushback. As the power was increased on the No 1 engine in preparation for the No 2 engine start, the resulting increase in thrust was greater than the counter-force provided by the tug and the aircraft started to move forwards. The towbar attachment failed and subsequently the aircraft's No 1 engine impacted the side of the tug, prior to the aircraft brakes being applied.

History of the flight

The accident happened during the hours of darkness. It was raining and the surface of the apron was wet. The flight crew were starting their third sector of the day, on the same aircraft, and were running

about 25 minutes behind schedule. The aircraft was operating with a deferred defect; the Auxiliary Power Unit (APU) was inoperative, which required the crew to carry out a ground-air start of one engine on stand and, subsequently, a cross-bleed start of the other engine once away from the stand. The procedure had been carried out successfully on the previous two sectors but both times there had been some difficulty in maintaining sufficient pneumatic duct pressure during the cross-bleed start. On both previous occasions the aircraft had been stationary with the parking brake set before the cross-bleed start was attempted.

The aircraft was parked on Stand D61L at Stansted Airport. The co-pilot received clearance from ATC to

start on stand and the procedure for a ground-air start was read out from the operations manual. The commander initiated the start sequence on engine No 1, but was unable to get sufficient engine rotation (N_2), so aborted the start. He contacted the groundcrew headset operator on the flight interphone, and asked if he could increase the air supply from the ground-air cart. This was done and, at the second attempt, engine No 1 was started successfully. The ground equipment was cleared away and pushback clearance was obtained. The operations manual was then consulted for the procedure relating to a cross-bleed start.

The pushback from stand D61L requires a ‘dogleg’ manoeuvre to be carried out, see Figure 1. As the tug was starting to straighten the aircraft onto the taxiway centreline, the headset operator called the commander and said ‘CLEAR TO START NUMBER TWO’. The commander

responded by stating that he would be increasing the thrust on the No.1 engine, to which the response was ‘OK’.

The commander increased the thrust to give an initial duct pressure of around 40 psi, in an attempt to prevent a recurrence of the previous slow starts. He was monitoring the N_2 rotation when he became aware that the nosewheel was skidding. He then heard the headset operator say “STOP PLEASE EMERGENCY STOP”, but he reported that this message did not make sense to him because, while he was being pushed back, the aircraft was under the control of the headset operator and the tug driver. Nevertheless, he reduced the No 1 engine thrust to idle. He questioned the headset operator several times, but did not get a reply, and then saw ground personnel waving at him. When he heard the headset operator say “SHUT IT DOWN NOW”, the commander advised him that there was no APU. He opened his window and looked

