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ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Aviation Occurrence Investigation – AO-2007-017
Preliminary

Fuel starvation – Jundee Airstrip, WA – 26 June 2007
VH-XUE
Empresa Brasileira de Aeronáutica S.A., EMB-120ER

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Abstract

While passing through 400 ft above ground level on final approach, the aircraft began an uncommanded yaw to the left. The crew decided to go around and on application of power, realised that the left engine had failed. The crew completed the emergency checks, transmitted a PAN call and diverted to Wiluna for a safe landing.

The investigation is continuing.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

History of the flight

On 26 June 2007 at 0639 Western Standard Time[1], an Empresa Brasileira de Aeronáutica S.A., EMB-120ER[2] aircraft, registered VH-XUE, departed Perth, WA, on a contracted charter flight to Jundee[3] Airstrip, WA. There were two pilots, one cabin attendant, and 28 passengers on the aircraft. The co-pilot was the handling pilot for the flight.

The aircraft's flight log for the flight indicated that there was 1,190 kg of fuel on board the aircraft prior to the departure from Perth. That amount included 680 kg residual fuel on board from the previous flight and 511 kg of fuel added immediately before the flight.

The crew reported that the departure, cruise, and descent segments of the flight proceeded normally. The weather was fine, allowing a visual approach to Jundee. The aircraft was established at 5 NM on a straight-in approach to runway 08 and was configured with flap 45 and landing gear down by 700 ft above the runway elevation. The crew reported that engine torque settings were approximately 25 per cent and the airspeed was reducing from 130 kts towards 111 kts, the reference speed for the approach (V_{REF}[4]). They recalled that the aircraft's enhanced ground proximity warning system (EGPWS) sounded '500 feet', in accordance with the normal operation of that system for a visual approach.

The crew reported that a short time later, they noticed a very subtle change in engine sound. Nothing appeared to be abnormal, and they neither heard, nor saw, any cockpit warnings or cautions. The crew said that the engine instruments were difficult to read because of sun glare[5]. The co-pilot noticed that the airspeed was close to V_{REF} and increased engine torque slightly to maintain speed. The crew reported that the aircraft then began to drift left of the runway centreline, and to slowly roll left. The co-pilot applied right control input to bring the aircraft back to the centreline but did not observe any response from the aircraft. He increased the amount of control input but there still appeared to be no response from the aircraft. The pilot in command assessed that the aircraft had reached a position from where a landing could not be achieved so he gave the instruction to go around. At that stage, the aircraft was about 300 ft above the runway elevation.

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1 The 24-hour clock is used in this report to describe the local time of day, Western Standard Time (WST), as particular events occurred. Western Standard Time was Coordinated Universal Time (UTC) + 8 hours.

2 The aircraft type is commonly referred to as a *Brasilia*.

3 Jundee Airstrip consisted of a 2,095 m long gravel runway 08/26 which included a 200 m sealed section at each end. The apron area was adjacent to the runway threshold.

4 V_{REF} is typically 1.3 times the aircraft's stalling speed with the flaps at the landing setting and the engines at idle thrust.

5 According to the Geoscience Australia website, at 0800 WST on 26 June 2007, the sun's position was 54 degrees 55 minutes in azimuth and 13 degrees 32 minutes in elevation.

The crew recalled that, as the pilot in command advanced the engine power levers at the commencement of the go-around, the aircraft yawed and rolled left 'aggressively'. The co-pilot applied right rudder and aileron but was unable to control the aircraft. He informed the pilot in command that he was unable to hold the control inputs, so the pilot in command placed his hands on the control yoke and his feet on the rudder pedals and assisted the co-pilot. Together, they were able to steady the aircraft's flight path, which they estimated at that time to have been approximately 100 ft above ground level, with 30 degrees bank left, and 100 to 111 kts airspeed. The crew reported that the stick shaker activated twice, and that each time they slightly reduced the control yoke back pressure. During that period, the EGPWS warning 'too low terrain' sounded. The co-pilot called for the flaps to be retracted to the 'flaps 25' position. After the pilot in command confirmed that the co-pilot had control, flap 25 was selected. The crew reported that the airspeed slowly began to rise above 111 kts and the left bank started decreasing, although full right aileron and rudder inputs were still required. The crew retracted the flaps to 15 degrees, and the co-pilot was able to return the aircraft to a wings level attitude. The aircraft achieved a positive rate of climb a short time later. The crew then retracted the landing gear.

Both pilots reported noticing during their efforts to regain control of the aircraft that a red master warning caption OIL PRESS (oil pressure) for engine number 1 (the left engine) had illuminated and an amber master caution for FUEL had illuminated on the multiple alarm panel. After the landing gear was retracted, they turned their attention to those warnings. They recalled that, in addition to the OIL PRESS and FUEL warnings, a low pressure light on the overhead fuel panel was illuminated, the white lights for both left electric boost pumps were ON, and the number 1 white engine electronic control (EEC) light was on. The fuel gauges were indicating just over 200 kg per side. The crew then completed the checklist actions for an engine failure in flight. They reported that when the left engine condition lever was placed in the feather position, there was a significant improvement in aircraft performance[6].

