

AAIU Report No. 1999/015
AAIU File No. 19980057
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Aircraft Type and Registration: Boeing B747-136, G-AWNN

No. and Type of Engines: Four Pratt & Whitney JT9D-7

Aircraft Serial Number: 20809

Year of Manufacture: 1973

Date and Time (UTC): 24th. October 1998, 0341 hrs

Location: Shannon Airport, RWY 24

Type of Flight: Scheduled Flight

Persons on Board: Passengers 290 Crew 18

Injuries: Passengers Nil Crew Nil

Nature of Damage: Nose Tyre Damage

Commanders Licence: Air Transport Pilots Licence

Commanders Age: 49 years

Commanders Flying Experience: 10,200 hours (All Types)
7,000 hours (B747)

Information Source: ATC Watch Manager, Shannon Airport.
AAIU Field Investigation

SYNOPSIS

At 0341 hrs on 24th. October 1998, flight BA 114 made a normal ILS approach and landing on to Runway 24 at Shannon Airport. On roll-out, the No. 2 engine surged in reverse thrust and was shut down. The aircraft continued its roll on the runway, and came to a halt with its nose just beyond the intersection of the runway and Taxiway Alpha. A turn was executed on the runway at this point. During the turn the nose wheels of the aircraft left the paved surface and entered on to the grass verge.

The incident was reported to the Air Accident Investigation Unit (AAIU) by ATC Shannon at 0400 hrs on 24th. October 1998. Two AAIU Inspectors arrived in Shannon at approximately 0945 hrs and proceeded to the aircraft location. The aircraft by this time had been moved from the incident site to the West apron area, with the approval of the AAIU Inspector.

History of the Flight

The aircraft was on a scheduled flight from Philadelphia to London Heathrow (LHR). The aircraft experienced strong tail winds on the Atlantic, such that the early crossing would necessitate a holding pattern prior to the airport opening at 0600 hrs. The Captain decided to divert to Shannon Airport, while en-route to London, in order to pick-up extra fuel.

The aircraft had been vectored on to the ILS approach and the ATC Controller gave the wind direction speed as 160° at 24 kts, gusting maximum 32 kts, minimum 14 kts.

The crew made an ILS approach to Runway 24 at Shannon Airport, with a drift of 10°. The approach was normal and the aircraft successfully touched down at 0341 hrs. On roll-out the No. 2 engine surged during thrust reversal. The Flight Engineer called "Reverse Surge" due to an abnormal rapid Turbine Gas Temperature (TGT) rise. The non handling pilot (NHP) returned the reverse thrust levers to reverse idle position. The aircraft came to a halt on runway 24 just beyond taxiway alpha, with half the length of the aircraft past the taxiway center-line. The controller then asked the Captain if he could turn left for Taxiway Alpha. The Captain answered in the affirmative, and the aircraft moved forward and towards the extended runway area opposite runway alpha, prior to executing an intended left hand turn.

Whilst in the turn, the aircraft was stopped and the Captain consulted with the First Officer, who was the handling pilot (HP), as to the position of the aircraft relative to the runway and taxiway. It seemed to the crew at one stage that the aircraft was not turning as it should, even though the tiller was full over, and it appeared to the Captain that the radius of turn was not what he would expect with the tiller in that position. As the turn continued the Captain was again dissatisfied with the rate of turn, and called for the turn to be stopped.

Meanwhile the Flight Engineer proceeded to cool the No. 2 engine by motoring the engine with the start system, thereby drawing ambient air through the engine. When the TGT had decreased to less than 100°C, an attempt was made to restart the engine. The restart was abandoned when the TGT reached 636°C. The duration of the restart was 20 seconds.

The crew requested a tug with the intention of pushing the aircraft back in order to continue the taxi to the ramp. Subsequent investigation however, showed that having completed almost 140° of the intended turn, the nose wheels of the aircraft had left the paved surface and become embedded in the grass verge, striking a taxiway light en-route. The aircraft came to rest with its nose wheels on the grass some 5 feet past the edge of the paved surface, finally settling at a heading of 124°. The time was 0403 hrs, and all engines were shut down. The passengers were then informed of the situation, i.e. that the aircraft had gone too close to the edge of the taxiway, and would require to be towed to the terminal. When the steps arrived to off load the passengers, the Captain inspected the noseleg which he found turned 20° to 30° to the left and the main gear straight. This was confirmed by the First Officer who on return to the flight deck, noticed that the body gear steering was armed.

On further examination however, it transpired that the circuit breaker for the body gear steering, located on the over head panel, had tripped.