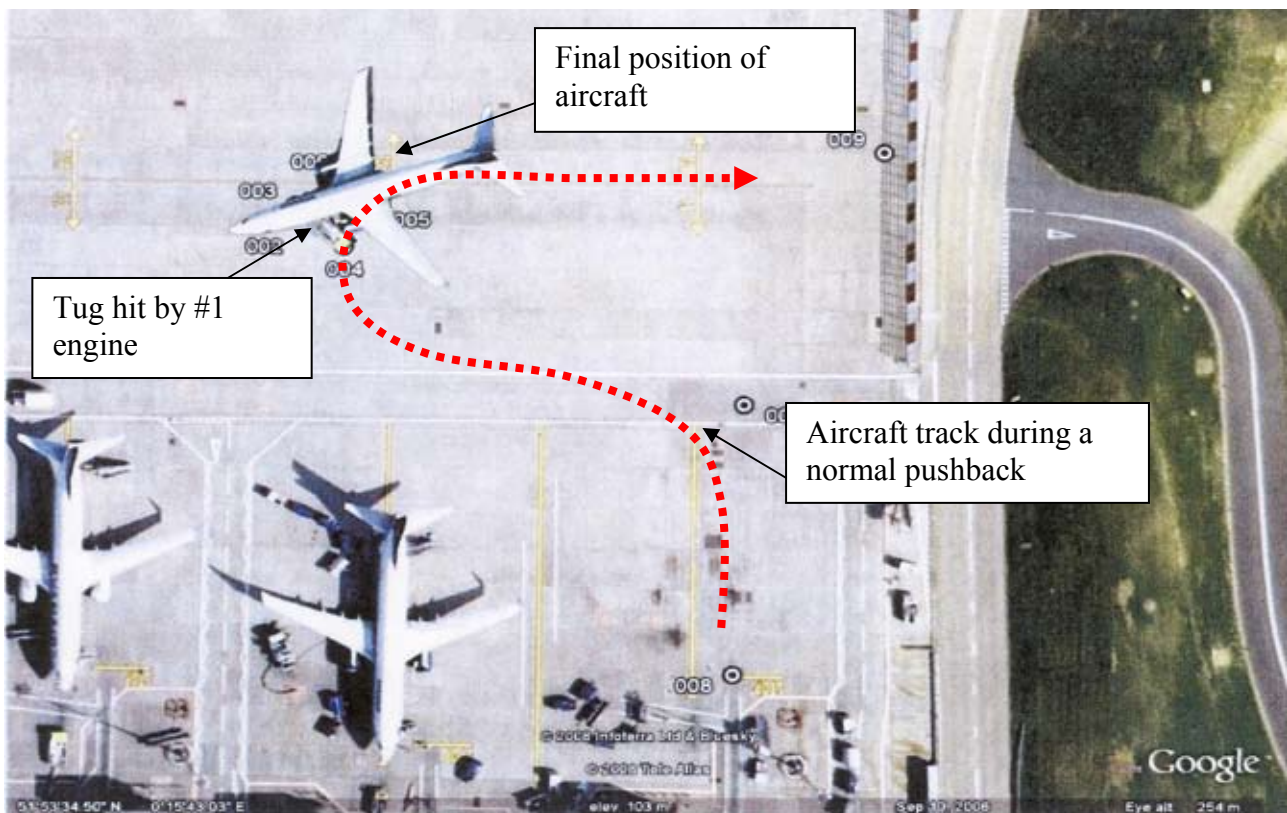


Figure 1
‘Dogleg’ pushback manoeuvre from Stand D 61 at London Stansted Airport

out to see what was happening, and then applied the brakes. The aircraft, and by now driverless tug, stopped moving. Shortly afterwards, engine No 1 was shut down. After the commander had checked outside, he spoke to the passengers to explain what had happened. They were subsequently disembarked from the aircraft by means of steps placed at the rear door.

Initial examination

It was apparent that the towbar attachment to the nose landing gear had failed as the aircraft started to move forward. Before it came to rest, it had contacted the tug with the nose cowl of the No 1 engine, and pushed the tug across the apron for a short distance.

Aircraft information

Procedures for pushback and towing of aircraft, and normal, ground-air and cross-bleed engine starts, were all provided in the company Operations Manual, shown in Figure 2.

The manufacturer provides a Flight Crew Training Manual (FCTM), which contains additional operational information for pilots, as follows:

'Push Back or Towing

Each operator should develop specific pushback and towing procedures and policies which are tailored for their specific operations. The flight operations and maintenance departments need to be primary in developing these procedures.'

and

'Engine start may be accomplished during pushback or towing, or delayed until pushback or towing is completed. Ground personnel should

be on headset to observe and communicate any possible safety hazards to the flight crew'

A review of data supplied by the manufacturer, with regard to duct pressure required for engine start, shows that it varies with ambient temperature and duct delivery air temperature. For the prevailing conditions at Stansted, an indicated duct pressure of approximately 35 psi needs to be maintained during engine start¹.

Ground handling pushback procedures

This type of accident had been anticipated by the ground handling agent responsible for the pushback of the operator's aircraft at Stansted. Their training material for headset operators stated that cross-bleed starts should not be permitted during pushback. Aircraft must be stationary and the park brake applied before start clearance can be given. The tug driver was aware of this requirement and advised that it was complied with in normal practice. The headset operator had successfully undergone this training, and passed an exam on the subject in December 2006, in order to gain company approval to operate in this capacity during pushback operations.

Information from personnel

Commander

The commander stated that he would not normally have intended to carry out a cross-bleed start while the aircraft was still being pushed back. However, when the headset operator said "CLEAR TO START", it had triggered the start process in his mind and he had

Footnote

¹ During a crossbleed start, the live engine is able to maintain the required pressure whilst delivering a high volume of air to the engine being started. It is often the case, however, that the air pressure from a ground-air vehicle falls significantly when delivering a high volume of air, and this may lead to a hesitant start, or a failure of the engine to start.

Pushback or Towing Procedure

The Engine Start procedure may be done during pushback or towing.

CAUTION: Do not use airplane brakes to stop the airplane during pushback or towing. This can damage the nose gear or the tow bar.

Starting with Ground Air Source (AC electrical power available)

Engine No. 1 must be started first.

