



**Australian Government**

**Australian Transport Safety Bureau**

**ATSB TRANSPORT SAFETY REPORT**

Aviation Occurrence Investigation – AO-2007-017

Final

**Fuel starvation**

**Jundee Airstrip, WA – 26 June 2007**

**VH-XUE**

**Empresa Brasileira de Aeronáutica S.A., EMB-120ER**





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**EMB-120ER**

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# CONTENTS

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<b>EXECUTIVE SUMMARY .....</b>	<b>ix</b>
<b>THE AUSTRALIAN TRANSPORT SAFETY BUREAU .....</b>	<b>xiv</b>
<b>1 FACTUAL INFORMATION .....</b>	<b>1</b>
1.1 History of the flight .....	1
1.2 Injuries to persons.....	7
1.3 Damage to aircraft .....	7
1.4 Personnel information.....	7
1.4.1 Pilot in command .....	7
1.4.2 Copilot .....	8
1.5 Aircraft information.....	8
1.5.1 Instrument panel layout .....	8
1.5.2 Cockpit alarm and indications .....	9
1.5.3 Engine instruments .....	10
1.5.4 Indications in the event of fuel starvation.....	11
1.5.5 Fuel quantity indicating system .....	12
1.5.6 Fuel totaliser .....	13
1.5.7 Dripless measuring sticks .....	14
1.5.8 Fuel low-level warning system .....	15
1.5.9 Fuel system maintenance history .....	15
1.5.10 Examination of the fuel quantity indicating system.....	16
1.6 Meteorological information.....	17
1.6.1 Local weather conditions .....	17
1.6.2 Sun position information .....	17
1.7 Aids to navigation.....	17
1.8 Communications .....	17
1.9 Aerodrome information .....	18
1.10 Flight recorders.....	18
1.11 Tests and research.....	20
1.11.1 Flight simulator replication of the occurrence by other pilots .....	20
1.12 Fuel quantity measurement processes.....	20
1.12.1 Regulatory requirements and guidance.....	20
1.12.2 Operator’s fuel quantity measurement procedures .....	22
1.12.3 Use of flight logs.....	23

1.12.4	Refuelling to a known quantity.....	24
1.12.5	Discrepancies between recorded and actual fuel quantities.....	24
1.12.6	Cross-checks of total fuel quantity at departure .....	25
1.12.7	Residual fuel quantity variations between days.....	25
1.12.8	Use of dripless measuring sticks.....	26
1.12.9	Recording of fuel used by maintenance personnel .....	26
1.12.10	Auditing of fuel use and recording practices .....	26
1.13	Related fuel quantity occurrences.....	27
1.13.1	Previous EMB-120 occurrence in Australia (14 January 2005).....	27
1.13.2	Other EMB-120 fuel-related occurrences .....	27
1.13.3	Other fuel-related occurrences.....	28
1.14	Communication of important safety information to the industry .....	28
1.15	Operational procedures.....	29
1.15.1	Crew resource management.....	29
1.15.2	Procedures for go-around.....	30
1.15.3	Procedures for operations on unpaved surfaces.....	31
1.16	Flight crew endorsement and line training requirements.....	32
1.16.1	Regulatory requirements.....	32
1.16.2	Operator's requirements .....	32
1.16.3	Other EMB-120 operators training requirements .....	33
1.17	Flight simulators .....	34
1.17.1	Background.....	34
1.17.2	Australian regulatory requirements.....	34
1.17.3	Overseas regulatory requirements.....	35
1.17.4	Use of simulators by Australian regional operators of turboprop aircraft with 19 seat or greater capacity .....	36
1.17.5	Transport category turboprop aircraft simulators in Australia.....	37
1.18	Recent serious occurrences involving transport category turboprop aircraft in Australia where aircraft handling was a factor.....	38
<b>2</b>	<b>Analysis.....</b>	<b>39</b>
2.1	Overview .....	39
2.2	Fuel quantity indicating system faults .....	39
2.3	Fuel quantity measurement.....	40
2.3.1	Regulatory guidance .....	40
2.3.2	Operators procedures and practices for fuel quantity check.....	41

2.3.3	Auditing of flight log fuel records .....	41
2.3.4	Fuel low level warning system .....	42
2.4	Flight crew performance.....	42
2.5	System for communicating important occurrence information to operators .....	43
<b>3</b>	<b>FINDINGS.....</b>	<b>45</b>
3.1	Contributing safety factors .....	45
3.2	Other safety factors.....	45
<b>4</b>	<b>SAFETY ACTIONS.....</b>	<b>47</b>
4.1	Aircraft operator .....	47
4.1.1	Fuel measuring procedures .....	47
4.1.2	Pilots inadequately prepared for event.....	47
4.2	Civil Aviation Safety Authority.....	48
4.2.1	Fuel measuring procedures .....	48
4.2.2	Regulatory guidance for fuel quantity measurement .....	50
4.2.3	No regulation for simulator training .....	51
4.2.4	Requirements for endorsement training.....	53
4.2.5	Dissemination of safety information.....	53
4.2.6	Other safety action taken by the Civil Aviation Safety Authority.....	54
4.3	Aircraft certification authorities .....	54
4.3.1	Fuel low level warning .....	54
4.4	Aircraft manufacturer .....	55
4.4.1	Dissemination of safety information.....	55
4.4.2	Other safety action taken by the aircraft manufacturer.....	55
4.5	Ansett Aviation Training .....	57
4.5.1	No EMB-120 flight simulator training facility in Australia.....	57

<b>APPENDIX A:</b>	<b>FUEL LOW LEVEL WARNING SYSTEMS: PREVIOUS OCCURRENCES AND RECOMMENDATIONS.....</b>	<b>59</b>
<b>APPENDIX B:</b>	<b>FUEL STARVATION-RELATED OCCURRENCES INVOLVING AUSTRALIAN REGISTERED AIRCRAFT OTHER THAN EMB-120 AIRCRAFT SINCE JANUARY 2005</b>	<b>63</b>
<b>APPENDIX C:</b>	<b>RECENT SERIOUS OCCURRENCES INVOLVING TRANSPORT CATEGORY TURBOPROP AIRCRAFT IN AUSTRALIA WHERE AIRCRAFT HANDLING WAS A FACTOR.....</b>	<b>67</b>
<b>APPENDIX D:</b>	<b>EMBRAER SERVICE NEWSLETTER .....</b>	<b>73</b>
<b>APPENDIX E:</b>	<b>SOURCES AND SUBMISSIONS.....</b>	<b>75</b>

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### Abstract

On 26 June 2007 at 0639 Western Standard Time, an Empresa Brasileira de Aeronáutica S.A. EMB-120ER aircraft, registered VH-XUE, departed Perth, WA on a contracted passenger charter flight to Jundee Airstrip. There were two pilots, one flight attendant, and 28 passengers on the aircraft.

While passing through 400 ft above ground level on final approach to Jundee Airstrip, with flaps 45 set, the aircraft drifted left of the runway centreline. When a go-around was initiated, the aircraft aggressively rolled and yawed left, causing the crew control difficulties. The crew did not immediately complete the go-around procedures. Normal aircraft control was regained when the landing gear was retracted about 3 minutes later.

The left engine had sustained a total power loss following fuel starvation, because the left fuel tank was empty. The investigation identified safety factors associated with the fuel quantity indicating system, the ability of the crew to recognise the left engine power loss, and their performance during the go-around. There were clear indications that the operator's fuel quantity measurement procedures and practices were not sufficiently robust to ensure that a quantity indication error was detected. The failure of that risk control provided the opportunity for other safety barriers involving both the recognition of, and the crew's response to, the power loss, to be tested. Organisational safety factors involving regulatory guidance, the operator's procedures, and flight crew practices were identified in those two areas. The operator introduced revised procedures for measuring fuel quantity and the Civil Aviation Safety Authority (CASA) initiated a project to amend the guidance to provide better clarity and emphasis.

The crew's endorsement and other training did not include simulator training and did not adequately prepare them for the event. There was no EMB-120 flight simulator facility in Australia and no Australian regulatory requirement for simulator training. In March 2009, an EMB-120 flight simulator came into operation in Melbourne, Vic. A workshop and discussion forum was conducted on 27 to 28 April 2009 for Australian Embraer 120 aircraft operators. All those operators were expected to commence utilising the simulator for flight crew endorsement training following that workshop.

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## EXECUTIVE SUMMARY

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On 26 June 2007 at about 0806 Western Standard Time, an Empresa Brasileira de Aeronáutica S.A. EMB-120ER (EMB-120ER) aircraft, registered VH-XUE, on a contracted passenger charter flight to Jundee Airstrip, WA almost impacted terrain after the crew lost normal control of the aircraft when they initiated a go-around at about 300 ft above ground level (AGL) on final approach at Jundee Airstrip. On board the aircraft were two pilots, one flight attendant, and 28 passengers.

The aircraft was in the landing configuration at the time, and the decision to go around was taken because the aircraft had become misaligned with the runway on late final approach. Unknown to the crew was the fact that the left engine had ceased operating a short time earlier. When the crew advanced the engine power levers to commence the go-around, they were startled when the aircraft yawed and rolled left aggressively in response to the engine power asymmetry. The copilot, who was the handling pilot, felt that he could not control the aircraft and asked the pilot in command to assist him on the controls. That situation, along with the aircraft's proximity to the ground, appeared to have distracted the crew to the extent that they did not complete all of the essential go-around procedures. As a result, the landing gear and flaps were not configured correctly until much later in the go-around sequence. The recorded performance of the aircraft during the go-around indicated that the avoidance of a collision with terrain was fortuitous with the altitude of the aircraft decreasing to 50 ft AGL at its lowest point.

The crew recalled that they had noticed during the go-around, the red master warning captions for oil pressure for the left engine, and a fuel master caution. After the landing gear had retracted, they turned their attention to those captions and saw that other captions, concerning the left engine, were also illuminated. They observed that the fuel quantity gauges were indicating just over 200 kg per side. The crew then completed the 'engine failure in-flight' actions. They reported that there was an immediate and significant improvement in aircraft performance when the left engine condition lever was placed in the feather position.

At that stage, the aircraft was heading in the approximate direction of Wiluna, about 30 km south-west of Jundee. The crew elected to continue in that direction and conducted a single-engine landing at Wiluna.

When the aircraft was examined at Wiluna, the right fuel gauge was indicating 150 kg and the left gauge 300 kg. A physical check revealed that the right tank contained 150 kg of fuel and that the left tank was empty. The aircraft's flight log indicated that there was 1,190 kg of fuel on board prior to the departure from Perth. Normal fuel consumption for the flight Perth to Jundee was in the range 750 - 900 kg, depending on atmospheric conditions.

The investigation focused on two main aspects – fuel quantity management and aircraft handling.

### ***Fuel quantity management***

Examination of the aircraft revealed that the outboard capacitance probe in the left tank quantity indicating system had failed. Abrasive damage found on the probe wiring loom, where it had rubbed against the airframe, had allowed electrical short circuiting, resulting in the failure of the probe.

The aircraft was not equipped with a fuel low-level warning system. However, it was fitted with dripless measuring sticks that provided a totally reliable means of validating the fuel quantity on board the aircraft before flight.

From the examination of the operator's flight logs, there were instances where significant discrepancies between the recorded fuel at shutdown from the previous day and the indicated fuel quantity before refuelling the following day, were apparently ignored by flight crew. Use of the dripless measuring sticks by flight crew to validate fuel quantity had been recorded in flight logs on only two occasions between 1 April and 25 June 2007.

There was evidence that flight crews did not have a proper understanding of the reasoning behind the fuel quantity check procedures, and the necessity for an independent validation of the fuel quantity by a totally reliable method. That situation resulted in a culture existing amongst crews of undue reliance being placed on the accuracy and reliability of the EMB-120 fuel quantity indicating system.

The Civil Aviation Safety Authority (CASA) published Civil Aviation Advisory Publication (CAAP) 234-1(1), which contained guidance regarding the establishment of fuel quantity before flight. In broad terms, the CAAP allowed two options for establishing fuel on board:

- full tanks, or 'a totally reliable and accurately graduated dipstick, sight gauge, drip gauge or tank tab reading'; or
- a cross-check by at least two different methods.

The CAAP did not clearly indicate whether, or why, one option had advantages, or was preferred, over the other. The CAAP, in effect, allowed operators to choose the method that suited, or perhaps was most convenient, to them. Because of operational considerations, many aircraft, including the EMB-120, were rarely operated with full tanks. The use of one of the 'totally reliable' methods such as a drip gauge (or dripstick in the case of the EMB-120) was not generally favoured by operators because those methods were seen as time consuming and, for best accuracy, necessitated the aircraft being on a level surface.

Two of the acceptable fuel quantity cross-check methods contained in the CAAP involved comparing the change in electrical gauge readings with a quantity determined independently, either from a fuel consumed indicator, or from a refuelling installation. The operator of the EMB-120ER used the latter method which, with regard to the subject occurrence, did not detect the fuel quantity error before the flight to Jundee. In fact, neither method would ensure detection of a fuel quantity error in cases where a gauge was under or over-reading by a constant amount, or when there was a gradually increasing error.

The purpose of procedures for flight crew to follow to establish the quantity of fuel on board was to provide assurance regarding the accuracy of the fuel quantity indicating system and that the correct amount of fuel was on board for the flight. Technical failures, such as fuel quantity indicating system malfunction, are unavoidable, and occur from time to time. Flight crew procedures and checks are intended to provide an additional layer in the safety system in the event of a technical failure. For that layer to be effective, those procedures and checks must be well designed, fully understood, and properly conducted by the users. In this occurrence, none of those criteria were present. Unambiguous guidance regarding

the importance of employing a ‘totally reliable’ method of establishing or validating fuel quantity, and more robust flight crew procedures and practices, are required to provide an appropriate level of assurance regarding fuel quantity measurement.

In addition to the occurrence involving the EMB-120ER, the ATSB is aware of three other occurrences since January 2005 involving Australian-registered turbojet or turboprop aircraft experiencing engine power loss due to similar fuel related problems. They included a Fairchild Metro III on 23 September 2005 (ATSB Report BO/200504768), a Boeing 747-338 on 5 February 2007 (ATSB Report BO/200700368), and a Cessna C404 Titan on 18 October 2007 (ATSB Report AO-2007-049). In each case, the practices used by the flight crew to establish fuel quantity before flight did not detect erroneous fuel quantity indications. The operators involved subsequently amended their procedures to include physical (e.g. dripstick) checks as a mandatory part of the procedures for establishing the quantity of fuel on board the aircraft.

It is possible that there are other examples among operators of aircraft where the procedures used to determine the quantity of fuel on board the aircraft do not provide an appropriate level of safety assurance. The CASA has initiated a project to amend the CAAP guidance to provide better clarity and emphasis.

### ***Aircraft handling***

There were a number of facets of the crew’s performance that led to the mishandling of the aircraft during the go-around:

- The crew did not detect the loss of fuel flow to the engine, or the engine power loss. Neither crew member had been exposed to an engine power loss situation on late final approach, either in training or during line operations.
- The crew did not keep the aircraft aligned with the runway during the approach. It is probable that more positive input of the flight controls would have allowed the aircraft to be kept aligned with the runway. However, the pilot flying was likely to have manipulated the controls in the manner and to the extent that he had become accustomed to during normal operations. In the asymmetric situation that arose, in what was at the time a novel situation, such a technique was unlikely to have been successful.
- The crew did not properly execute the go-around procedure. The behaviour of the aircraft after the flight crew increased power to go around was, from their perspective, abnormal and without reason or warning. It was likely that the aircraft’s behaviour alarmed and focused each crew member to the extent that they were unable to function effectively as a unit in the areas of decision making and task sharing.
- There was a delay in the crew’s diagnosis of the situation. The aircraft was at or near the limits of its performance envelope for a significant period after the go-around was initiated.

The quality of the crew’s performance depended largely on their ability to recognise the engine power loss, and to respond to the situation by functioning effectively as a team.