The crew of the aircraft afterwards indicated to the investigators that they had difficulty during the turn in determining the exact profile of the runway taxiway intersection as it applied to the paved surfaces. They brought to the attention of the investigators the fact that the runway and taxiway edge lights did not exactly parallel to the paved edge.

On a subsequent inspection of No. 2 engine several hours later, the Reverse Actuated Bleed System (RABS) switch cam pivot bolt was found in the engine cowling.

Injuries to Persons

There were no injuries.

Damage to Aircraft

A piece of rubber was removed from the LH nose tyre on striking the taxiway light. Both nose wheels were replaced following the incident.

Other Damage

One taxiway light damaged by nose wheel, necessitating replacement.

Meteorological Conditions

Weather conditions at Shannon Airport at 0340 hrs on 24th. October 1998 were as follows:-

Wind (True):-	160/20 Kt, Gusting 31 Kts
Visibility:-	10 Km
Present Weather:-	Light Rain
Cloud:-	FEW 700 ft., BKN 1,200 ft., BKN 2,000 ft
Temperature:-	12°C
Dew Point:-	11°C
QNH:-	993 hpa

Communications

Communications were established between the aircraft and ATC Shannon on frequency 118.7 (TWR), 121.4 and 124.7 (App)

Aerodrome Information

The paved surface of the runway is 60 metres wide. Runway 24 white lights are approximately 5 metres in from the edge and the white side stripe marking another 2.3 metres in towards the centre, thus leaving a declared runway width of 45.40 metres. The Taxiway Alpha is 23 metres in width. The taxiway lights at the curve are situated on the grass out from the unbroken double yellow taxi edge line and are 15 metres apart at this point. The row of taxiway lights retain the curvature until it meets the first runway white light which is situated 5 metres out from the edge of the paved surface. The runway white side stripe which marks the commencement of the declared runway is another 2.3 metres out from the white light. Two of the row of taxiway lights are situated on the runway paved surface but are outside of the declared runway area. The triangular paved area almost opposite the junction of RWY24 and Taxiway Alpha (see Annex A) is part of a disused runway and is not in use. It is outside the white runway stripe line and the line of runway lights and is not therefore considered as part of the runway. There is a painted centreline from Runway 24 to Taxiway Alpha for the purpose of guiding aircraft from Runway 24 to Taxiway Alpha.

Flight Recorders

Both CVR and FDR were removed from the aircraft and handed over to the AAIU Inspectors. The tapes were subsequently analysed and the CVR and FDR returned to the aircraft operator. No useful data was obtained from the CVR on the incident as it was still switched on at 0600 hrs. If left on, the CVR tape self erases after 30 minutes.

Other Aircraft Information

The Steering System

Nose wheel steering is provided for directional control during taxiing. Hydraulic power is used to turn the nose wheels from zero to 70° on either side. When the nose wheels are turned to 20° the body gear steering is armed. Steering is controlled by tillers on both sides of the cockpit. Body gear steering supplements nose gear steering for directional control during towing or taxiing of the aircraft. As the nose gear turns in one direction, the body gear turns smaller proportional angles in the other direction.

The body gear steering arming circuit is de-activated whenever the body gear ARM/DISARM switch on the P5 over head panel is in the DISARM position, or the arming switch on the rudder disconnect quadrant is de-activated.

The body gear steering actuators have two lock operated switches which illuminate the "GEAR NOT CENTRED" light on the P2 centre instrument panel, and UNLOCKED lights on the Flight Engineer's P4 panel when the actuator locks are not engaged.

The minimum width for a 180 degree turn in accordance with the Boeing 747 - 100/200 Operations Manual is 43.3 M (142 feet) when the turn is initiated at 10 kts, 70° nose steering, the body gear steering armed/activated and without differential braking. If the body gear steering is de-activated the minimum pavement width for a 180° turn is 51.82 metres (170'). Taxi speed, ground wind speed and direction, centre of gravity, runway conditions and nose wheel steering will affect the turn radius and location of the turn centre.

To execute a turn on this runway the outboard starboard wheel truck would have to have passed within 1 metre of the right hand edge of the declared runway before the turn was executed. The body gear steering would have to be operative and the wind direction and speed favourable. As it was, the wind speed was 160°/24 kts, which was counteracting the turning process.

Engine Surge

Reverse thrust is used after touch down to decelerate the aircraft. The reverse thrust procedure commences at touch down and is reduced to 'reverse idle' at 80 kts. This is to prevent possible engine surge at speeds below 50 kts. If an engine surge does take place with a resulting high TGT the engine start lever should be moved to the CUTOFF position. When the aircraft has cleared the runway, the Flight Engineer should complete the over-temperature checklist procedure.