When cleared to start:

APU BLEED air switch OFF

Engine No. 1 start Accomplish

Use normal start procedures.

WARNING: To minimize the hazard to ground personnel, the external air should be disconnected, and engine No. 2 started using the Engine Crossbleed Start procedure.

Engine Crossbleed Start

Prior to using this procedure, ensure that the area to the rear is clear.

Engine BLEED air switches ON

APU BLEED air switch OFF

PACK switches OFF

ISOLATION VALVE switch AUTO Ensures bleed air supply for engine start.

Engine thrust lever (operating engine) Advance thrust lever until bleed duct pressure indicates 30 PSI²

Use normal start procedures with crossbleed air.

After starter cutout, adjust thrust on both engines, as required.

Figure 2

Extract from the Company Operations Manual

Footnote

² The duct pressure gauge is located on the overhead panel above the co-pilot's seat.

automatically begun the procedure. He remarked that, had there been any guidance in the Operations Manual regarding the potential risk of carrying out a cross-bleed start during pushback, then he would have seen it and would not have increased the left engine thrust.

The instruction to stop given by the headset operator as the aircraft started to overpower the tug, had not made sense to him because he thought the aircraft was still being moved by the tug. However, the commander was aware that, as cautioned in the Operations Manual, brakes must not be used while the aircraft is being pushed or towed. He was mindful that the flight was running late but considered that it was not necessarily a factor in the accident.

Co-pilot

The co-pilot was monitoring the ATC frequency during the pushback and also had the interphone selected at a low level. He became aware of a juddering during the push and heard the headset operator say "STOP" and repeated this to the commander. Because it was dark outside, he was unaware of the relative motion of the aircraft and was surprised when he later saw the positions of the tug and aircraft.

The co-pilot had been qualified on this aircraft type for about six months. During his initial training he had carried out cross-bleed starts in the simulator, but not on a stand requiring pushback. He commented that he had never, until the day of the incident, carried out a cross-bleed start during line operations.

Tug driver

The tug driver had carried out this 'dogleg' pushback on many previous occasions. He knew that a cross-bleed start was not allowed during pushback under his company operating procedures and was surprised when

he heard the engine power increasing. He felt the tug start to lose grip and attempted to steer to correct, but then realised that he was being pushed by the aircraft. He saw that he was being forced towards the engine and, as it came closer, decided to get out of the way. He opened the cab door and, after running clear of the area towards the front of the aircraft and the headset operator, turned around and started waving and shouting to attract the flight crew's attention.

Headset operator

The headset operator was shocked by the event and was not available for interview after the accident.

Recorded information

Pertinent recordings were recovered from the Cockpit Voice Recorder (CVR) and the Flight Data Recorder (FDR) installed on the aircraft. These showed that engine No 1 had been started on stand, after clearance was given by ATC, and in communication with the ground crew. Permission was given by ATC to push back and, again, the flight crew and ground crew coordinated this with each other. The aircraft was pushed back in a 'dogleg' manoeuvre from the initial heading of 225° through to 157° before a turn back towards 315°. Just after this reversal in direction, the ground crew said to the flight crew that they were clear to start engine No 2. The flight crew responded by stating that they would increase the power on engine No 1; this was acknowledged by the ground crew. Approximately 20 seconds later, with the heading increasing through approximately 230°, the N_1 of engine No 1 started to increase, reaching a peak of 51% N_1 within ten seconds, before a slow reduction in power.

Approximately 10 seconds after the peak in N_1 speed, the aircraft heading increased to just over 300°M when the ground crew called "...STOP PLEASE EMERGENCY

STOP". At this point the aircraft had a ground speed of approximately 1.5 kt, although the direction of travel was not recorded. Clarification of the situation was sought by the flight crew from the ground crew. Within three seconds of the emergency stop call the N_1 of engine No 2 registered a small increase from 0% to 1%, later peaking at just over 2%; the igniters had not been triggered. Just under 10 seconds from the start of the emergency stop call, the aircraft brakes were applied and the 'inertial' ground speed fell to zero. Further urgent requests from the ground crew to "STOP" were recorded as were further flight crew queries about the problem. Fifty seconds after the initial emergency call the ground crew instructed "SHUT IT DOWN NOW"; the flight crew responded, stating that there was no APU, following which the recordings stopped.