The regulatory requirements for endorsement allow training solely in the aircraft, or a mix of training in a flight simulator and the aircraft. For pilot in command, the requirements were:

- flying training was to include at least 5 hours flying time in conformity with specified criteria involving general handling, takeoff, instrument flying, asymmetric flight, and night flying, plus
- at least 50 hours flight time as pilot in command under supervision; or
- 25 hours flight time as pilot in command under supervision, and the successful completion of an approved training course in an approved synthetic trainer.

In the case of a copilot, the syllabus was to include at least 3 hours flying time, which was to cover takeoff, medium and steep turns, asymmetric flight, night flying and general handling.

The EMB-120 type endorsement training the pilot and copilot had received, was conducted solely on the aircraft and did not include any simulator training. For their type endorsement, they each completed about 7 hours flight time, followed by 50 hours line training. The pilot in command completed a further 6 hours flight time plus 83 hours in command under supervision for his command endorsement. In terms of flight time, therefore, their training had exceeded the extant regulatory requirements.

For important safety reasons, training in many sequences involving critical in-flight emergency situations, can only be conducted in a flight simulator. Among the most important of those situations are those involving an engine malfunction at a critical stage of flight. The only means of safely conducting such training is in a flight simulator.

Typically, EMB-120 endorsement training utilising a flight simulator involved 20 hours simulator time, plus 2 hours aircraft time. Because simulator training exercises are conducted on a crew basis, trainees, in effect, receive 40 hours simulator training time. Importantly, in addition to being exposed to the full range of emergency situations, pilots are able to practice crew coordination in those situations.

At the time of the occurrence, there was no EMB-120 flight simulator in Australia. There were EMB-120 simulators in Europe and the US. However, significant time and costs were involved for Australian operators to utilise those overseas facilities. As a result, EMB-120 type training in Australia was conducted by each operator 'in house', and solely on the aircraft. The only training for sequences that could not be safely conducted in the aircraft during flight was via class room or cockpit discussion.

The crew of XUE had never been exposed to an engine failure on late final approach in the landing configuration. They were, therefore, confronted by a novel situation on approach to Jundee and, arguably, were not equipped to respond effectively in terms of either aircraft handling or crew coordination.

A similar argument would apply to many other possible emergency situations that could occur in the EMB-120 aircraft, and other sophisticated multi-engine aircraft. In that regard, the operator was probably no different to many other Australian operators of turboprop aircraft, where similar deficiencies were likely to have been present when flight crew training did not include any flight simulator training.

In March 2009, an EMB-120 flight simulator was commissioned in Melbourne, Vic. Subsequently, under the guidance of CASA, all Australian EMB-120 operators

began conducting flight crew endorsement, and some recurrent, training in the simulator.

Since 1995, the ATSB has investigated four serious occurrences, in addition to the subject occurrence, in which aircraft handling following actual or simulated engine failures was a factor. Three of those occurrences, one of which involved two fatalities, occurred during simulated engine failure training exercises. They were:

- Fairchild Industries Inc SA227-AC, VH-NEJ, Tamworth, NSW 16 September 1995 (Investigation Report 9503057),
- Fairchild Industries SA227-AC Metro III, VH-TAG, 33km ENE Canberra, ACT 21 November 2004 (Aviation Occurrence Report 200404589), and
- Beech 1900D Airliner, VH-NTL, Williamtown, NSW 13 February 2000 (Aviation Safety Report BO/2000000492)

The fourth occurrence involved Beech Aircraft Corporation King Air C90, VH-LQH, Toowoomba, Qld on 27 November 2001, in which the pilot and three passengers were killed following an actual engine failure on takeoff (Aviation Occurrence Report 200507077).

There appears to be a gap between the quantity and quality of training that can be achieved via the minimum endorsement requirements when simulator training is not used, compared to that which can be achieved when a simulator is used. Given the complexity of modern transport category aircraft and the benefits of simulator training, the ATSB considers that in cases where a flight simulator is available in Australia, then it should be mandated for endorsement training. The ATSB issued a recommendation to CASA to take action to address that safety issue.

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# THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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

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](http://www.atsb.gov.au).

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# 1 FACTUAL INFORMATION

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## 1.1 History of the flight

On 26 June 2007 at 0639 Western Standard Time<sup>1</sup>, an Empresa Brasileira de Aeronáutica S.A. EMB-120ER<sup>2</sup> aircraft, registered VH-XUE, departed Perth, WA on a contracted passenger charter flight to Jundee Airstrip. There were two pilots, one flight attendant, and 28 passengers on the aircraft. At 0806, on final approach for runway 08 (runway heading 082° M) at Jundee, the left engine sustained a total power loss due to fuel starvation. The crew, unaware of the power loss, elected to conduct a go-around at about 300 ft above ground level (AGL) because of difficulties in maintaining alignment with the runway centreline. During the go-around, the crew experienced significant difficulty in controlling the aircraft's attitude and airspeed and reported that the stick shaker<sup>3</sup> activated on two occasions before they regained control of the aircraft. The minimum altitude of the aircraft during the go-around was about 50 ft AGL. After regaining control of the aircraft, the crew diverted to Wiluna, which was located 42 km south-west of Jundee.

In subsequent interviews, the crew recalled that the departure, cruise, and descent segments of the flight proceeded normally. The weather was fine, and the crew elected to conduct a straight-in approach to Jundee. The copilot was the handling pilot for the flight.

Table 1 provides the sequence of events associated with the approach and go-around at Jundee. The information was obtained from the aircraft's Digital Flight Data Recorder (DFDR), and is supplemented from information obtained from interviews with the crew (in italics). Additional information regarding warning and alarm signals not recorded on the DFDR, but predicted from flight simulation testing, is included [in square brackets].<sup>4</sup> Because the aircraft's electrical power was operating for greater than 30 minutes after the occurrence, the cockpit voice recorder contained no information of relevance to the occurrence.

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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 A stick shaker is a mechanical device connected to the control yoke to warn the flight crew that the aircraft is close to aerodynamically stalling.

4 The triggering of the various warning and alarm signals associated with the performance of the number-1 engine was not recorded and it was not clear from the engine performance data when the various warnings and alarms would have been displayed to the crew. At the request of the Australian Transport Safety Bureau (ATSB), further investigation was undertaken by the aircraft manufacturer in an EMB-120 flight simulator to determine the sequence and timing of caution and warning activations that the crew should have received during the engine power loss under the in-flight conditions that pertained at the time. That detail provided by the manufacturer is included in the sequence of events table and denoted by underlined text. The warning and caution system is described in Section 1.6.

**Table 1: Sequence of events<sup>5</sup>**

Approx local time	Altitude, Airspeed	Event
0754:51		Aircraft at top of descent (flight level 250).
0804:05	4,125 ft 198 kts	Flap 15 selected. <i>The crew reported that landing gear was selected down just after the flap 15 selection.</i>
0805:38	2,678 ft 142 kts	Flap 25 selected.
0806:05	2,493 ft 128 kts	Flap 45 selected. Torque for both engines increased from below 20% to about 40%. <i>The crew reported that when the copilot called for flap 45, the pilot in command called out that the reference speed for the approach (Vref) was 111 kts. The operator's procedures required that flap 45 be used for all landings to unsealed runways, which included Jundee (see Section 1.20.3).</i>
0806:05	2,416 ft 124 kts	Flaps reached 45-degree position. Left engine torque decreased to about 30%, right engine torque remained at about 38%. <i>The crew reported that the aircraft was configured for landing and that the 'Before Landing' checklist was completed at about 700 ft AGL.</i>
0806:16	2,344 ft 120 kts	Aircraft descended through 500 ft above runway elevation. <i>The crew reported that, at 500 ft AGL, the aircraft's enhanced ground proximity warning system (EGPWS) sounded '500 feet', in accordance with the normal operation of that system. The copilot (as handling pilot) called out 'visual – continue' in accordance with normal procedures for a visual approach. The pilot in command estimated that the wind at the time was 15 kts from 040 degrees. He also recalled noting around that time that the left fuel gauge indicated about 200 kg and the right about 250 kg.</i>

<sup>5</sup> The listed time for each event is approximate only. However, the elapsed time between events is based on recorded flight data. Airspeed figures refer to calibrated airspeed. Altitude figures were adjusted from the recorded pressure altitude by considering the recorded altitude on landing at Wiluna, and assuming that the air pressure at Jundee airstrip (1,845 ft above mean seal level (AMSL)) and Wiluna (1,649 ft) was the same. Other parameters have been rounded to the nearest whole number. Fuel flow was recorded in pounds / hour and was converted to kg / hour for the purposes of this table. Landing gear position, thrust lever positions, fuel quantity and cockpit alerts and cautions were not recorded.

0806:24	2,279 ft 117 kts	<p>Left engine torque increased to about 40%. Right engine torque remained stable at about 38%.</p> <p><i>The copilot recalled that shortly after the 500 ft call he noticed a subtle change in the engine sound. He discerned that, although the engine instrument displays were difficult to read because of sun glare (see also Section 1.6.3 Engine instrument panel), the engine parameters all appeared normal and the left and right gauge pointers were relatively symmetrical. The aircraft was on profile for the approach, but as the airspeed was decreasing towards Vref, he increased power to maintain speed.</i></p> <p><i>The pilot in command recalled noting that the copilot made a few control corrections for the crosswind and that everything appeared normal.</i></p>
0806:29	2,229 ft 114 kts	<p>Left engine power loss. Left engine fuel flow decreased from 207 kg / hour to 21 kg / hour 6 seconds later. Left engine torque decreased from 42% and reached 0% 5 seconds later. Right engine fuel flow and torque remained unchanged.</p> <p><u>[Predicted events:</u></p> <ul style="list-style-type: none"> <li>- <u>amber FUEL light on multiple alarm panel (MAP)</u></li> <li>- <u>amber left LOW PRESS light on overhead fuel feed panel</u></li> <li>- <u>left fuel pump ON lights on fuel feed panel began flashing</u></li> <li>- <u>amber MASTER CAUTION light on glareshield panel and associated single chime]</u></li> </ul> <p><i>The crew did not recall seeing or hearing any cockpit warnings or cautions before commencing the go-around (at 0806:35). The copilot recalled that the aircraft began to drift left of the runway centreline, and to slowly roll left. He thought this may have been because the wind had changed. He applied right control input to bring the aircraft back to the centreline but did not observe any response from the aircraft. He then increased the amount of control input, but there still appeared to be no response from the aircraft. The pilot in command recalled that the aircraft was drifting left of the runway centreline at this time.</i></p>
0806:33	2,141 ft 110 kts	<p>Aircraft descended through 300 ft above runway elevation.</p> <p><u>[Predicted events:</u></p> <ul style="list-style-type: none"> <li>- <u>amber ELEC light on MAP</u></li> <li>- <u>amber left GEN BUS OFF light on overhead electrical panel</u></li> <li>- <u>amber MASTER CAUTION light on glareshield panel and associated single chime]</u></li> </ul>

		<i>The crew recalled that the copilot advised the pilot in command that he could not bring the aircraft back to the centreline and he suggested that they go around. The pilot in command assessed that the approach was not stabilised at 300 ft in accordance with the operator's stabilised approach criteria (see Section 1.20.3), so he called for a go-around.</i>
0806:35	2,130 ft 110 kts	Go-around initiated. Right engine torque began to increase. Aircraft began to roll left.  <i>The crew recalled that, as the copilot advanced the engine power levers at the commencement of the go-around, the aircraft yawed and rolled left 'aggressively' before the copilot could complete the standard call ('Going round, set power, flaps 15; see Section 20.2). The copilot 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. The pilot in command placed his hands on the control yoke and his feet on the rudder pedals and assisted the copilot.</i>
0806:38 to 0806:39		[Predicted events: <ul style="list-style-type: none"> <li>- <u>red EEC(engine electronic control) 1 light on glareshield panel</u></li> <li>- <u>white MANUAL light on overhead EEC panel</u></li> <li>- <u>red MASTER WARNING light on glareshield panel</u></li> <li>- <u>triple chime followed by ENGINE CONTROL voice message</u></li> <li>- <u>red OIL PRESS 1 light on MAP</u></li> <li>- <u>red master WARNING light on glareshield</u></li> <li>- <u>triple chime followed by 'OIL' voice message]</u></li> </ul>
0806:39	2,084 ft 109 kts	Right engine torque reached 125%. Roll attitude 7 degrees left. Aircraft heading started to diverge left from 079° M.  <i>At some stage during the go-around, the crew noticed 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 MAP.</i>
0806:42	2,065 ft 107 kts	Altitude temporarily stabilised at about 220 ft above runway elevation (until 0806:39). Roll attitude 13 degrees left. Heading 073° M.
0806:48	2,065 ft 103 kts	Right engine torque reached 150%. Two seconds later it decreased, reaching 130% by 0806:33. It remained in the range 125 to 130% until 0807:47. Roll attitude 16 degrees left. Heading 061° M.
0806:59	2,085 ft 96 kts	Flap 25 selected. Roll attitude 34 degrees left. Heading 014° M.

		<p><i>After deciding that aircraft control was stabilised, the copilot called for the flaps to be retracted to the 'flaps 25' position.</i></p> <p><i>The pilot in command reported that he selected flap 25 after confirming that the copilot had control of the aircraft.</i></p>
0807:00	2,068 ft 97 kts	Altitude started to decrease again. Roll attitude 35 degrees left. Heading 004° M. Pitch attitude had reached 9 degrees nose-up.
0807:02	2,053 ft 100 kts	<p>Roll attitude reached maximum value (40 degrees left). Heading 346° M. Pitch attitude 1 degree nose-up.</p> <p><i>The crew recalled that the stick shaker activated twice during the go-around, and that each time they slightly reduced the control yoke back pressure to remove the warning. The EGPWS warning 'too low terrain' also sounded at some time during the go-around.</i></p>
0807:05	1,990 ft 103 kts	Flaps reached 25° position. Roll attitude 37 degrees left. Heading 319° M.
0807:10	1,898 ft 105 kts	Aircraft reached lowest altitude, equivalent to about 50 ft above runway elevation. Altitude increased in subsequent seconds. Roll attitude 14 degrees left. Heading 285° M. Pitch attitude 9 degrees nose-up.
0807:20	2,009 ft 95 kts	Airspeed reached lowest recorded value (95 kts). Roll attitude 7 degrees left. Heading 272° M. Pitch attitude reached highest value (12 degrees nose-up).
0807:56	2,089 ft 103 kts	Roll angle stabilised at about wings-level. Pitch attitude 6 degrees nose-up. Heading stabilised 198° M.
0809:30	2,539 ft 111 kts	Flap 15 selected.
0809:41	2,597 ft 117 kts	<p>Flap zero selected.</p> <p><i>The crew recalled that after raising the flaps the landing gear was selected up.</i></p>
0810:55	3,407 ft 134 kts	<p>Left engine shutoff selected.</p> <p><i>After the landing gear was retracted, the crew turned their attention to the warnings they had noted earlier. They recalled that, in addition to the OIL PRESS and FUEL warnings, the amber left LOW PRESS light on the overhead fuel feed panel was illuminated, the white lights for both left electric boost pumps were ON, and the number-1 white EEC light was on. The fuel gauges were indicating just over 200 kg per side. The crew then</i></p>

		<i>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.<sup>6</sup></i>
0810:57	3,421 ft 134 kts	<p><u>[Predicted events:</u></p> <ul style="list-style-type: none"> <li>- <u>ELEC amber light illuminated on MAP,</u></li> <li>- <u>left AUX GEN OFF BUS amber light illuminated on electrical panel (on overhead panel) and</u></li> <li>- <u>respective master CAUTION amber light on glareshield panel illuminated with its associated single chime.</u></li> </ul> <p><u>The auxiliary generators are also driven by the propeller gearbox and they are disconnected when the respective propeller speed is 70% or lower.]</u></p>
0811:06	3,539 ft 135 kts	<p><u>[Predicted events:</u></p> <ul style="list-style-type: none"> <li>- <u>amber HYD light on MAP</u></li> <li>- <u>amber left MAIN PUMP LOW PRESS on overhead hydraulic panel</u></li> </ul> <p><u>amber MASTERCAUTION light on glareshield panel with associated single chime]</u></p>
0812:28	3,603 ft 167 kts	<p>Press-to-talk switch activated.</p> <p><i>The crew reported that they levelled the aircraft at 3,400 ft (the lowest safe altitude). Because Wiluna was close by, the aircraft was heading in the direction of Wiluna, and the runway at Wiluna was sealed, the crew decided to land there. The pilot in command transmitted a PAN<sup>7</sup> emergency message to air traffic control, advising an engine failure and that they were diverting to Wiluna.</i></p>
0818:31		Aircraft landed at Wiluna.