The Flying Manual engine over temperature procedure states:-

"During ground operation other than the start accomplish this procedure immediately when EGT exceeds 650°C at idle thrust or when a tailpipe fire is reported. if a surge occurs during reverse operation and it does not clear straight away, carry out the first action of this checklist immediately. The remainder of the checklist should be carried out once the runway is cleared.

- | | | |
|--------------------------|---|---------|
| (1) Start Lever | - | CUT OFF |
| Bleed Air Valve Switches | - | OPEN |
| Pack Valves | - | Closed |
- Allow maximum pneumatic air for engine motoring.*

- (2)** When N2 on affected engine is below 20%:-

Engine Ignition Switch	-	GROUND START
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When N2 of the affect engine has decreased to below 20 % place the engine ignition switch to GROUND START and motor for 30 seconds to cool the engine.

- *if engine limits have not been exceeded, continue motoring and initiate a normal start if desired.*
- *if engine limits have been exceeded, discontinue motoring and do not re-start".*

Analysis

Reverse Thrust

The action of the Flight Engineer in shutting down the No. 2 engine, following the surge during reverse thrust at aircraft roll-out, was in accordance with the correct procedure. Although the Flying Manual states that the ground restart should be carried out once the runway is cleared, the Flight Engineer motored the engine to cool it down because the aircraft could not be cleared from the runway.

Body Gear Control

It cannot be stated whether the control circuit breaker was tripped prior to the turn, during the turn, or following the turn. The technical log following the incident does not record that a full Body Gear Steering System Test was carried out following the incident. The circuit breaker (CB) found tripped, supplies current to a solenoid which brings hydraulic pressure to the system. Only a short circuit or low resistance in the solenoid would cause the CB to trip. No such fault was reported and it is assumed that this electrical circuit was not faulty.

There were no recorded details of body gear steering problems from the date of the previous aircraft's routine inspection on 29 September 1998, and none reported since the date of the incident.

If the body gear system was in operation then the P2 panel "GEAR NOT CENTRED" and the Flight Engineers panel "GEAR UNLOCKED" lights would have illuminated during any nose wheel steering turn greater than 20°. During the incident the wheel angle went from +61° to -73°. The Flight Engineer was engaged in motoring the No. 2 engine and may not have been in a position to notice the non-illumination of lights on his panel.

Although not required by the flying manual, the crew should have noticed the absence of the "GEAR NOT CENTRED" warning lights, when they became concerned about the turning rate of the aircraft and the proximity of the paved surface edge.

Although the crew attempted to use the cross runway extension taxiway Alpha, to increase the available turning area, in the prevailing weather and lighting conditions, it would have been prudent to have taxied to the expanded hammerhead area at the end of the runway to perform the turn.

No record of the body gear steering system check was available prior to the aircraft leaving for LHR following the incident. This check would necessitate the disconnection of the actuator assembly from the torsion links as per Maintenance Manual, Page 501, Chapter 32-53-00. It must be assumed therefore that the CB was pushed in and a taxi check carried out before ferry departure. A nose landing gear inspection was carried out in accordance with Chapter 5-51-07, of the Maintenance Manual. The No. 2 engine thrust reverser was locked out prior to departure back to London Heathrow.

Runway / Taxiway Configuration

The crew failed to execute a 180° on the runway, just beyond the intersection of Runway 24 and Taxiway Alpha. In order to complete the turn the aircraft's heading would have to have reached 060°, whereas the final heading recorded in the turn was 124°. The runway and taxiway lights are correctly positioned in accordance with the ICAO recommendations. The blue taxiway edge lights follow the curvature of the taxiway. The curvature line is continuous and integrates into the white runway lighting system without any discontinuity. If the wheels of the aircraft were kept within the area bounded by the integrated lighting system the aircraft would have been free to continue its taxi. As it was, the aircraft's nose wheel breached this line destroying one of the lights in the process before coming to rest on the grass.

Engine Surge

As the computed air speed average reading from the FDR during the engine surge was 90 kts, it is unlikely that the surge was caused by a low forward air speed. The fact that none of the other three engines experienced a surge would indicate that the surge was probably caused by a fault in the thrust reversal system of this engine.