Engineering examination

Accident site

The aircraft and tug had been removed from the accident site prior to the commencement of the AAIB investigation, as the collision had occurred on an active taxiway. However, the positions of the tug and the aircraft's wheels had been marked on the taxiway using spray paint. A skid mark was present to the left of the taxiway centreline, leading to and terminating at, the point where the aircraft nose gear tyre position had been marked on the ground. A short skid mark was located at the left rear corner of the area which had been marked as the tug position.

Photographic evidence

Photographs were taken immediately after the accident by attending airport staff. These show the towbar had disconnected from the aircraft, but that it was still attached to the front of the tug, and aligned approximately along the tug's centreline. The tug was

located in front of the aircraft's left engine, aligned at an angle of 45° to the right of the engine centreline. The engine cowl had contacted the top edge of the tug, in line with its right rear wheel, and the tug was canted over to the left (looking towards the front of the tug).

Aircraft, tug and towbar damage

A large dent and a crease along the outside edge of the cowl, at the four o'clock position looking aft, was present on the aircraft's No1 engine nose cowl, together with an open crack along the circumference of the nose cowl leading edge where the cowl had distorted. Paint had been removed along the line of the crease and blue paint from the tug had transferred onto the cowling across the whole depth of the dent, Figure 3. The left nosewheel tyre tread exhibited a large cut and missing sections of tread. The towbar attachment bar on the front of the nose landing gear had been distorted.

A large section of scuffed paint was evident on the right rear bodywork above the rear wheel of the tug, but the tug was otherwise undamaged. A single shear bolt had failed on the towbar and the two lugs which clamp over the aircraft attachment bar had broken off.



Figure 3
Cowling damage

Tug and towbar details

The tug was a TMX100 model, manufactured by TLD. It weighed approximately 12.5 tonnes and had a drawbar pull (DBP) of 9,090 daN. It was last serviced on 4 September 2008, in accordance with a routine maintenance schedule. Its next scheduled service was due on the 18 November 2008. Both the tug and its tyres appeared to be in good condition, with no reported defects. Apart from the damage sustained in the accident, the towbar also appeared to be in good condition. This was last serviced on 22 October 2008.

Analysis

Operational analysis

The attempted start of the No 2 engine during the pushback appears to have been initiated without either the headset operator or the commander originally having intended it to take place. Although the procedures of the ground handling company stated that cross-bleed starts were not to be carried out on pushback, the aircraft Operations Manual did not contain a similar instruction. It was the aircraft manufacturer's recommendation that operators should devise their own procedures for pushback and start, but guidance was given that the area behind the aircraft should be checked as clear.

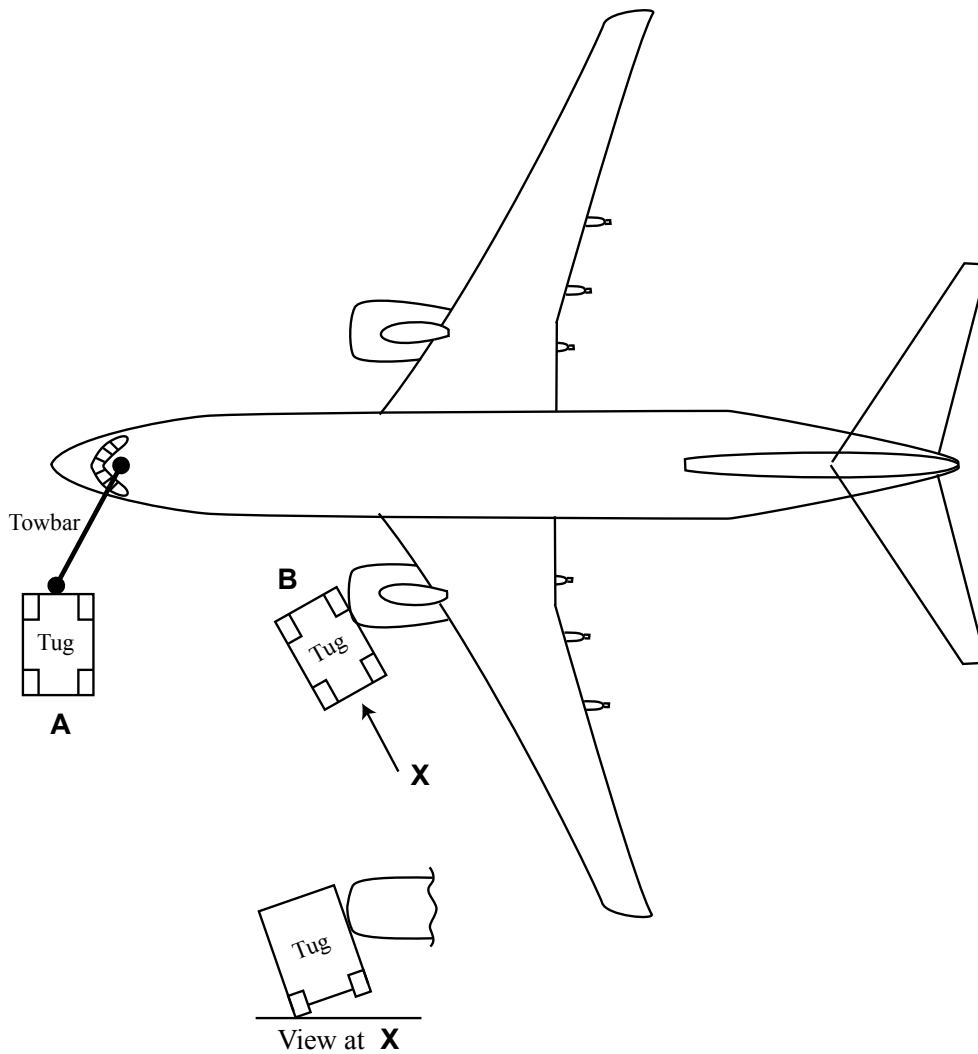
The headset operator should have been aware that clearance was not to be given for a cross-bleed start until the pushback had been completed. It is most likely, therefore, that he had simply forgotten this when he gave the clearance. This, however, acted as a trigger for the commander to start the No 2 engine. Had it had been stated in the Operations Manual that cross-bleed starts were not to be made during pushback, the commander considered that he probably would not have done so.