The aircraft's flight log 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. After shutting down the aircraft at Wiluna, the crew recorded that the fuel gauges indicated there was 370 kg fuel remaining.

Following the occurrence, the operator dispatched engineers to examine the aircraft. They reported that the cockpit fuel quantity indicators displayed 300 kg (left tank)

<sup>6</sup> 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.

<sup>7</sup> Radio code indicating uncertainty or alert, general broadcast to widest area but not yet at level of MAYDAY.

and 150 kg (right tank). A physical check of both tanks revealed that the left tank contained no fuel, and the right tank contained 150 kg of fuel.

## **1.2 Injuries to persons**

There were no injuries to any of the crew or passengers.

## **1.3 Damage to aircraft**

Because the recorded flight data indicated that the engine limitations may have been exceeded during the go-around, the engine manufacturer suggested that the reduction gear box of the right engine be removed and overhauled. That action was subsequently taken by the aircraft operator.

## **1.4 Personnel information**

### **1.4.1 Pilot in command**

The pilot in command had 3,040 total flying hours. He obtained a Commercial Pilot (Aeroplane) Licence on 12 October 2000 and an Air Transport Pilot (Aeroplane) Licence on 21 July 2005. Prior to commencing employment with the operator, he had 746.4 hours as pilot in command of multi-engine aircraft and no previous turbine-engine aircraft experience.

On 21 August 2006, the pilot in command obtained an EMB-120 copilot endorsement with the operator, which involved 7.6 hours flight time. He was cleared for line operations as a copilot on 20 September 2006 (after 50 hours supervised flight time), and logged a total of 260.8 hours as a copilot. He obtained a command endorsement from the operator on 19 January 2007, which involved 6.2 hours flight time. He initially did not pass a clearance to line check after 50 hours in command under supervision. The check pilot noted no problems with his knowledge of systems or procedures, but believed he required further experience to increase his confidence. He passed the second check after 83.8 hours with no problems noted. After being cleared for line operations as pilot in command on 19 February 2007, the pilot in command completed 298.0 hours in that role. His total experience on the EMB-120 at the time of the occurrence was 648.8 hours.

Prior to completing his command endorsement, his last proficiency check was the renewal of his multi-engine command instrument rating on 15 December 2006. Management and check and training pilots advised that they had no concerns regarding the pilot in command's ability.

The operator's *Flight Standards Manual* stated that all new crew members had to complete a crew resource management (CRM) theory course 'as soon as practicable', and that all crew members 'shall receive refresher training in this subject within every two years'. The pilot in command had not completed a CRM course during his time with the operator. He had completed a Bachelor of Aviation degree in July 2003, which included a subject on human factors.

The pilot in command stated that he was well rested and in good health at the time of the occurrence. He had conducted 3.9 hours flying on the day prior to the

occurrence, with his duty time finishing at 1300. He conducted no duties for the operator on the previous 10 days.

## **1.4.2 Copilot**

The copilot had 1,618.3 hours total flying hours. He obtained a Commercial Pilot Licence (Aeroplane) on 2 January 2003. Prior to commencing employment with the operator, he had no previous turbine-engine aircraft experience and 25.5 hours as pilot in command of multi-engine aircraft.

On 21 April 2005, he obtained an EMB-120 copilot endorsement with the operator, which involved 6.7 hours flight time. He was cleared for line operations as a copilot on 17 May 2005 (after 50 hours supervised experience). He had a total of 1,356.1 hours as a copilot on EMB-120 aircraft.

The copilot's last aircraft proficiency check was completed on 10 May 2007. Management and check and training pilots advised that they had no concerns regarding the copilot's ability, and that he was above average as a handling pilot. The copilot provided EMB-120 ground school training as part of his employment.

The copilot completed a 1-day CRM course with the operator on 12 October 2005. In late 2004, prior to commencing employment with the operator, he completed human factors and CRM training as part of a multi-crew training program with another airline. That training included a series of nine line orientated flight training (LOFT) style exercises in a generic simulator based on a large passenger jet aircraft. The sessions had an emphasis on areas such as decision-making, communication skills, and threat and error management.

The copilot stated that he was well rested and in good health at the time of the occurrence. He conducted no duties for the operator during the previous 4 days.

## **1.5 Aircraft information**

The EMB-120ER<sup>8</sup> was a twin turboprop engine aircraft with a maximum take-off weight of 11,990 kg. The aircraft was certified in the transport category for the carriage of passengers and freight. In the passenger role, it had a maximum seating capacity of 30 passengers. It was powered by two Pratt & Whitney Canada PW118 turboprop engines.

At the time of the occurrence, there were 22 EMB-120 aircraft on the Australian civil aircraft register.

VH-XUE was manufactured in 1989 and placed on the Australian register in 1995. According to the maintenance records, the aircraft had completed 22,597 operating hours and 26,044 cycles at the time of the occurrence.

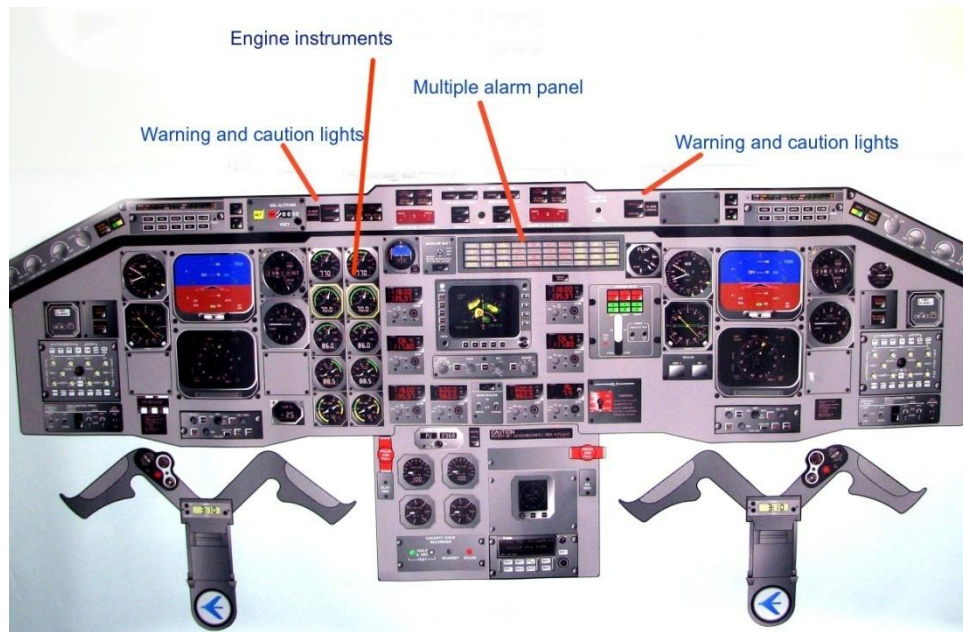
### **1.5.1 Instrument panel layout**

The main cockpit instrument panel is depicted in the schematic at Figure 1.

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<sup>8</sup> The letters ER denote an 'Extended Range' version of the EMB-120 aircraft.

**Figure 1: Schematic of EMB-120 instrument panel**



An overhead panel (Figure 2) included control switches and indicators for various aircraft systems, including the engine control (A), fuel (B), electrical (C), and hydraulic (D) systems.

**Figure 2: Overhead control panels**

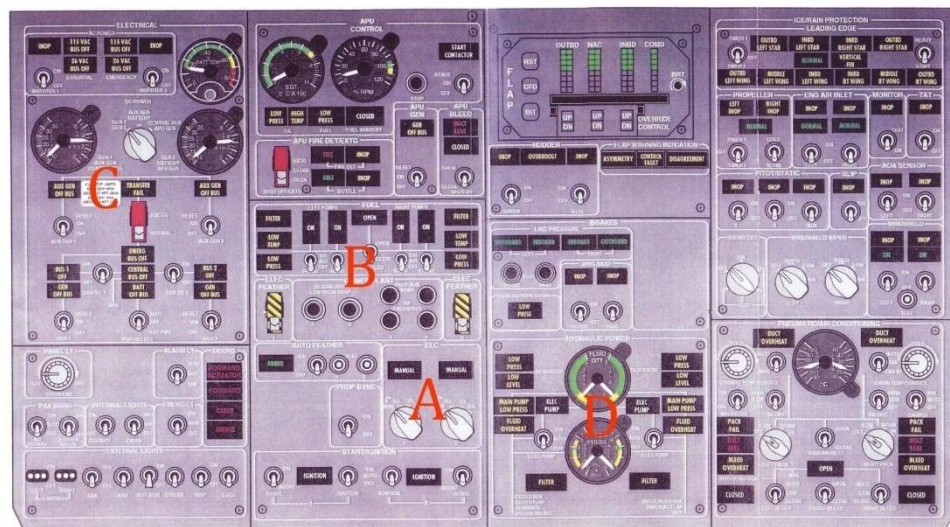


Figure 1-4. Overhead Panel

Note: This edge adjacent to front of cockpit roof

## 1.5.2 Cockpit alarm and indications

There were alarm and indication lights in the cockpit that provided information on failures identified by the legend inscribed thereon, or by a combination of that legend and the adjacent panel inscriptions. Legends were readable only when

illuminated and were coloured red or amber according to the seriousness of the failure and the degree of urgency attached to the crew's response as follows:

- Red – a failure or malfunction requiring immediate action and representing a hazard to the aircraft that could lead to an unsafe flight condition (that is, a 'warning').
- Amber – a failure not requiring immediate action (that is, a 'caution').

The alarm and indication lights remained illuminated as long as the fault persisted.

Green and white indication lights provided information regarding the status of some aircraft systems as follows:

- Green – indicated normal operation for systems where a positive indication of correct functioning was desirable.
- White – indicated normal operation of systems not normally required, or of standby system operation when the main system had failed.

The multiple alarm panel (MAP) consisted of a panel of captions to alert the crew to failures of specific components and systems within the aircraft. The panel layout was as shown in Figure 1, with the red warning captions occupying the central four columns of the panel.

When a fault occurred, the appropriate caption began flashing. Additionally, the red WARNING or the amber CAUTION lights (as appropriate) on the instrument panel in front of each control position (Figure 1) also began flashing. The aircraft was also equipped with an aural alert system that included synthesised voice messages, discrete tones, and chimes. Three chimes (Level 3) sounded in the event of a situation that required immediate action by the crew. One chime (Level 2) sounded when immediate crew awareness and subsequent crew action was required. A Level 2 chime took priority over voice messages. For example, in the case of an electronic engine control failure, the crew would hear three chimes followed by an 'engine control' voice message. Low engine oil pressure would generate a Level 3 chime, followed by an 'oil' voice message.

Checks following the occurrence confirmed that the various alarm and warning systems on the aircraft were functioning normally.

### **1.5.3 Engine instruments**

Figure 3 shows the two columns of engine instruments for the left and right engines. The instruments were, from top to bottom:

- intra-turbine temperature
- percentage engine torque,
- percentage propeller speed
- low pressure and high pressure spool speed indication
- a combined gauge showing oil temperature and pressure.

All gauges, except for oil, displayed information in analogue and digital formats. The torque gauges were highlighted by a yellow border.

**Figure 3: The two columns of five instruments for numbers 1 and 2 engines (dark shading)**



#### **1.5.4 Indications in the event of fuel starvation**

The manufacturer advised that in the event of fuel starvation, a fuel low pressure condition would exist and cause the fuel low pressure light to commence flashing. The sequence of events would be as follows:

- LOW PRESS and Fuel Pump ON lights flashing on the fuel panel (located in the overhead panel).
- FUEL light illuminated on the Multiple Alarm Panel (light is amber).
- CAUTION light flashing (on the glareshield panel and cancellable through the ALARM CANCEL SWITCH, caution light is accompanied with a single chime aural alarm)
- Due to the engine starvation a shutdown will occur, with the following engine parameters reducing:
  - torque indication
  - fuel flow indication
  - low pressure spool speed indication (NL)
  - high pressure spool speed indications (NH)
  - intraturbine temperature indication (T6)
  - propeller speed indication (NP)
  - oil pressure indication.

- When oil pressure reaches 40 psi, an OIL PRESS 1 or OIL PRESS 2 light will illuminate on the MAP (light is red) and a WARNING light will flash on the glareshield panel (cancellable through the ALARM CANCEL SWITCH).

The manufacturer advised that there would also be other indications and warnings associated with the electrical and hydraulic systems, and the EEC as follows:

- When high pressure spool speed fell below 50%, the ELEC amber light on the MAP and the left GEN OFF BUS amber light would illuminate on the overhead electrical panel. The respective master CAUTION amber light on the glareshield panel would also illuminate, accompanied by a single chime.
- When high pressure spool speed fell below 25%, the EEC 1 red light on the glareshield panel and the MANUAL white light on the overhead EEC panel would illuminate. An associated master WARNING red light on the glareshield panel would also illuminate, accompanied by a triple chime and an ENGINE CONTROL voice message.
- When propeller speed dropped below 70%, the ELEC amber light on the MAP, and the left AUX GEN OFF BUS amber light on the overhead electrical panel would illuminate. The respective master CAUTION amber light on the glareshield panel would also illuminate, accompanied by a single chime.
- When hydraulic pressure fell below 1,500 psi (there is a hydraulic pressure gauge on the overhead panel), the HYD amber light on the MAP, the left MAIN PUMP LOW PRESS amber light on the overhead hydraulic panel would illuminate. The respective master CAUTION light on glareshield panel would also illuminate, accompanied by a single chime. (As the electric hydraulic pump was probably on AUTO position (the normal position during flight), the electrical hydraulic pump probably provided hydraulic pressure for the green hydraulic system, with its associated ELEC PUMP white light illuminated on the hydraulic panel.)

### **1.5.5 Fuel quantity indicating system**

There were inboard and outboard fuel tanks in each wing of the aircraft. The tanks were interconnected and acted as a single reservoir. The fuel systems for each wing were identical and independent. The aircraft operating manual stated that the aircraft's maximum fuel capacity was 2,622 kg (3,340 L), including 22 kg (28 L) of unusable fuel. Those figures were based on an average fuel density of 0.785 kg/L.

The quantity of fuel in the aircraft's tanks was measured by an electrical capacitance indicating system. Each wing was fitted with six capacitive fuel sensor units or probes. There were four fuel sensor probes in each outboard tank and two in each inboard tank. Capacitance measured by each probe varied depending on the length of the probe that was immersed in fuel. The system was designed so that total tank capacitance (and thus indicated fuel quantity) was not affected by changes in aircraft attitude.

A fuel management panel (Figure 4) was positioned in the centre section of the cockpit instrument panel. The panel featured fuel quantity indicators and fuel flow indicators for the left and right fuel systems.

**Figure 4: Fuel management panel**



The fuel quantity indicators displayed, in 100-kg units, the total fuel quantity in the corresponding wing. The quantity indication was compensated for temperature and fuel density. The indicators displayed zero when there was no usable fuel remaining.

The fuel flow indicators displayed the fuel flow, in kg per hour, for each engine. The fuel flow indicators were independent of the fuel quantity indicating system.