The crew reported that they levelled the aircraft at 3,400 ft (the lowest safe altitude). The aircraft was heading in the direction of Wiluna[7] at that stage and, because the runway at Wiluna was sealed, the crew decided to land there. The pilot in command transmitted a PAN[8] emergency message to air traffic control, advising an engine failure and that they were diverting to Wiluna. The crew reported that the landing at Wiluna was uneventful.

Flight recorders

The aircraft was fitted with a digital flight data recorder (DFDR) and a cockpit voice recorder (CVR).

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6 The automatic propeller feathering system did not activate unless three conditions were met. Those were that the torque on both engines was greater than 62 percent, both power lever angles were greater than 62 degrees, and the automatic feathering system was ARMED.

7 Wiluna was approximately 50 km south-west of Jundee.

8 Radio code indicating uncertainty or alert, general broadcast to widest area but not yet at level of MAYDAY.

Preliminary examination of the DFDR data indicated that the data was generally consistent with the account of the event provided by the flight crew. It showed an interruption to the fuel flow to the left engine, and a consequent loss of torque about five seconds later, as the aircraft was below 500 ft above ground level on final approach to Jundee. During the go-around, the aircraft veered left from a heading of about 070 degrees M to about 190 degrees M and its roll attitude exceeded 30 degrees left bank. The right propeller torque limits were exceeded during the go-around. Landing gear position was not a recorded parameter. The preliminary examination also indicated that some of the parameters might contain some spurious data.

The CVR recorded the most recent 30 minutes of crew communications and radio transmissions. Because the aircraft's electrical power supply was operating for greater than 30 minutes after the occurrence, the CVR contained no information of relating to the occurrence.

Examination of aircraft at Wiluna

The operating company dispatched engineers to examine the aircraft. They reported that the cockpit fuel quantity gauges displayed 300 kg (left tank gauge) and 150 kg (right tank gauge). A physical check revealed that the left tank contained no fuel, and the right tank contained 150 kg fuel. Further examination revealed a fault in the outboard-most fuel quantity measurement probe from the left tank (see Fuel quantity indicating system description below).

All fuel probes from the left tank and the wiring loom for the left tank quantity indication system were removed from the aircraft for further examination.

Fuel system maintenance history

According to the aircraft maintenance documents, the aircraft underwent a '4C' maintenance check in late 2006. That check included a check of the fuel quantity indication system on 15 October 2006. No defects of the system were reported as a result of that check.

On 22 October 2006, an inspection of the fuel quantity wiring harness in the area of control cable tension checks was conducted with no defects found. Between that date and this occurrence, only one fuel quantity indication system defect was recorded. That was written up as 'fuel totaliser indicating incorrectly'. The record indicated that the fault was rectified by replacing the totaliser.

Fuel quantity indicating system

The aircraft was equipped with an electrical capacitance type fuel quantity indicating system. Each wing was fitted with six capacitive type fuel sensor units or probes. There were four fuel sensor probes in each outboard tank, and two in each inboard tank. The systems for each wing were identical and independent.

Two cockpit fuel quantity indicators, one for each wing, displayed, in kilograms, the total fuel quantity in the corresponding wing (Figure 1). A fuel totaliser display was positioned immediately above the fuel quantity indicators. It displayed digitally

the total amount of fuel used or the total amount remaining, depending on the function selected by the flight crew.

Figure 1: Fuel indicating panel in the cockpit centre console instrument group.

The aircraft was also equipped with dripless measuring sticks (sometimes referred to as ‘magna sticks’) that enabled the manual measurement of the fuel quantity in each wing. There were three dripless measuring sticks for each outboard tank, and one for each inboard tank. The dripless stick system consisted of a magnet floating on the surface of the fuel in the tank and a calibrated stick. The sticks were unlocked via access points on the lower surface of the wing and allowed to lower until the floating magnet attracted the upper end of the stick (Figure 2). That enabled the level of the fuel to be determined. A conversion table carried on the aircraft was used to convert the value indicated on the stick to fuel tank quantity in kg. Accurate quantity measurement using the dripless sticks required the aircraft to be laterally level.

Figure 2: Showing a dripless stick in the lowered position, indicating 2.8 on the measurement scale.

Fuel quantity measurement procedures

Civil Aviation Order (CAO) 20.2, paragraph 6.1 stated:

> The operator of an aircraft having a maximum take-off weight of more that 5 700 kg and engaged in commercial operations must ensure that the operations manual contains instructions and procedures for the pilot in command of the aircraft to verify the quantity of fuel on board the aircraft before flight.
>
> *Note* See Airworthiness Bulletin 28-002 for advice on instructions and procedures that may be adopted to verify the quantity of fuel on board an aircraft before flight.