The ground crew and the flight crew, because of their

physical positions, had different perceptions of what was happening as the aircraft moved forward. The ground crew did not appreciate that the flight crew had very little information as to what was happening outside the aircraft so consequently, when they tried to give instructions, the words they used were not understood by the flight crew. When the commander asked for more information he did not get a response. The flight crew did not realise what had happened, leading the commander to question the ground crew instructions, because he did not want to carry out an inappropriate action, or to deprive the aircraft of electrical power under conditions of darkness.

Engineering analysis

Plotting of the ground markers identified that, in its final position, the aircraft was pointing approximately 30° to the left of the taxiway centreline, Figure 1. Although the pushback procedure used on this stand is known as a 'dogleg' pushback, the aircraft actually transcribes a path closer in shape to a letter 'S'. In order to achieve this, the tug faces almost at right angles to the centreline of the aircraft prior to the manoeuvre being completed, Figure 4. Given the angle of the towbar relative to the aircraft as a consequence of this manoeuvre, the tug would have been able to exert relatively little resistive force to the forward movement of the aircraft. The aircraft's nosewheels would also have been pushed to a high angle of turn at this point so, as the aircraft moved forward, the tyres skidded rather than rolled, leaving the ground marks observed. The tug driver vacated his cab, given its increasing proximity to the aircraft's operating engine, leaving the tug in the path of the oncoming aircraft. The left engine then contacted the side of the tug, rotating it and pushing it sideways. At this point, the pilot applied the brakes and stopped the aircraft.



- A** Approximate position of tug relative to the aircraft when the aircraft began to move forward
- B** Position of tug relative to the aircraft when the aircraft came to rest

Figure 4

Diagram showing the approximate relative positions of tug and aircraft

Attempting starts with 30 psi indicated pressure resulted in the ‘hesitant’ start of the right engine experienced by the crew during the two previous sectors. Analysis of the flight data for the accident shows that the left engine had achieved 51% N_1 during the aborted right engine start. This is consistent with an attempt to increase duct pressure sufficiently to prevent a repeat of the start problems experienced during the previous sectors, but does not appear to have been excessive. However, once

the aircraft began to move forward the resistive force applied by the tug was acting almost perpendicular to the aircraft thrust line and quickly resulted in an overload of the towbar attachment. This removed any ability of the tug to prevent further forward movement of the aircraft. Although the tug in use was relatively lightweight and the taxiway conditions were wet, these were not considered to be significant contributory factors in this case.

Safety action

Since this event, the operator has added the following information to their Part-A - Operations Manual, Section 8.2.6.4.2:

*'Flight Crew shall **not** attempt to crossbleed start until:*

- *Pushback is complete, **and***
- *The park brake is set, **and***
- *The tug is disconnected, **and***
- *ATC clearance is obtained.'*