### **1.5.6 Fuel totaliser**

A fuel totaliser display, positioned immediately above the fuel quantity indicators, displayed digitally the total amount of fuel used or the total amount remaining, depending on the mode of operation selected by the flight crew as follows:

- operation of the FCTN button alternated the display between FU (Fuel Used) and FR (Fuel Remaining)
- operation of the PULL TO SET knob in the FU mode reset the fuel used display to zero
- operation of the PULL TO SET knob in the FR mode copied the fuel quantity indicated by the Fuel Quantity Indicators
- fuel remaining could be set manually by rotating the PULL TO SET knob. A clockwise rotation increased the indicated fuel remaining and counter-clockwise rotation decreased the indicated fuel remaining.

In the fuel used function, the displayed value was based solely on inputs from the fuel flow transmitters since the totaliser had been last reset. In the fuel remaining function, the displayed value was the difference between the initial total fuel on board when the totaliser was last reset (obtained from the fuel quantity indicating system) and the fuel used. Therefore, other than when the fuel totaliser was reset,

the displayed quantity was determined in a manner which was independent of the fuel quantity indicating system.

The APU was not equipped with a fuel flow transmitter, but APU fuel burn was estimated from discrete signals. The aircraft maintenance manual (Section 28-43-00, page 3) included the following information:

C. When applicable, APU fuel consumption is determined by means of three discrete signals sent by the APU control switches (Ref. 49-74-00), which cause the totalizer to add predetermined rates to the fuel consumed. When the APU operates without a load, the signal corresponds to a 45 pph consumption (20.4 kg/hr). Operation with the generator on corresponds to a 53 pph (24 kg/hr) consumption. Operation with bleed air corresponds to a 90 pph (40.8 kg/hr) consumption, and operation with generator on and bleed air corresponds to a 98 pph (44.5 kg/hr) consumption.

Note: The APU fuel burned from the time the APU was started (usually maintenance action upon aircraft power up) to the time the fuel totaliser was reset (usually pilot action while performing the 'before start' procedures) will not be computed in the fuel consumed for that flight leg on the fuel totaliser. The aircraft operator used 60 kg/hr as a standard allowance for APU fuel burn.

### **1.5.7 Dripless measuring sticks**

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 were allowed to lower until the floating magnet attracted the upper end of the stick (Figure 5). That enabled the level of the fuel to be determined.

A conversion table carried on the aircraft was used to convert the reading on the stick to a fuel tank quantity in kilograms. Accurate quantity measurement using the dripless sticks required the aircraft to be laterally level.

Dripless measuring sticks, along with other physical check methods, are the most reliable means of establishing fuel quantity.

**Figure 5: A dripless stick in the lowered position, indicating 2.8 on the measurement scale**



### **1.5.8 Fuel low-level warning system**

The EMB-120 was not equipped with a fuel low-level warning system, nor was it required by regulation. The aircraft manufacturer advised that the EMB-120 was certified in accordance with ANAC (Agência Nacional de Aviação Civil), complying with RBHA (Regulamento Brasileiro de Homologação Aeronáutica) Part 25, which did not require the incorporation of a fuel low-level warning system. The equivalent US Federal Aviation Regulation (FAR) Part 25 also did not require the incorporation of a fuel low-level warning system.

As a result of recent occurrences involving other turboprop and turbojet aircraft, three European national investigation agencies<sup>9</sup> have issued recommendations for aircraft certification standards to be enhanced to require fuel low-level warning systems on all such aircraft, and to ensure that such systems where fitted are independent of the fuel quantity indicating system. Further details on those recommendations are provided in Appendix B.

### **1.5.9 Fuel system maintenance history**

According to the aircraft maintenance documentation, on 21 August 2006, a fuel tank wiring inspection revealed a damaged section at the left wing tip. That damage

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<sup>9</sup> Those agencies included the Irish *Air Accident Investigation Unit* (AAIU), the Italian *Agenzia Nazionale per la Sicurezza del Volo* (ANSV), and the UK *Air Accident Investigation Branch* (AAIB).

was repaired on 1 September 2006. On 11 September 2006, the aircraft underwent maintenance action to repair damaged fuel quantity indicating system wires at the inboard probe in the left tank. The aircraft underwent a maintenance check on 5 October 2006 that included the calibration of the fuel quantity indication system.

On 22 October 2006, an inspection of the fuel quantity wiring harness was carried out. No defects were reported. Between that date and the occurrence, only one fuel quantity indication system defect was recorded. That occurred on 15 February 2007, and referred to the fuel totaliser not indicating the correct quantity when reset. The fault was rectified by replacing the totaliser.

The aircraft's flight logs noted an event on 6 December 2006 when 280 kg of fuel was removed from the left wing tank. Subsequently, the same amount was added to the left tank. That amount corresponded to half of the recorded total fuel quantity on board the aircraft at the time (580 kg). The reason for the apparent defueling of the left wing was not stated on the relevant flight log; nor was any detail contained in the aircraft maintenance records.

#### **1.5.10 Examination of the fuel quantity indicating system**

When the aircraft was examined after the occurrence, the left fuel tank was empty, while the fuel quantity indicator displayed 300 kg. A check of the overall capacitance of the left fuel quantity indicating system revealed that it was out of limits on the low side. The capacitances of all left side probes (while still installed) were also out of limits on the low side. When the left side probes were removed and bench tested, all tested correctly except probe number-6 (the left outboard probe), which showed similar below-limits capacitance as it did while installed. After a replacement probe was fitted in the number-6 position, the total system capacitance returned to the correct value.

The right fuel quantity indicating system was checked and confirmed serviceable.

A visual inspection of the left wing indicating system wiring harness in situ did not reveal any abnormality. The harness was subsequently removed from the aircraft and inspected under magnification. That inspection revealed several areas of damage to the loom, particularly on the number-6 probe wires (Figure 6). There was evidence that those wires had been short circuiting to the metal airframe structure inside the wing tank and also between the AC supply, DC positive and DC negative wires. That caused intermittent and hard short circuits and arcing, leading to the failure of two diodes on the number-6 probe. There was no record that the loom had been removed from the aircraft since its manufacture in 1989.

The aircraft manufacturer advised that it was aware of only one other instance of fuel quantity indicating system malfunction in EMB-120 aircraft (see also Section 1.13.1). That malfunction occurred in September 2001 and involved the right fuel quantity indicator reading fluctuating approximately 300 pounds (136 kg). The problem was traced to a faulty cannon plug on the back of the indicator.

**Figure 6: Wiring loom showing exposed wire and abraded insulation layers**



## **1.6 Meteorological information**

### **1.6.1 Local weather conditions**

The Bureau of Meteorology (BoM) advised that a high pressure system was directing a north to north-east airflow across the occurrence area. The Bureau also advised that there were no weather observations at Jundee. However, the 0900 synoptic observation from Wiluna showed temperature as 12° C and a northerly wind at 2 kts. The weather was described as ‘cloud not observed or not observable’. The crew’s report of the weather was consistent with this information.

### **1.6.2 Sun position information**

According to the Geoscience Australia website, at 0806 on 26 June 2007, the sun’s position was 055° T in azimuth (053° M) and 15° in elevation. Consequently, during the approach to Jundee, the sun was located about 24° left of the aircraft’s heading and 15° above the horizon.

## **1.7 Aids to navigation**

Not relevant to the circumstances of the incident.

## **1.8 Communications**

Communications between the aircraft and air traffic control during the flight were normal.

## 1.9 Aerodrome information

Jundee Airstrip was privately operated. It consisted of a 2,095 m long gravel runway 08/26, which included a 200 m sealed section at each end. The runway elevation was 1,845 ft above mean sea level (AMSL). The apron area was adjacent to the runway 26 threshold. The terrain in the vicinity of the airstrip was reported to have been flat, with vertical obstacles limited to a few metres.

Wiluna Airstrip was located 42 km south-west of Jundee. It had a sealed runway 15/33, which was 1,811 m long, and an unsealed runway 03/21, which was 1,219 m long.

## 1.10 Flight recorders

VH-XUE was fitted with a flight data recorder (FDR) and a cockpit voice recorder (CVR) as required by Australian regulations.

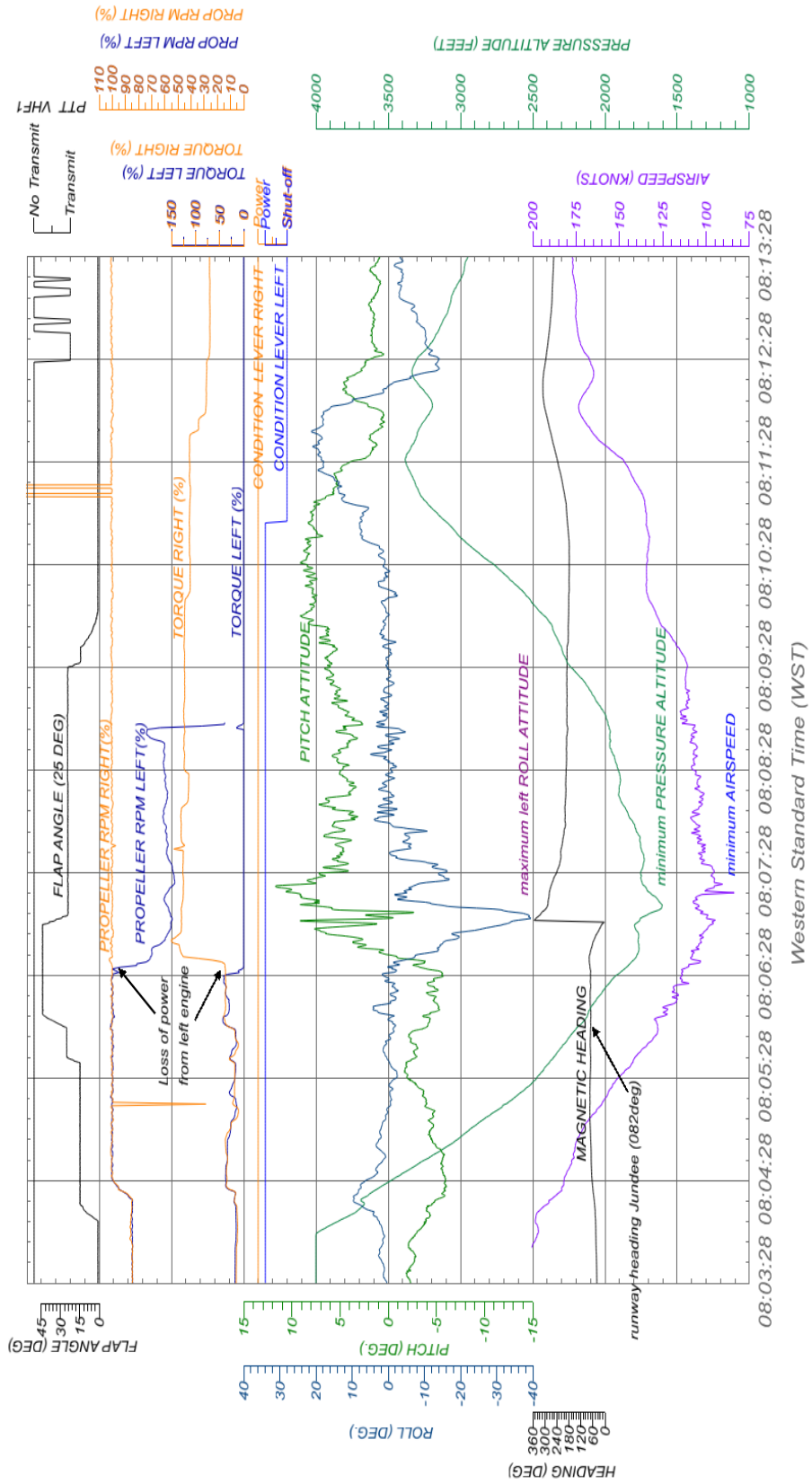
The CVR was an L-3 Communications Aviation Recorders model A100S, which was capable of recording four channels of audio for a duration of 30 minutes. The CVR was successfully downloaded and the recorded information recovered. It was found that information relating to the incident had been overwritten by ground running carried out by engineers engaged in fault finding activity on the aircraft after the incident.

The FDR was an L-3 Communications Aviation Recorders model F1000, which was capable of recording a minimum of 25 hours of aircraft operation. The L-3AR model F1000 FDR utilises a method of data compression which can result in more than 25 hours of information being recorded. The FDR was successfully downloaded.

The recovered data included a landing and 19 complete sectors, about 39 hours 12 minutes of aircraft operation, which included the incident flight and the subsequent diversion to Wiluna. The incident flight was plotted and the related data analysed. It was noted that the propeller RPM recording system exhibited unusual characteristics, indicating a possible problem with the transducer or wiring connecting the transducer to the flight data acquisition unit.

A plot of the FDR data for the final approach and go-around is at Figure 7. The parameters displayed include, with respect to aircraft systems, flap angle, propeller and torque values for both engines and engine condition lever position. The displayed aircraft performance values include pitch and roll attitude, magnetic heading, pressure altitude and airspeed.

Figure 7: Recorded FDR parameters for approach and go-around



## 1.11 Tests and research

### 1.11.1 Flight simulator replication of the occurrence by other pilots

At the time of the occurrence involving VH-XUE, another Australian EMB-120 operator had arranged for two of its pilots to attend EMB-120 simulator training overseas.<sup>10</sup> That operator was approached by a Civil Aviation Safety Authority (CASA) representative to have its pilots replicate the VH-XUE event in the simulator. That exercise was subsequently undertaken.

The pilots involved reported that a scenario was developed where an engine was failed on late final approach with full flap selected and the landing gear down. A missed approach was then initiated. One hundred per cent torque was applied, flap 15 was selected, and the propeller was not feathered. The pilots found that they could not maintain control of the aircraft and the simulator 'crashed' after turning through about 90 degrees. Similar results were obtained using 110 and then 120% torque. A successful but 'untidy' go-around, during which the stick shaker operated a number of times, was achieved when they used torque levels similar to those they had been told were used by the crew of VH-XUE.

The pilots involved also reported that they attempted to continue the approach after the engine had 'failed'. They found that the aircraft could rapidly lose alignment with the runway to the extent that a landing could not be achieved. They found that with a windmilling propeller, flap 45, and landing gear down, greater than 90% per cent torque was required to maintain airspeed and the approach path. Further, there was little change in engine noise when the engine failure was initiated. The first noticeable indication they received was a single alert chime followed by the illumination of the ELEC and MAIN GEN OFF BUS captions on the MAP.

The pilots added that their responses in the simulator were against the background of knowing that an engine was going to 'fail'. They considered that detecting and responding to an actual and unexpected engine failure situation would have been considerably more challenging.

## 1.12 Fuel quantity measurement processes

### 1.12.1 Regulatory requirements and guidance

Civil Aviation Regulation (CAR) 234(1) stated:

- (1) The pilot in command of an aircraft must not commence a flight within Australian territory, or to or from Australian territory, if he or she has not taken reasonable steps to ensure that the aircraft carries sufficient fuel and oil to enable the proposed flight to be undertaken in safety.

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<sup>10</sup> At the time of the occurrence, there was no EMB120ER simulator in Australia. Local operators who wished to undertake simulator training had to travel to facilities in the US or Europe.

- (2) An operator of an aircraft must take reasonable steps to ensure that an aircraft does not commence a flight as part of the operator's operations if the aircraft is not carrying sufficient fuel and oil to enable the proposed flight to be undertaken in safety.

Civil Aviation Order (CAO) 20.2 (*Air Service Operations – Safety Precautions Before Flight*) provided further requirements. As of 8 May 2006, it stated:

- 6.1 The operator of an aircraft having a maximum take-off weight of more than 5700 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 (AWB) 28-002, dated 15 May 2006, stated:

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 aircraft's fuel gauge system is known to be reliable.

Civil Aviation Advisory Publication (CAAP) 234-1(1) was revised in November 2006 to provide similar guidance as that contained in AWB 28-002.<sup>11</sup>

Prior to May 2006, CAO 20.2 included as regulatory requirements the advisory cross check methods included in AWB 28-002.<sup>12</sup> As part of a regulatory change process, CASA stated that those requirements appeared to be unique to Australia. It proposed changing the requirements to be consistent with the outcome-based rules

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<sup>11</sup> In late 2007, AWB 28-002 was withdrawn as a listed CASA publication. The first method of cross check listed in the CAAP was worded as follows: 'Check of visual readings (tab, dip, drip, sight gauges) against fuel consumed indicator readings'.