Airworthiness Bulletin 28-002 dated 15 May 2006 stated the following:

> Unless assured that the aircrafts tanks are completely full, or a totally reliable and accurately graduated dipstick, sight gauge, drip gauge or tank tab reading can be done, the pilot should endeavour to use the best available fuel quantity cross-check prior to starting. The cross-check should consist of establishing the fuel on board by at least two different methods, such as:
>
> 1. Check of visual readings (tab, dip, drip, sight gauges against electrical gauge readings); or
> 2. Having regard to previous readings, a check of electrical gauge or visual readings against fuel consumed indicator readings; or
> 3. After refuelling, and having regard to previous readings, a check of electrical gauge or visual readings against the refuelling installation readings; or

4. Where a series of flights is undertaken by the same pilot and refuelling is not carried out at intermediate stops, cross-checks may be made by checking the quantity gauge readings against computed fuel on board and/or fuel consumed indicator readings, provided the particular aircrafts fuel gauge system is known to be reliable.

The operator published fuel quantity checking procedures in its Brasilia Flight Operations Manual. Those procedures were as follows:

> Prior to flight, a check of the total fuel on board must be carried out by two separate methods. The difference between these two checks shall be less than 60 kg.
>
> Acceptable methods of cross checking fuel for the [Operator's] Brasilia are:
>
> • Check of magna stick readings against electrical gauge readings; or
>
> • Having regard to previous readings, a check of electrical gauge or magna stick readings against fuel consumed indicator readings; or
>
> • After refuelling, and having regard to previous readings, a check of electrical gauge or magna stick readings against the refuelling installation readings; or
>
> • Where a series of flights is undertaken by the same pilot and refuelling is not carried out at intermediate stops, cross-checks may be made by checking the quantity gauge readings against computed fuel on board and/or fuel consumed indicator readings, provided the particular aircrafts fuel gauge system is known to be reliable.
>
> The APU [auxiliary power unit] burn allowance of 58 kg per hour may be considered when making the fuel cross check.
>
> When using the magna sticks, significant variations may occur if the aircraft is not level. A check of level may be made on the EADI. A pitch of ± 2° is allowable. The recommended practice when using the magna sticks is the [sic] take the reading then immediately return the stick to the locked position.

The investigation interviewed pilots from the operator regarding the processes they used to cross-check the fuel quantity prior to flight. Several of the pilots reported that their checks involved comparing the electrical gauge readings after refuelling with the gauge readings prior to refuelling plus the fuel added during refuelling.

Flight crew

The pilot in command held an airline transport pilot (aeroplane) licence. His total flying experience was 3,010 hours, of which 540 hours were on EMB 120ER aircraft.

The copilot held a commercial pilot (aeroplane) licence. His total flying experience was 1,620 hours, of which 1,310 hours was on EMB 120ER aircraft.

Ongoing investigation activities

The ongoing investigation will include the following:

- examination and testing of the fuel quantity indicating system components

- examination of maintenance activities involving the fuel quantity indicating system
- examination of flight logs for all flights undertaken by the aircraft since the last calibration of the fuel quantity indicating system
- examination of fuel quantity measurement and cross checking practices and procedures of the operator involved in the occurrence, and other Australian Brasilia operators
- the design and functionality of the fuel quantity management of company flight logs
- standardisation of fuel quantity management practices of company pilots
- refinement of the recorded flight data
- examination of the flight crew's handling of the aircraft during the occurrence
- flight crew training practices, facilities and requirements relevant to the occurrence.

SAFETY ACTION

Aircraft operator

On 1 July 2007, the operator amended its fuel quantity management procedures to require:

- a dripless stick reading to be carried out each day and for the results to be recorded on the flight log
- auxiliary power unit (APU) fuel burn to be recorded on the flight log
- the aircraft to be placed unserviceable and engineering assistance requested if dripless stick readings differed from the fuel gauge readings by more than 3 percent
- all flight logs to be checked on a daily basis
- the conversion factor for Jet A1 fuel to be changed from 0.8 kg per litre to 0.785 kg per litre.

Civil Aviation Safety Authority

On 3 July 2007, the Civil Aviation Safety Authority issued a series of directions to the operator which addressed fuel quantity measurement procedures and flight crew training.

The Civil Aviation Safety Authority is also intending to review Airworthiness Bulletin 28-002 to ensure that there is no ambiguity in relation to what are appropriate independent processes for fuel quantity checks

ATSB Safety Action

Background information

In addition to the occurrence involving VH-XUE, the ATSB is aware of two other occurrences since January 2005 involving engine power loss due to fuel starvation in turbo-prop aircraft with a maximum take-off weight (MTOW) above 5,700 kg. In each case, the practices used by the flight crew did not detect erroneous fuel quantity indications. The operators involved subsequently amended their procedures to include dripstick checks as a mandatory part the procedures for establishing the quantity of fuel on board the aircraft.

It is possible that there are other examples among turbo-prop operators of aircraft with a MTOW greater than 5,700 kg where the procedures used to determine the quantity of fuel on board the aircraft do not include independent comparative checks of fuel quantity.

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The ATSB suggests that all turboprop operators take note of the following safety issue and review their processes accordingly:

> The processes used by some turboprop operators for checking the fuel quantity on board prior to flight have not used two methods of sufficient independence. In particular, the practice of using a comparison of a gauge indication after refuelling with the gauge indication prior to refuelling plus the fuel added is not adequate to detect gradually developing errors in gauge indications.