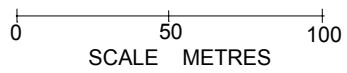
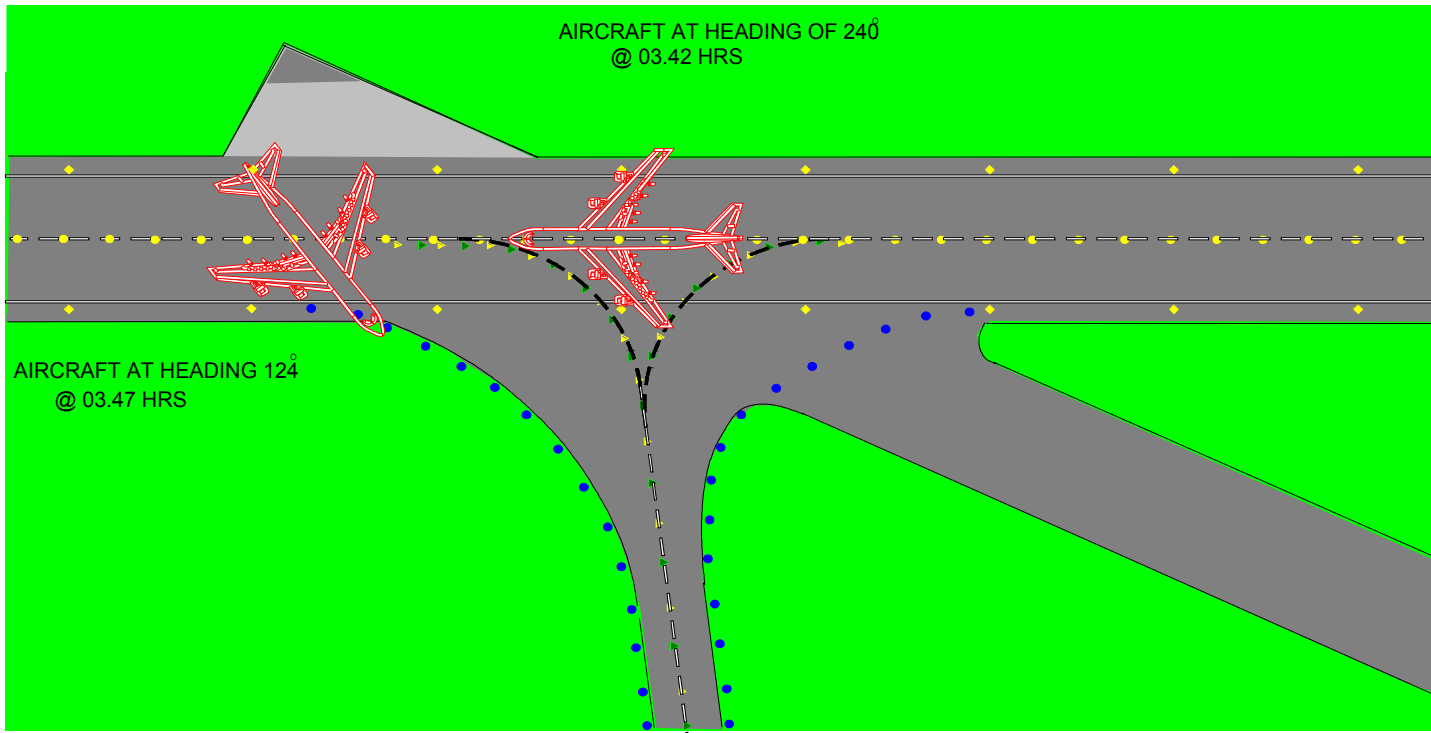
The cause of the No. 2 engine surge during roll-out was probably caused by the migration of the RABS cam pivot bolt in the thrust reverser bleed valve. This would cause the bleed valve to disturb the flow of air through the engine, thus causing the surge.

Conclusions

1. The aircraft crew should not have attempted to execute a 180° turn on Runway 24 at Shannon airport, particularly at night and with the weather conditions prevailing. In the prevailing weather and lighting conditions it would have been more prudent to continue to the end of the runway, turn in the area provided and back track on the runway to turn off at taxiway Alpha.
2. In cutting off the No. 2 engine following the surge during reverse thrust, the Flight Engineer was correct and his action was in accordance with the flying manual.
3. The cause of the failure of the body gear steering to operate could not be confirmed. However, due to its non-operation the aircraft could not have been turned in the paved surface area available at the runway/taxiway Alpha intersection.
4. No evidence was found that the body gear steering system was defective which would have increased the radius of aircraft turn.

Note: This report sustains no recommendations.

ANNEX A



LEGEND

- RUNWAY EDGE LIGHTS
- RUNWAY EDGE MARKINGS
- RUNWAY & TAXIWAY CENTRE-LINE MARKINGS
- RUNWAY CENTRE-LINE LIGHTS
- RUNWAY EDGE LIGHTS
- TAXIWAY CENTRE-LINE LIGHTS