<sup>12</sup> Prior to May 2006, CAO 20.2 also stated that the cross-check procedures 'must be specified by the operator, together with an allowable discrepancy which must not exceed 3 per cent of the higher amount'.

of the US Federal Aviation Administration (FAA) and the European Aviation Safety Authority (EASA). Accordingly, CAO 20.2 was amended on 8 May 2006.

### 1.12.2 Operator's fuel quantity measurement procedures

The operator published fuel quantity checking procedures in its *Flight Operations Manual* and its *Brasilia Flight Operations Manual*.

The *Flight Operations Manual* stated:

Aircraft with a MTOW exceeding 5700 Kg shall not commence a flight unless the PIC [pilot in command] has ensured that the fuel quantity on board has been confirmed by use of two separate cross check methods. The maximum discrepancy between the two methods shall be the quantity defined in the aircraft type operations manual...

The *Brasilia Flight Operations Manual* stated:

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 aircraft's fuel gauge system is known to be reliable.

The APU 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 [electronic attitude display indicator]. A pitch of  $\pm 2^\circ$  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 operator reported that, prior to May 2006, its procedures included 3° as the maximum allowable discrepancy. When the amended CAO was issued in May 2006, the operator changed the allowable discrepancy for the EMB-120 to 60 kg. The rationale for that change was that, while 60 kg was less than 3% at maximum and higher fuel quantities, it was close to 3% at the quantities that were used in most day-to-day operations. The operator advised that the change was reported to CASA and incorporated into the operator's manual.

### 1.12.3 Use of flight logs

The operator provided flight crew with a flight log for recording aircraft operational data for each day's operations. The 'fuel load' section of the log contained columns for recording fuel quantity information for each flight (Figure 8).

**Figure 8: Fuel Load section from a sample flight log**

Total Fuel Qty At Dept	Fuel Load					
	Burn	Residual	Added	Doc #	Port	Refuel Date
		600	1112	814680	PH	20/6
1700	760	940				
940	200	740	506	110 DECKET	LST	20/6
1240	610	630*	1532	814695	PH	20/6
2080	780	1300				
1300	760	540				

As shown in Figure 8, there were four columns in the flight log for recording fuel quantity information:

- total fuel quantity at departure
- burn (or fuel used during a flight)
- residual (or fuel remaining at the end of a flight)
- added (or fuel added prior to the next flight).

The *Flight Operations Manual* included the following guidance on use of the flight log:

The figure placed in the 'Fuel Total' column of the Flight Log Form shall be the fuel total as read from the fuel gauges (corrected if necessary), not the calculated fuel total.

Crews shall consistently check the fuel burns against the residual fuel figure for accuracy on every sector.

Fuel on board gauge readings are to be checked prior to departure by adding the fuel quantity uplifted, as per the release note, to the fuel quantity remaining at the end of the previous flight which has been recorded on the Flight Log.

In addition to the flight crew, six other company EMB-120 pilots were interviewed, including the EMB-120 fleet manager and a training-and-checking pilot. In terms of how flight logs were completed, those pilots reported:

- The 'total fuel quantity at departure' was read from the totaliser set to the 'fuel remaining' mode after refuelling had been completed. The totaliser was preferred to the fuel quantity indicators because it provided a digital presentation that was easier to read than a gauge pointer.

- Most pilots reported that they obtained the ‘burn’ fuel by calculating the difference between the ‘total fuel quantity at departure’ and the ‘residual’ at the end of a flight. Three pilots, including the fleet manager, stated that they obtained ‘burn’ fuel from the totaliser set to the ‘fuel used’ mode.
- ‘Residual’ fuel was read from the totaliser set to the ‘fuel remaining’ mode after the engines had been shutdown and before the totaliser had been updated.<sup>13</sup> For the first flight of the day, the ‘residual’ fuel was generally copied from the final residual figure from the previous flight log.
- ‘Added’ fuel was obtained by converting the refuelling docket quantity in litres to kilograms. The operator’s manuals prescribed that ‘0.8’ was to be used as the specific gravity of aviation turbine fuel for the conversion.

The investigation team reviewed a sample of the operator’s flight logs (see 1.17.5). This review revealed that, of the 22 different pilots in command who completed aircraft flight logs, only three appeared to use the totaliser ‘fuel used’ function to calculate fuel ‘burn’. Those pilots included the fleet manager, the pilot in command of VH-XUE on the occurrence flight (who changed to the practice following 4 April 2007 after being advised to do so by the fleet manager) and another pilot in command (who changed to the practice after 18 June 2007).

#### **1.12.4 Refuelling to a known quantity**

The operator’s pilots reported that, for operational reasons, they rarely refuelled the EMB-120 aircraft to full capacity during normal operations. However, the review of flight logs noted that there were four occasions when the occurrence aircraft may have been refuelled to full capacity. On 6 November 2006, 19 December 2006 and 29 April 2007, the recorded totals prior to departure were close to the published capacity of the fuel system (2,600 kg, assuming a specific gravity of 0.785). On 28 April 2007, the recorded total prior to departure was 2,700 kg and that exceeded the manufacturer’s fuel capacity of 2,622 kg.

#### **1.12.5 Discrepancies between recorded and actual fuel quantities**

The flight logs for VH-XUE were reviewed to identify potential events or factors that could explain the discrepancy between the recorded fuel quantity and the actual fuel quantity that was evident on the occurrence flight. The flight logs for the operator’s other five EMB-120 aircraft were also reviewed for the period 1 April 2007 to 25 June 2007 for comparison purposes.

The review of the flight logs also revealed that for each EMB-120 aircraft during the period 1 April to 25 June, the total fuel added exceeded the total fuel used by about 3% of the fuel added. That excess was due to two factors:

- The operator’s use of a specific gravity for Jet A1 fuel of 0.8 to convert fuel litres to kilograms (a specific gravity of 0.785 was used predominantly through

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<sup>13</sup> It was reported that some pilots regularly reset the totaliser during flight. The reason for doing a reset was to ensure that the fuel remaining display matched the fuel gauge display. It was reported that, by the end of a flight, the difference between the two figures was often about 20 to 30 kg if the totaliser was not reset.

the industry and, immediately following the occurrence, the operator amended its procedures to require that value to be used). The numerical difference between the fuel added and fuel used would have been less if 0.785 had been used.

- The 'burn' figures did not include APU fuel that was burned before the total fuel at departure figure was calculated.

Until April 2007, the figures for VH-XUE were similar to the operator's other EMB-120 aircraft. However, between April 2007 and the occurrence date, the exceedance for VH-XUE (about 0.3% of fuel added) was much less than for the other aircraft. Most of that difference appeared to be due to VH-XUE having a higher recorded fuel burn after about March 2007.

Overall, due to the practices for recording fuel information, it was not possible to track with precision when erroneous fuel quantity indications began.

#### **1.12.6 Cross-checks of total fuel quantity at departure**

Consistent with the operator's procedures, the operator's pilots reported that the 'total fuel quantity at departure' was cross-checked against a figure calculated by adding the 'residual' from the previous flight and the 'added' fuel. A discrepancy of 60 kg or more between the indicated total fuel and the calculated total fuel figures required resolution to the satisfaction of the crew. If the discrepancy could not be resolved, then driplless measuring sticks were used to confirm the quantity in the tanks. The reason for any discrepancy of 60 kg or more was noted in the 'comments / observations' section of the flight log.

The pilots reported that the most common reason for a discrepancy between the totaliser total fuel figure and the calculated total fuel figure was due to APU fuel burn prior to obtaining the total fuel quantity at departure. APU fuel burn was not normally recorded on the flight log. However, if APU fuel burn explained a discrepancy of 60 kg or more between the totaliser total fuel figure and calculated total fuel figure, then APU fuel burn would be noted in the 'comments / observations' section.

The review of flight logs found that during the period 1 April to 25 June 2007, there were 68 occasions across all six EMB-120 aircraft when the difference between the recorded 'total fuel quantity at departure' figure was 60 kg or more different to the applicable calculated figure. On 51 occasions, the reason provided was 'APU burn'. No reason was provided on 15 occasions. Seven of the 51 events involved VH-XUE. Flight logs for VH-XUE during the period 15 October 2006 to 31 March 2007, indicated a similar pattern. In all but one instance where the difference was 60 kg or greater, the total fuel quantity at departure was less than the calculated amount. The only exception involved VH-XUE, which occurred on 30 April 2007.

#### **1.12.7 Residual fuel quantity variations between days**

Pilots reported that prior to the first flight of the day, they compared the residual figure recorded from the previous flying day with the quantity indicated by the totaliser or fuel quantity indicating system. There was no procedure to follow in the event of a discrepancy between the residual figure and the indicated figure. Some pilots reported that they would wait to conduct a cross-check after fuel was added.

If the total fuel quantity check was within limits, then no further action was required.

Further examination showed that:

- During the period 1 April to 25 June 2007, there were 29 occasions involving all six EMB-120 aircraft when the final residual fuel at the end of a day's operations was different to the residual figure on the flight log for the first flight the following day.
- On nine occasions, the difference was 60 kg or more. No reasons were provided on the flight log to explain those differences.
- On most of the occasions, the change in the residual figure brought the calculated total fuel figure to within 60 kg of the totaliser total fuel figure for the first flight of the following day.
- Flight logs for VH-XUE during the period 15 October 2006 to 31 March 2007 indicated a similar pattern to the other aircraft during the period 1 April to 25 June 2007.

#### **1.12.8 Use of dripless measuring sticks**

The operator's pilots reported that dripless measuring sticks rarely had to be used to resolve fuel quantity discrepancies. Several pilots reported that they had been shown how to use dripless measuring sticks during line training, but had not needed to use them in normal operations. It was also reported that, if they were used, this would not always be documented on the flight logs.

The review of flight logs identified two instances that recorded the use of dripless measuring sticks. Both involved the same pilot in command and were used to confirm discrepancies in the totaliser total fuel figure and the calculated total fuel figure following maintenance activities. Neither instance involved the occurrence aircraft.

#### **1.12.9 Recording of fuel used by maintenance personnel**

There have been previous occurrences where use of fuel during maintenance activities, such as engine ground runs, was not recorded (see ATSB Investigation Report BO/200504768<sup>14</sup>). In contrast, the review of flight logs used by the operator of VH-XUE revealed many instances where maintenance personnel had recorded fuel used during maintenance activities.

#### **1.12.10 Auditing of fuel use and recording practices**

The operator's *Flight Standards Manual*, Section 1.6.2, listed the responsibilities of the flight operations manager. One of those was to 'audit the safety, quality and cost efficiency of all flight operations'.

Pilots reported that the flight logs were audited on a sample basis by a pilot delegated by the fleet manager. Each flight log was checked for its accuracy, but there was no analysis of recorded fuel quantity data beyond more than one flight

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14 [http://www.atsb.gov.au/publications/investigation\\_reports/2005/AAIR/aair200504768.aspx](http://www.atsb.gov.au/publications/investigation_reports/2005/AAIR/aair200504768.aspx).

log. Any problems identified on the flight logs were notified to the relevant pilots. When problems were identified, they usually related to weight and balance or flight hours rather than fuel figures.

## **1.13 Related fuel quantity occurrences**

### **1.13.1 Previous EMB-120 occurrence in Australia (14 January 2005)**

The ATSB aviation safety occurrence database included one previous event involving fuel starvation in an EMB-120 aircraft on 14 January 2005. That event was classified by the ATSB as a Level 5<sup>15</sup> occurrence. Consequently, there was no ATSB investigation and only minimal information was obtained from the operator regarding the occurrence. However, following the VH-XUE occurrence, the operator involved in the 14 January 2005 occurrence provided further information on the event to the ATSB.

That operator advised that, during the 14 January 2005 event, the right engine ceased operating shortly after the crew observed a low fuel pressure caution. At the time, the right fuel quantity indicator was fluctuating between 300 and 500 kg, while the left was steady at 500 kg. After a single-engine approach and landing, the right indicator read 250 kg, and the left 500 kg. Prior to departure, both the left and right indicators showed 1,500 kg. A subsequent check revealed that the right tank contained no fuel. A faulty number-6 fuel probe was found to have caused the incorrect indication. The reason for the faulty probe was not determined.

Before the flight, the crew noticed a discrepancy between the gauge reading of 900 kg and the recorded fuel remaining figure of 400 kg from the previous flight. However, because the aircraft had just returned from maintenance, they assumed that fuel had been added by engineering staff, but had not been recorded. The crew's fuel quantity check, based on the residual fuel being 900 kg, fell within the required 3% margin.

Immediately following the occurrence, the operator amended its procedures to require that the driplless measuring sticks be used to confirm the fuel quantity before the first flight of the day. A further direction prohibited an aircraft being dispatched in the event of a discrepancy between the residual fuel recorded in the flight log and the gauge indication.

### **1.13.2 Other EMB-120 fuel-related occurrences**

On 22 February 2008, the aircraft manufacturer advised the ATSB that another in-flight engine power loss due to fuel starvation involving an EMB-120 aircraft occurred in Europe on 20 February 2008. Preliminary information indicated that, shortly after commencing descent from flight level (FL) 190, the crew observed a right engine fuel pressure low warning. They then noticed that the engine torque

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15 Resource constraints limit the number of investigations that the ATSB can initiate and conduct each year. As such, difficult decisions are often required in determining which occurrences are investigated. Where a decision is made not to investigate, details of the occurrence are included in the ATSB's data base for trend monitoring and/or future reference (see [www.atsb.gov.au](http://www.atsb.gov.au)).

was zero. There was 400 kg fuel indicated by both fuel quantity indicators at the time. The crew secured the engine and completed an uneventful landing at the destination airport.

A check revealed that the right wing tank contained no fuel. Before the flight, the crew had found a discrepancy between the refuelling panel quantity indicator and the cockpit indicator for the right tank. The matter was reported to have been rectified and agreement achieved between the refuelling panel and cockpit indicators, and the right tank fuel quantity after shutdown on the previous flight. There was no information as to whether a drip stick reading had been taken to confirm the fuel quantity. The manufacturer was gathering further information on the occurrence, including recorded flight data.

The aircraft manufacturer advised that it knew of four other instances of fuel starvation in EMB-120 aircraft. They included:

- November 1993 - During landing phase, left engine auto shutdown. Continued landing sequence without incident. Found left engine flamed out due to no fuel. Fuel totaliser, both master fuel quantity indicators and both fuel repeaters, showed indication to be correct. Replaced left fuel quantity indicator. Indication checks normal against driplless stick. After fuelling the aircraft, all engine parameters check normal. TAT, 12,106.6 Hours.'
- December 1993 - While enroute ... the right engine torque went to zero. Shut engine down and feathered prop, and landed ... without incident. Maintenance inspected system and found that the right fuel quantity gauge was reading 500 lbs high, and the right engine had run low on fuel. Maintenance removed and replaced the right fuel quantity gauge, IAW the Embraer maintenance manual Chap 28-41-00. System ops checked good. Aircraft approved for return to service.'
- June 1999 - The right fuel indicator was stuck in 510 lbs, and the right tank become empty. This condition caused the flame out on the right engine. ... event was solved by replacing the fuel quantity indicator.'
- 14 January 2005 - No details were available.

### **1.13.3 Other fuel-related occurrences**

In addition to the 14 January 2005 occurrence and the 26 June 2006 occurrence involving EMB-120 aircraft, there were three other occurrences investigated by the ATSB involving power loss on an engine due to fuel starvation in commuter or transport category aircraft. Each of those occurrences involved a technical failure of the fuel quantity indicating systems and problems associated with the operators' procedures for cross checking fuel quantity. Further details of those occurrences are provided in Appendix B.

## **1.14 Communication of important safety information to the industry**

It became apparent during the investigation that there was little formal or informal communication between Australian EMB-120 operators aside from a conference sponsored by the aircraft manufacturer that was held every 2 years. That conference was usually attended by all the Australian operators and included a 'closed-door'

operators-only session, which provided the opportunity for the exchange of information. It was at such a session in November 2005 where details regarding the 14 January 2005 occurrence were discussed, but the operator of VH-XUE was unable to attend that session of the conference. As a result of learning of the 14 January 2005 occurrence, the other Australian EMB-120 operators at the conference amended their procedures to require daily drip stick measurements of fuel quantity.

The aircraft manufacturer advised that it had not been notified of the 14 January 2005 occurrence. The manufacturer had in place a system for issuing *Operator Advisory* notices concerning safety and other information regarding an aircraft type to all operators of that type, and indicated that events such as that of 14 January 2005 would result in the issuing of an *Operator Advisory*.

While the ATSB obtained only descriptive event data about the 14 January 2005 occurrence, a CASA inspector conducted an examination of the occurrence. However, CASA did not advise other Australian EMB-120 operators or the manufacturer of the circumstances of the occurrence, or of the revised fuel quantity measurement procedures that had been introduced as a result.

## 1.15 Operational procedures

### 1.15.1 Crew resource management

Section 2.4 of the operator's *Flight Standards Manual*, stated that the Crew Resource Management (CRM) theory course was to be completed by all new crew members as soon as practicable and that all crew members would receive refresher training in the subject at least every 2 years.

Section 3 of the operator's *Flight Operations Manual* was titled Crew Resource Management. It included information on threat and error management, decision making, and the support process between crew members.

Section 3.8 of the *Flight Operations Manual* addressed 'crew coordination' and specified the responsibilities of the pilot flying and the monitoring pilot as follows:

#### 3.8.5 Pilot Flying [PF]

The Pilot Flying [PF] shall primarily be responsible for flying the aircraft and maintaining a good lookout when in visual conditions

In circumstances where the Monitoring Pilot [MP] is preoccupied with a task or under a high workload, the Flying Pilot may assist with other tasks provided the action does not deter from the primary task of flying the aircraft.

During abnormal and emergencies, the Pilot Flying shall confirm checklist actions.

#### 3.8.6 Monitoring Pilot [MP]

The monitoring pilot's primary duty is to provide support to the flying pilot. The duties shall include:

Provide assistance in maintaining a good lookout in visual conditions;

Make radio calls and passenger PA's;

Action the airborne sections of the normal checklists;

Action cockpit paperwork including trip records, trend records, navigation logs, load sheets and TOLD [takeoff and landing data] cards;

Tune and identify radio navigation aids as directed by the PF;

Action GPS operational needs;

Manipulate weather radar; and

Action specific tasks at the request of the PF.

When descending in cloud, monitor for visual reference and call when established visual.

Identify aircraft malfunctions during abnormals and emergencies.

Read and action (if physically possible) checklist items during abnormals and emergencies.

### 1.15.2 Procedures for go-around

The operator's *Brasilia Flight Operations Manual, Section 2, Normal procedures*, defined the procedures for a go-around from final approach with both engines operating. *Section 2, Abnormal and Emergency Procedures*, paragraph 3.3.4 defined the procedures for a single engine go-around/missed approach. The initial actions were identical for both procedures and were as follows:

FLYING PILOT	MONITORING PILOT
<p>Call, "<b>GOING AROUND, SET POWER, FLAP 15</b>"</p> <p>Press the Flight Director Go-Around button and pitch up to follow the command bar. At the same time Advance Power Levers to within 10% of the pre-determined target torque</p> <p>When a positive rate of climb is established call, "<b>GEAR UP</b>"</p>	<p>Set the pre-determined target torque, select Flaps to 15 and call, "<b>POWER SET</b>". and call "<b>FLAPS 15</b>" when 15 flap is indicated</p> <p>Select Gear Up and when fully retracted call "<b>GEAR UP</b>"</p>

Those procedures reflected the aircraft manufacturer's recommended procedures.

### 1.15.3 Procedures for operations on unpaved surfaces

#### ***Aircraft manufacturer***

The aircraft manufacturer published procedures for operations on unpaved surfaces in Supplement 14 to the *EMB120 Brasilia Airplane Flight Manual*. The supplement stated that:

Non-normal landing can be made with either flap 25 or flap 45, as applicable,  
and

Normal landing must be made with flaps 45.

#### ***Aircraft operator***

The operator's *Brasilia Flight Operations Manual, Section 2, Normal Procedures*, paragraph 2.11.3, included the following information regarding flap selection:

Flap 25 shall be the landing flap selection for all instrument approaches unless the runway length or surface requires Flap 45.

Paragraph 1.9.2, *Unpaved Runway Operational Requirements*, in Section 1 of the operations manual stated that flap 45 must be used for landings on unpaved surfaces, but that flap 25 or 45 could be used as required in the case of a non-normal landing on an unpaved surface.

#### ***Flap selection***

The operator's *Brasilia Flight Operations Manual, Section 2*, paragraph 2.11.3, *Flap Selection*, was as follows:

For runway approaches to aerodromes requiring Flap 45, the selection of Flap 45 shall not be made until the aircraft has been established visual. For circling approaches to aerodromes requiring Flap 45, the selection of Flap 45 shall not be made until the aircraft is positioned on final approach to the runway. In both cases, aircraft must be stabilised in the final approach configuration by 300' AGL.

The operator advised that the majority of landings conducted away from the operator's home base were to unpaved runways, and therefore required flap 45 in accordance with the manufacturer's procedures. Landings on sealed runways were almost always done in the flap 25 configuration.

The operator reported that pilots were made aware during training that once flap 45 had been selected, or when the aircraft reached 300 ft above runway elevation, the approach should be continued to landing in the event of an engine failure. Training had also included the requirement to use no more than flap 25 for single-engine approaches.

## 1.16 Flight crew endorsement and line training requirements

### 1.16.1 Regulatory requirements

Civil Aviation Order (CAO) 40.1.0 prescribed the requirements for aircraft endorsements. CAO 40.1.4.4 stated that, to fly as pilot in command or copilot, the holder of a class endorsement for the aeroplane must:

- be familiar with the systems, the normal and emergency flight manoeuvres and aircraft performance, the flight planning procedures, the weight and balance requirements and the practical application of take-off and landing charts of the aircraft to be flown’;
- have sufficient recent experience or training in the aeroplane type, or in a comparable type, to safely complete the proposed flight; and
- hold a specific endorsement for any ‘special design feature’ of the aircraft.

For aircraft with a maximum take-off weight of more than 5,700 kg, CAO 41.1.0 detailed separate syllabus requirements and conditions for acting as pilot in command and copilot. For pilot in command, these were:

- flying training was to include at least 5 hours flying time in conformity with specified criteria involving general handling, takeoff, instrument flying, asymmetric flight, and night flying, plus
- at least 50 hours flight time as pilot in command under supervision; or
- 25 hours flight time as pilot in command under supervision, and the successful completion of an approved training course in an approved synthetic trainer.

In the case of a copilot, the syllabus was to include at least 3 hours flying time, which was to cover takeoff, medium and steep turns, asymmetric flight, night flying and general handling.

For aircraft with a maximum take-off weight of 5,700 kg or less<sup>16</sup>, the CAO did not include any requirements regarding the number of flying hours the endorsement training for that weight class of aeroplane was to include.

### 1.16.2 Operator’s requirements

At the time of the occurrence, Section 2.7 of the aircraft operator’s *Flight Standards Manual* included the following information regarding endorsement training:

Although the following table specifies the minimum aircraft experience required for aircraft endorsement, the flight time necessary to meet the required proficiency standard may be more than the minimum.

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<sup>16</sup> For example, the Beech King Air 200 has a maximum take-off weight of less than 5,700 kg. The King Air 200 is a high performance, sophisticated turboprop aircraft that is used for fare-paying passenger, aerial work and private corporate operations. There were 38 King Air 200 aircraft on the Australian register at the time of publication of this report.

Aircraft type	Minimum endorsement hours
Turbo-prop < 5700 kg	5
Turbo-prop > 5700 kg command	5
Turbo-prop >5700 kg	3

The hours required for an endorsement to be conducted in the simulator are detailed in the type specific training manual.<sup>[17]</sup>

The syllabus for flight training for the relevant aircraft endorsement is contained in the applicable type specific training manual.

Aircraft endorsement training is currently conducted in the aircraft with the exception of the Dash 8 and Metro aircraft whereby the endorsement training may be conducted in the appropriate Flight Simulator.

Section 2.10.3 of the *Flight Standards Manual* stated that:

...at the completion of a check to line, the candidate must have completed at least:

- In the case of EMB-120 pilot in command, 50 hours in command under instruction, and
- In the case of EMB-120 copilot, 30 hours line training.

Of relevance to the occurrence, the syllabus for EMB-120 flight training included, in Sortie # 4, a simulated emergency procedure followed by engine shutdown and restart above 8,000 ft, a simulated single-engine circuit procedure and go-around with flaps 25 set, and a single-engine approach and landing. Sortie #5 included a circuit and landing, and a go-around, in simulated asymmetric conditions. Sortie # 6 included a simulated asymmetric instrument approach and overshoot. At the time, those elements were similar to the syllabus content for other Australian operators of the EMB-120.

### 1.16.3 Other EMB-120 operators training requirements

A US-based operator of a large fleet of EMB-120 aircraft advised that:

- for passenger-carrying operations, it used a system where 80% of check flights were completed in an EMB-120 simulator and 20% in the aircraft
- the simulator was used for all endorsement and recurrent training
- EMB-120 endorsement training involved 20 hours simulator training and 2 hours aircraft training
- upgrade training from copilot to PIC involved 20 hours simulator training and 2 hours aircraft training
- up to 50 hours line training was undertaken following endorsement training.

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<sup>17</sup> The operator's *Brasilia Training Manual* did not contain any information regarding EMB-120 simulator training.

The aircraft manufacturer advised that its initial and recurrent EMB-120 training system was approved by the national regulator. Initial (endorsement) training involved 20 hours minimum and annual recurrent training involved a minimum of 8 hours, plus a check flight. The training could be completed on the aircraft or in a simulator, but was usually done in the simulator for cost and safety reasons.

## **1.17 Flight simulators**

### **1.17.1 Background**

The importance of flight simulators as efficient and effective tools in flight crew training is widely recognised and accepted. Flight crew training in some emergency procedures, including major systems failures during critical flight phases, is generally not able to be practised in an aircraft because of safety considerations. Simulators are not similarly constrained or limited.

In the case of an EMB-120 flight simulator, for example, there were about 225 separate malfunctions that could be practised to the extent where the crew operated switches and controls, and observed and experienced the outcomes, as they would in the real situation. In contrast, only about 13 emergency procedures and system malfunctions could be safely demonstrated and practiced in the actual aircraft. Training for other malfunctions that could not be safely demonstrated and practiced in the aircraft, was subject to limitations such as height restrictions, touching as opposed to operating controls and switches, or classroom discussion, which substantially reduced training effectiveness in those areas.

Large airlines generally are able to afford to purchase and operate simulators for training their own crews. Without the benefits of economies of scale afforded to large airlines, operators of smaller fleets were generally unable to afford their own simulators. That was the situation for Australian EMB-120 operators in the period leading up to the occurrence. The only means by which they could conduct simulator training was to send crews to a facility outside Australia. At the time of the occurrence, there were EMB-120 simulators in North America, South America, and Europe. The costs, both in dollar terms, and in terms of time away, of sending crews for simulator training at those locations, were significant.

### **1.17.2 Australian regulatory requirements**

At no time before the occurrence had the operator of VH-XUE used flight simulators as part of its EMB-120 flight crew training. There was no Australian regulatory requirement for simulators to be used for flight crew training and there was no EMB-120 flight simulator facility in Australia.

Civil Aviation Order (CAO) 40.1.0 (as amended) stated that ‘the person seeking the endorsement must ... undertake flying training, or training in an approved synthetic flight trainer appropriate to the type of aeroplane, in normal and emergency flight manoeuvres and procedures in that type of aeroplane’

CAO 40.2.1 (Instrument ratings) stated:

A synthetic flight trainer may be approved for the purpose for accruing instrument time as required by paragraph 8.3 of this section, and to meet specified flight test and recent experience requirements.

There was provision in the Orders for simulator training to be conducted at locations outside Australia, provided those simulators had appropriate approvals.

### **1.17.3 Overseas regulatory requirements**

#### ***USA***

The US Federal Aviation Administration (FAA) Regulations Part 121.409 – Operating Requirements: Domestic, Flag, and Supplemental Operations, Subpart N – Training Program, was titled *Training courses using airplane simulators and other training devices*. It listed the conditions under which flight simulators may be used as part of an approved training program. Those requirements included that the:

- training must include at least 4 hours at the controls for each trainee
- program includes at least the manoeuvres and procedures (abnormal and emergency) that may be expected in line operations
- program must include line oriented flight training that involved a complete crew
- approved simulator must provide training in low-altitude windshear avoidance.

#### ***Europe***

The European Aviation Safety Agency NPA No 2008-17B – draft decision on acceptable means of compliance and guidance material on the licensing and medical certification of pilots, included the following guidance in regard to flight simulators:

- A simulator shall be used for simulated asymmetric flight, if one is available.
- Simulated engine failure during takeoff must be conducted at a safe altitude unless carried out in a flight simulator.
- A flight simulator shall be used for practical training and testing if the simulator forms part of an approved type-rating course.
- Training in engine failures between  $V_1$  and  $V_2$ , in windshear at takeoff and landing, in collision avoidance system operation, and in ‘tuck under and Mach buffets after reaching the critical Mach number, and other specific flight characteristics of the aeroplane (e.g. Dutch Roll)’, shall only be conducted in a simulator.

## **Canada**

Canadian Aviation Regulation S744.115(8) included the following conditions affecting the use of flight simulators:

Synthetic training devices should be used for training at every opportunity. The term synthetic training device refers to full flight simulators and flight training devices.

Canadian air operators may use a foreign simulator for the purpose of training, licensing or checking flight crews, provided those simulators have TCA [Transport Canada] approval.

For turbo-jet aircraft, the required training may be conducted on the aeroplane only if a synthetic flight training device is not available in North America. For pressurized turbo-prop aircraft, Transport Canada encourages carriers to conduct training on the simulator, or to use a combination of training in an FTD [flight training device] and the aeroplane.

## **New Zealand**

The New Zealand Civil Aviation Rules, Part 121.579 *Manoeuvres requiring a flight simulator*, stated:

Each holder of an air operator certificate shall ensure a flight simulator is used where a non-normal or emergency manoeuvre is to be conducted during training, practice, or a competency check that—

- (1) if mishandled, would create an unacceptable risk to the aeroplane, crew members, or third parties; or
- (2) is carried out in close proximity to the ground or water; or
- (3) involves the need to fail any system for training that cannot be readily failed in the aeroplane without an unacceptable risk to the aeroplane, crew members, or third parties; or
- (4) involves actions necessary to complete any procedures required by 121.77(d) (4) that cannot be realistically carried out in an aeroplane.

### **1.17.4 Use of simulators by Australian regional operators of turboprop aircraft with 19 seat or greater capacity**

At the time of the publication of this report, there were 18 Australian operators of turboprop aircraft of 19 seats or greater capacity. The fleets of some of those operators comprised several of one aircraft type and other fleets comprised one or two of a specific aircraft type. Some fleets comprised two or three different types in a fleet size of less than 10 aircraft. As part of the investigation, a sample batch of 12 operators was surveyed regarding simulator training (because the larger single-type regional airline fleets were mature users of simulators, they were not included in the survey).

Information gained during the survey included the following:

- All operators were in favour of using simulators for initial and recurrent training, recognising the ability to undertake training in all aircraft emergency situations, along with training two-pilot operations, as the prime advantages of simulator training.

- Where there was the relevant simulator type in Australia, most operators utilised the simulator for endorsement training, while some also performed recurrent training in the simulator.
- Operators who did not utilise Australian-based simulators cited travel costs and time away as the reasons. Their preference, however, was to use simulators for endorsement and recurrent training. Those operators were located in northern and western Australia.
- In a few cases, an operator's fleet included only one or two 19-seat turboprop aircraft for which there was no simulator in Australia. Those operators reported that the costs involved in sending pilots to overseas simulator facilities were considered prohibitive, although they preferred simulator training.
- All operators who utilised simulator training reported that CRM training was an integral component of endorsement and, where applicable, recurrent training.
- CRM training for operators who did not utilise simulator training generally involved a 1-day course once per year.
- All operators thought that mandating the use of simulators for flight crew training in 19-seat turboprop aircraft was a good idea. Some operators thought that cost would be an issue in some cases and suggested some form of subsidisation would help 'level the playing field'.
- Operators not using simulators reported that they conducted emergency training in the aircraft to the extent that it could be safely undertaken. Training for other emergencies was covered 'by discussion'.
- Endorsement training in a simulator usually involved 20 to 32 hours 'flight' time, with half that time as flying pilot and the other half as monitoring pilot but functioning as part of the crew. That compared with endorsement training that was conducted solely on the aircraft, which typically involved between 5 and 7 hours flight time with a check and training pilot.
- The majority of the operators surveyed believed that generic, fixed-base flight simulators had the potential to provide significant training benefits. Some operators had their own generic simulators, which they used for training in emergency procedures and some aspects of instrument flying. However, such training had not been approved by CASA as a substitute for training in an aircraft or a type-specific full flight simulator. CASA had not discouraged the use of generic simulators, but required the operator to demonstrate the benefit before credits could be awarded for generic simulator use.
- Some operators had received bonuses from clients because they had moved to conduct training on simulators. In general, however, the use of simulators did not bring any significant advantage from external agencies such as insurance companies or clients.

#### **1.17.5 Transport category turboprop aircraft simulators in Australia**

There were organisations in Australia and internationally that operated one or more simulators and provided training to outside parties on a commercial basis. One such organisation in Australia operated simulators for the SAAB 340A/B, Metro III, Dash 8-Q100/Q200/Q300 and Beech 200 turboprop aircraft. That same organisation

acquired an EMB-120 flight simulator in mid-2008 and that facility became operational in April 2009.

The organisation reported that it had undertaken an analysis of the real cost of aircraft training compared to full flight simulator training. The results indicated that even when taking into account airfares, accommodation and allowances for aircrew, simulator training was the cheaper option. The organisation reported that aircraft operators generally look only at initial operating costs such as fuel to determine the viability of aircraft training versus simulator training. That was not a true determination when all aircraft operating costs, including: maintenance, insurance, depreciation, air navigation charges and aircraft rescheduling and crew costs were taken into consideration.

## **1.18 Recent serious occurrences involving transport category turboprop aircraft in Australia where aircraft handling was a factor**

Since 1995, there have been five serious occurrences involving transport category turboprop aircraft in Australia where aircraft handling was a factor. Aside from the subject occurrence, the others were:

- Fairchild Industries Inc SA227-AC, VH-NEJ, Tamworth, NSW 16 September 1995. Two trainee pilots were killed, and the endorsing pilot seriously injured after the aircraft was mishandled during a simulated engine failure on takeoff at night.
- Beech 1900D Airliner, VH-NTL, Williamtown, NSW 13 February 2000. During a training flight, the crew lost control of the aircraft on two occasions while conducting engine failure training exercises.
- Beech Aircraft Corporation King Air C90, VH-LQH, Toowoomba, Qld 27 November 2001. The pilot and three passengers were killed when control of the aircraft was lost following an engine failure as the aircraft became airborne.
- Fairchild Industries SA227-AC Metro III, VH-TAG, 33km ENE Canberra, ACT 21 November 2004. The crew lost control of the aircraft twice while conducting engine failure training exercises.

Summaries of those occurrences are included at Appendix D.

## 2.1 Overview

In this serious incident, the left engine lost power following fuel starvation due to lack of fuel in the left tank, which occurred at a critical stage of the flight when the aircraft was in a high drag configuration, at low speed, and close to the ground. Central to the development of the incident was the fact that the crew did not detect the engine power loss. Consequently, when the aircraft became misaligned with the runway, they initiated a go-around in the expectation of a normal aircraft response.

The crew was surprised by the significant roll and yaw, consequences of asymmetric thrust, and did not complete the standard go-around initial actions of setting engine power and selecting flaps 15, and retracting the landing gear. Those omissions severely limited the performance of the aircraft and the amount of aircraft control available to the crew. Flaps 25 was selected 24 seconds after the go-around was initiated. During that time, the aircraft turned left through about 45°, rolled to 34° left bank, the speed decreased from 110 to 96 kts, and the aircraft descended to about 250 ft above ground level (AGL). After the flaps reached 25°, aircraft performance deteriorated further with the speed in the range 95 to 97 kts for 12 seconds, and the altitude decreasing to about 50 ft AGL. The flaps were fully retracted and the landing gear retracted 3 minutes 6 seconds after the go-around was commenced. The left engine shut-off was selected 4 minutes 20 seconds after the go-around was commenced.

The stick shaker operated twice during the go-around, but because stick shaker operation was not a flight recorder parameter, the timings of those events could not be established. The recorded flight data indicated that the aircraft remained on the limit of its performance limits for about 1 minute 21 seconds after the go-around was initiated. The avoidance of a ground collision during that period was fortuitous.

The investigation identified safety factors associated with the fuel quantity indicating system, the ability of the crew to recognise the left engine power loss, and their performance during the go-around. There were clear indications that the fuel quantity measurement procedures and practices employed by the operator were not sufficiently robust to ensure that a quantity indication error was detected. The failure of that risk control provided the opportunity for other safety barriers involving both the recognition of, and the crew's response to, the power loss, to be tested. Organisational safety factors involving regulatory guidance, the operator's procedures, and flight crew practices were also identified in those two areas.

## 2.2 Fuel quantity indicating system faults

The comparison between the fuel tank contents and the fuel quantity indicator readings after the occurrence, confirmed that the left indicator was over-reading. The nature of the damage to the left tank number-6 fuel probe was consistent with the over-reading being as a result of short circuit activity in the damaged section of the wiring loom. The condition of the wiring indicated that it was likely to have been gradually deteriorating over time and due, in part, to slight rubbing of the wires against one another during normal aircraft operations. The nature and location of the damage meant that it was unlikely to have been evident during normal

maintenance activities. The consequence of the probe and loom damage was to alter system capacitance and feed erroneous signals to the fuel quantity indicator, irrespective of whether the probe was, or was not, immersed in fuel. Regardless of the nature of the fuel quantity indication system malfunction, if the crew had taken a drip stick reading before the flight, it is very likely that the left fuel quantity indicator error would have been discovered.

Analysis during the investigation of flight logs did not reveal when the fuel quantity indicator began to over-read. However, the practices of not accurately recording auxiliary power unit (APU) burn fuel quantities and of using a specific gravity value of 0.8, limited the effectiveness of the analysis. Nevertheless, it was apparent that the recorded fuel quantity data for the Empresa Brasileira de Aeronáutica S.A. EMB-120ER aircraft, registered VH-XUE, in March 2007, demonstrated characteristics that were different from the remainder of the operator's fleet, and which were not evident previously. On that basis, it is possible that errors in the fuel quantity indicating system of VH-XUE were present for some time before the fuel starvation event at Jundee.

The only prospect of the flight crew detecting the erroneous fuel quantity indication before the flight was to check the fuel quantity by a method that was completely independent of the capacitance fuel quantity indicating system. The only means of achieving that in the EMB-120 aircraft was by using the dripless measuring sticks.

## **2.3 Fuel quantity measurement**

Safety factors involving fuel quantity measurement encompassed regulatory guidance on fuel quantity checks and the operator's procedures and practices for measuring fuel quantity.

### **2.3.1 Regulatory guidance**

In broad terms, the guidance contained in the Civil Aviation Safety Authority's (CASA's) Civil Aviation Advisory Publication (CAAP) 234-1(1) (as revised in November 2006), and previously included in Civil Aviation Orders (CAOs), allowed two options for establishing fuel on board:

- full tanks, or 'a totally reliable and accurately graduated dipstick, sight gauge, drip gauge or tank tab reading'; or
- a cross-check by at least two different methods.

The CAAP did not clearly indicate whether, or why, one option had advantages, or was preferred, over the other. For example, the use of the phrase 'totally reliable' could be interpreted as meaning that the methods associated with that phrase were the only 'totally reliable' methods. The CAAP, in effect, allowed operators to choose the method that suited, or perhaps was most convenient, to them.

Two of the acceptable fuel quantity cross-check methods contained in the CAAP, involved comparing the change in electrical gauge readings with a quantity determined independently, either from a fuel consumed indicator, or from a refuelling installation. However, neither of those methods would ensure detection of a quantity indication error in cases where a gauge was under or over-reading by a constant amount, or when there was a gradually increasing error. Only in cases where fuel was added to an empty tank, or the aircraft tanks were filled to

maximum capacity, would that method reveal a gauge error (See also Section 4, Safety Actions).

The CAAP did not explain with sufficient emphasis that the purpose of the fuel quantity check was to confirm the integrity of the fuel quantity indicator, and that a 'totally reliable method' provided the highest level of assurance in that regard. The guidance, therefore, lacked clarity and direction and most likely influenced the method chosen by operators to establish fuel quantity.

### **2.3.2 Operators procedures and practices for fuel quantity check**

The fuel cross-check procedures that were published in the operator's *Brasilia Flight Operations Manual*, were a direct copy of the CAAP guidance. The operator's procedures were, therefore, consistent with the CAAP in that regard (as were the procedures of a number of other operators - See Section 1.18). The practice of checking fuel quantity by comparing added fuel with the difference in gauge readings before and after refuelling had, for the most part, become embedded within the pilot group. The complete absence (apart from two instances involving the same pilot) of recorded use of the dripless measuring sticks demonstrated a lack of understanding of the purpose of the check. It also implied a level of confidence and trust in the fidelity of the fuel quantity verification method in common use. In other words, there were signs that a culture existed within the flight crew group of undue reliance being placed on the accuracy and reliability of the fuel quantity indicating system.

The discrepancies in fuel quantity that had been recorded in the flight logs had been attributed in many instances to 'APU burn'. In some cases, noteworthy differences between the indicated fuel quantity before refuelling and the recorded residual fuel from the previous day were ignored. It is possible that, for some pilots, 'APU burn' became a convenient means of accounting for discrepancies. The practice of some pilots of ignoring a disparity between fuel quantity indication and the recorded residual fuel from the previous day until after refuelling had been completed may, at least in part, have been because there was no procedure to cover that situation. However, it might also have been because, in a general sense, discrepancies when cross checking fuel quantity appeared to have become accepted as the norm amongst crews, rather than the exception.

The evidence regarding the use of the fuel quantity totaliser indicated that there were differences across the pilot group in the way that the fuel totaliser was used. There appeared to be an incomplete understanding of the operation of the fuel totaliser amongst some of the pilots that it was a system of measurement of fuel used that was independent of the fuel quantity indicating system.

In summary, the operator's procedures and practices that were intended to control the risks associated with fuel quantity indicating systems, were ineffective.

### **2.3.3 Auditing of flight log fuel records**

The operator's auditing of fuel logs provided an opportunity for detecting errors in fuel calculations, and for checking that crews were correctly following procedures. At a higher level, it provided the opportunity for long-term statistical analysis of fuel usage of individual aircraft as well as the entire fleet. The company's audit

process was not effective in any of those areas. It did not detect several instances where differences of greater than 60 kg were noted in cross checks and there was no apparent action taken to resolve those discrepancies by the flight crew. There was also no process for analysing fuel usage trends. Long-term statistical analysis of fuel usage across the operator's fleet of EMB-120 aircraft would have highlighted the issues that were apparent from the review undertaken as part of the investigation (as detailed at paragraph 1.16.2). In turn, that might have lead to a deeper examination of the fuel quantity indicating system in VH-XUE.

### **2.3.4 Fuel low level warning system**

It is likely that the occurrence could have been avoided if the aircraft had been equipped with a fuel low level warning system that was independent of the fuel quantity indicating system. However, the certification standards against which the aircraft was designed did not require the fitment of such a system. In the past few years, following a series of fuel quantity-related occurrences, European investigation agencies have issued safety recommendations for certification standards to be enhanced to require independent fuel low level warning systems in turboprop and turbojet aircraft (see Appendix B).

## **2.4 Flight crew performance**

The absence of cockpit voice recorder data of the occurrence, limited the extent to which the crew's performance and interaction could be examined. Further, and as might be expected after such an experience, the crew's recollection of the event was incomplete in some areas. However, there was sufficient evidence available to enable some conclusions to be drawn.

There were a number of facets involving the crew's performance that could be classified as safety factors:

- The crew did not detect the loss of fuel flow to the engine, or the engine power loss. Sun glare was a possible mitigating factor in terms of the crew noticing that various warning and caution lights below the glareshield on the instrument panel had illuminated. However, it was not clear why the crew did not hear the accompanying warning chimes that, as far as could be determined, were functioning at the time of the occurrence.<sup>18</sup> Significantly, those events occurred in circumstances where the crew were engaged in flying a high workload segment of the flight and had no reason to suspect that there was not adequate fuel on board the aircraft. Further, neither crew member had been exposed to an engine power loss situation on late final approach, either in training or line operations. The situation was, therefore, novel and unique for the crew. If the crew had been exposed to engine power loss on final approach situations in a flight simulator, it is likely that their diagnosis of the situation would have been more timely and effective
- The crew did not keep the aircraft aligned with the runway during the approach. It is likely that more positive input of the flight controls would have allowed the aircraft to be kept aligned with the runway. However, the pilot flying was likely

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<sup>18</sup> There have been several previous occurrences where crews in high workload situations have not heard cockpit alarms.

to have manipulated the controls in the manner and to the extent that he had become accustomed to during normal operations. In the asymmetric situation that arose, in what was at the time a novel situation, such a technique was unlikely to have been successful. The experience reported by the pilots who attempted to replicate the occurrence in a flight simulator (See Section 1.16.1) provided an indication of the effort and difficulty the crew of VH-XUE would have had in maintaining runway alignment.

- The crew did not execute the go-around procedure. The behaviour of the aircraft after power was increased to go around was abnormal and, from the crew's perspective, without warning. The roll and pitch attitude changes reflected in the flight data occurred despite the opposite rudder and aileron inputs initially applied by the pilot flying. Although the crew performed some tasks in a coordinated manner, they were unable to devote proper attention to the correct procedure. It is likely that the unexpected behaviour of the aircraft alarmed and focused the crew to the extent that they were unable to function effectively as a crew.
- There was a delay in the crew's diagnosis of the situation. The crew's recollection of two stick shaker activations, the enhanced ground proximity warning system (EGPWS) warnings, and the recorded flight data, confirmed that the aircraft was at, or near the limits of its performance envelope until after the flaps reached the 25° position; some 35 seconds after the go-around was initiated. Subsequently, more than 3 minutes elapsed before the left propeller was feathered. The absence of cockpit voice recording information prevented the proper examination of the crew's activities during that period. Nevertheless, the delay in executing the go-around procedures provided clear evidence that the crew's actions were uncoordinated during the go-around.

The quality of the crew's performance depended largely on their ability to recognise the engine power loss, and to respond to the situation by functioning effectively as a team. There was strong evidence that the training they had received did not adequately prepare them in either of those areas.

The training the crew had completed, while meeting regulatory requirements, was not best practice for a complex, twin-engine turboprop aircraft such as the EMB-120. For important safety reasons, training in many sequences involving critical in-flight emergency situations can only be conducted in a flight simulator. Without the benefit of simulator training, the crew was not adequately equipped to effectively respond to an engine power loss on final approach in the flaps 45 configuration. A similar argument would likely apply to many other possible emergency situations in the aircraft. In that regard, the operator of VH-XUE was probably no different to many other Australian operators of turboprop aircraft when flight crew training is conducted without access to a flight simulator.

## **2.5 System for communicating important occurrence information to operators**

The information regarding the January 2005 fuel starvation event involving an EMB-120 aircraft from another operator was known by a number of parties, but not the operator of VH-XUE. Receipt of that information by the operator of VH-XUE would have provided an opportunity for the occurrence to be avoided.



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## 3

## FINDINGS

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From the evidence available, the following findings are made with respect to the engine power loss and near loss of control involving Empresa Brasileira de Aeronáutica S.A., EMB-120ER, registered VH-XUE, at Jundee, WA, on 26 June 2007 and should not be read as apportioning blame or liability to any particular organisation or individual.

### 3.1 Contributing safety factors

- Regulatory guidance regarding the measurement of fuel quantity before flight lacked clarity and appropriate emphasis and did not ensure that the fuel quantity measurement procedures used by operators included two totally independent methods. *[Safety issue]*
- The practices used by the operator's pilots for measuring and logging of fuel quantity were inconsistent. *[Safety issue]*
- Faults within the fuel quantity indicating system caused the left fuel quantity indicator to over-read.
- The left engine lost power when the fuel in the left tank was exhausted.
- The flight crew did not detect the engine power loss.
- The aircraft became misaligned with the runway.
- The flight crew did not complete the go-around procedure actions.
- There was a significant delay before the crew configured the aircraft appropriately for one-engine inoperative flight.
- The absence of simulator training meant that the endorsement and other training the flight crew had undergone did not adequately prepare them for the event. *[Safety issue]*
- There was no regulatory requirement for simulator training in Australia. *[Safety issue]*
- The minimum requirements for endorsement training where simulator training was not involved did not ensure pilots were aware of indicators and/or aircraft behaviour during critical emergency situations. *[Safety issue]*
- The aircraft operator was not aware of important safety-related information regarding the EMB-120 fuel system. *[Safety issue]*

### 3.2 Other safety factors

- There was no EMB-120 flight simulator training facility in Australia.
- The aircraft was not equipped with a fuel low level warning system.
- The certification standard to which the aircraft was built did not require the aircraft to be equipped with a fuel low level warning system. *[Safety issue]*



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## 4 SAFETY ACTIONS

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The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

### 4.1 Aircraft operator

#### 4.1.1 Fuel measuring procedures

##### ***Safety issue***

The practices used by the operator's pilots for measuring and logging of fuel quantity were inconsistent.

##### ***Action taken by the 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%
- all flight logs to be checked on a daily basis
- the conversion factor for Jet A1 fuel to be changed from 0.8 kg/L to 0.785 kg/L.

##### ***ATSB assessment of response/action***

The action taken by the operator appears to adequately address the safety issue.

#### 4.1.2 Pilots inadequately prepared for event

##### ***Safety issue***

The absence of simulator training meant that the endorsement and other training the flight crew had undergone did not adequately prepare them for the event.

### ***Action taken by operator***

In April 2009, following the certification of an Empresa Brasileira de Aeronáutica S.A., EMB-120 flight simulator in Melbourne, Vic., the operator began utilising the simulator for its EMB-120 flight crew training.

### ***ATSB assessment of response/action***

The action taken by the operator appears to adequately address the safety issue.

## **4.2 Civil Aviation Safety Authority**

### **4.2.1 Fuel measuring procedures**

#### ***Safety issue***

The practices used by the operator's pilots for measuring and logging of fuel quantity were inconsistent.

#### ***Action taken by the Civil Aviation Safety Authority***

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

On 26 September 2008, CASA provided the following details regarding the actions it had taken in response to the occurrence involving VH-XUE:

#### **A summary of CASA activities regarding the aircraft operator since 3 July 2007**

CASA has taken the following actions following the 26 June 2007 incident:

- Simultaneously with the ATSB investigation, CASA has conducted a review of [the operator].
- Issued a [Civil Aviation Regulation] CAR 215 direction to the operator in relation to fuel measurement.

- Issued a Show Cause Notice (SCN) and Supplementary Show Cause Notice (SSCN) to the operator:
  - The SCN was issued following initial enquiries into the fuel exhaustion incident at Jundee;
  - the enquiries indicated serious deficiencies in the determination of fuel quantity on board the aircraft and significant training inadequacies in crew understanding, identification, implication and handling of engine failure and asymmetric flight in the approach to land phase of flight; and
  - the SSCN was issued when further investigation led to the conclusion that there were gross deficiencies within the organisation in being able to ensure appropriate flight safety outcomes.
- Conducted audits and operational surveillance activities.
- Held a show cause conference.
- Investigated the chief pilot for administrative anomalies:
  - A Part IIIA investigation was not undertaken. Following the receipt of anecdotal advice that the Chief Pilot's flight and duty time documents were being altered, CASA issued a demand for his log book and related documentation to be produced; and
  - following review, the anecdotal information could not be substantiated....
- The operator's AOC was varied to include new conditions:
  - 34 conditions were appended to the organisation's AOC that imposed specific requirements upon all the accountable key personnel and which affected the flight operations, training, maintenance and safety departments of the organisation<sup>19</sup>.
- Issued CAR 215 direction on aircrew proficiency.
- Observed changes in the operations manual that incorporated revised procedures for:
  - Fuel measurement for flight;
  - Pilot training; and
  - Proficiency check for aircrews.
- Following an extensive audit of [the operator], CASA noted that the company's CEO elected to leave the company.

CASA continues to undertake systems and operational surveillance of [the operator].

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<sup>19</sup> The aircraft operator reported that all 34 conditions were addressed and subsequently removed as conditions on the operator's Air Operators Certificate.

### ***ATSB assessment of response/action***

The action taken by CASA appears to adequately address the safety issue.

## **4.2.2 Regulatory guidance for fuel quantity measurement**

### ***Safety issue***

Regulatory guidance regarding the measurement of fuel quantity before flight lacked clarity and appropriate emphasis and did not ensure that the fuel quantity measurement procedures used by operators included two totally independent methods.

### ***Action taken by the Civil Aviation Safety Authority***

On 26 September 2008, CASA advised:

#### **The status of CASA's review of its guidance material relating to separate processes for fuel quantity measurement checks**

The second edition of the Air Transport Communication (AT com)<sup>20</sup> advised of impending amendments to Civil Aviation Advisory Publication (CAAP) 234. In amending CAAP 234, clear guidance will be given to industry regarding the two independent means of ensuring the correct amount of fuel is onboard an aircraft.

The amended CAAP 234 will emphasise the responsibilities of the Pilot-in-Command and the operator in adhering to the manufacturer's guidance in determining the amount of fuel onboard an aircraft.

CASA would like to emphasise the point that crews utilise all means provided by the manufacturer to ascertain correct fuel quantity. In this instance there was a manufacturer's recommended procedure that aircraft fuel quantity is independently confirmed using a separate facility incorporated into the aircraft. Had this crew followed that guidance, the incident would not have experienced its near catastrophic outcome.

The second edition of the AT com advised industry that changes to CAAP 234 were forthcoming. The AT com is intended as an informal means of raising topical issues inclusive of alerting operators of intended changes. CASA is not reliant on it to convey the information as variations documentation is undertaken through our formal process.

The process of amending CAAP 234 is currently being undertaken and this involves detailed consultation with various stakeholders.

#### **A summary of any changes to CASA regulatory oversight activities relating to fuel management or fuel quantity cross-checking processes**

Fuel quantity cross-checking processes have been added as a distinct element within operational surveillance activities. Where a deficiency in the fuel cross checking procedures is identified, it is raised with the operator. The matter remains under close scrutiny until resolved to the satisfaction of CASA.

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<sup>20</sup> On 1 March 2009, CASA changed the name of the publication from *AT com* to *CASACom*.

### ***ATSB assessment of response/action***

The ATSB is concerned that, at the time of publication of this report, the CAAP 234-1(1) amendment had still not been released. The ATSB will continue to monitor the progress of the CAAP review.

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

It is possible that there are other examples among turboprop 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. On 14 September 2007, the ATSB issued AO-2007-017-Safety Advisory Notice-013, which stated:

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.

On 25 February 2008, the ATSB advised CASA and all Australian operators of EMB-120 aircraft of the investigation report regarding the EMB-120 engine power loss occurrence in Europe on 20 February 2008. In the meantime, the ATSB re-emphasises AO-2007-017-Safety Advisory Notice-013 (above), which was initially issued on 14 September 2007.

## **4.2.3 No regulation for simulator training**

### ***Safety issue***

There was no regulatory requirement for simulator training in Australia.

### ***Action taken by the Civil Aviation Safety Authority***

A summary of CASA activities to facilitate the use of full flight simulators and/or flight training devices follows:

The following inter-related activities are in the process of implementation:

- A combined workshop activity with Ansett Aviation Training, Capiteq Limited trading as AirNorth, Network Aviation Pty Ltd, Skippers Aviation Pty Ltd, PelAir Aviation Pty Ltd and CASA was held on 27, 28 April 2009.
- CASA has initiated a review of CAR 217 Training Organisations and Training Centres. This programme of review was prompted following investigations that revealed AOC holder training inconsistencies.
- A Component of the 'CAR 217 Training Organisations and Training Centres Special Emphasis Review' is to establish the level of company oversight and involvement with training and simulation, programmes that have been outsourced.
- Civil Aviation Order 40.2.1 - Instrument Rating, Section 12A, 'Renewal using an overseas flight simulator training provider' has been added to include the option of instrument proficiency checks being conducted by an overseas simulator provider. This is to enable an instrument rating renewal where a specific type simulator is not available in Australia:
  - This amendment needs to read in conjunction with Advisory Circular AC 60-2 (1) of May 2007;
  - The Advisory Circular identifies that CASA recognises the flight simulator qualifications certificates issued by Canada, Hong Kong (Special Administrative Region of China), New Zealand, the United States of America, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom; and
  - Civil Aviation Order 40.1.0 - Aircraft Endorsement - Aeroplanes, Section 6. This facilitates an option for instrument rating renewals to be associated with the issue of an aircraft type rating.

### ***ATSB assessment of response/action***

The activities undertaken by CASA appear to have facilitated increased use of simulators for endorsement and other training. However, the ATSB remains concerned that there is no regulatory requirement for simulator training when a suitable simulator is available in Australia.

### **ATSB safety recommendation AO-2007-017-SR-084**

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority address this safety issue.

#### **4.2.4 Requirements for endorsement training**

##### ***Safety issue***

The minimum requirements for endorsement training where simulator training was not involved did not ensure pilots were aware of indicators and/or aircraft behaviour during critical emergency situations.

##### ***Response from the Civil Aviation Safety Authority***

On 28 April 2009, CASA advised as follows:

CASA has identified that there is a risk of interpretive conflict within [Civil Aviation Order] CAO 40.1.0. As a result, this CAO is under review to identify further areas of similar risk. Once complete, the results of this review will be dealt with at the Executive level of CASA.

In amplification of its response, CASA advised that the reference to ‘interpretive conflict’ related to the requirements in CAO 40.1.0 that made reference to aspects associated with aircraft complexity (including familiarity ‘with the systems, the normal and emergency flight manoeuvres and aircraft performance, the flight planning procedures, the weight and balance requirements and the practical application of take-off and landing charts of the aircraft to be flown’) compared to the minimum conditions (flying time) for acting as pilot in command and co-pilot (see 1.16.1).

##### ***ATSB assessment of response***

The ATSB acknowledges the information provided by CASA. The ATSB will monitor the progress of the review of CAO 40.1.0.

#### **4.2.5 Dissemination of safety information**

##### ***Safety issue***

The aircraft operator was not aware of important safety-related information regarding the EMB-120 fuel system.

##### ***Action taken by the Civil Aviation Safety Authority***

On 28 April 2009, CASA advised:

The CASA Communication (CASACom) publication, previously known as the Air Transport Communication (ATCom) has been developed to allow the Civil Aviation Safety Authority to promptly communicate identified safety and operational issues to all Air Operator Certificate holders and is available on the CASA website.

##### ***ATSB assessment of response/action***

The action taken by CASA appears to adequately address the safety issue.

#### **4.2.6 Other safety action taken by the Civil Aviation Safety Authority**

Although not identified as a safety issue during this investigation, in June 2007, CASA undertook a review of a number of low capacity air transport operators. The aim of that review was to enable CASA to prioritise its surveillance of those operators. A summary of that review, known as the 'T13 initiative', follows:

In June 2007, CASA reviewed general aviation operators who were conducting significant passenger carrying operations, and in relation to which oversight responsibilities were due to be transferred from the General Aviation Operations Group (GAOG) to the Air Transport Operations Group (ATOG) in December 2007. The original list comprised of 19 operators, but this was subsequently reduced to 13. The review assessed the risk of each operator to assist in prioritising future surveillance of the operators. [The operator] was not part of this process.

### **4.3 Aircraft certification authorities**

#### **4.3.1 Fuel low level warning**

##### ***Safety issue***

The certification standard to which the aircraft was built did not require the aircraft to be equipped with a fuel low level warning system.

##### ***Action taken by other investigating bodies***

The investigation of a number of similar occurrences by the Irish Air Accident Investigation Unit (AAIU), the Italian Agenzia Nazionale per la Sicurezza del Volo (ANSV), and the UK Air Accident Investigation Branch (AAIB) identified a similar safety issue. In each case, the response by those investigation agencies was to issue safety recommendations that sought the enhancement of the relevant certification standards to require the installation of independent fuel low level warning systems in turboprop and turbojet aircraft.

##### ***ATSB assessment of response/action***

The recommendations by the Irish AAIU, Italian ANSV, and the UK AAIB appear to adequately address this safety issue.

## 4.4 Aircraft manufacturer

### 4.4.1 Dissemination of safety information

#### ***Safety issue***

The aircraft operator was not aware of important safety-related information regarding the EMB-120 fuel system.

#### ***Action taken by Empresa Brasileira de Aeronáutica S.A.***

The aircraft manufacturer confirmed that any issues submitted to the Air Safety Department were analysed for possible impact on other operators and disseminated via Air Safety Representative located around the world. They disseminated information, to all operators, of the two events that were advised of and subsequently sought details of the third event once there were aware of it.

#### ***ATSB assessment of response/action***

The action taken by Empresa Brasileira de Aeronáutica S.A. appears to adequately address the safety issue.

### 4.4.2 Other safety action taken by the aircraft manufacturer

As a result of this and other similar EMB-120 incidents, the following safety actions were also taken by the aircraft manufacturer in order to provide additional guidance to flight crews.

#### ***Amendment to maintenance manuals***

At the time of the occurrence, the Empresa Brasileira de Aeronáutica S.A. EMB-120 Maintenance Manual included a section titled *Fuel Quantity Indication System – Inspection/Check*. The manual required a general visual inspection of the fuel quantity indication system wiring harness to be conducted and stated that if repair was required, the procedures detailed in the aircraft Wiring Manual should be followed.

In April 2007, the manufacturer amended the wiring manual to include the following:

#### CAUTION

DO NOT PERFORM ANY KIND OF REPAIR TO WIRES OR CABLES INSIDE FUEL TANKS.

#### 4. Splicing Fuel Critical Cables

WARNING: DO NOT REPAIR THE FUEL CRITICAL CABLE HARNESS. IF YOU DO NOT OBEY THIS PRECAUTION, AN EXPLOSION CAN OCCUR IN THE FUEL TANKS.

A. Replace the whole segment of damaged fuel critical cables. Splicing fuel critical cables is not permitted.

On 17 March 2008, Embraer issued Service newsletter (SNL) 120-28-0008 which ‘...inform[s] the operators about the instructions for the FQIS in-tank harness installation, in order to avoid the possibilities of FQIS wiring chafing with other components installed in the fuel tanks’. A copy of that newsletter is at Appendix D.

***Flight crew procedures in the event of engine failure***

On 14 May 2008, the manufacturer issued Operational Bulletin No 120 – 001/08 that was applicable to all EMB-120 aircraft operated under ANAC (Agência Nacional de Aviação Civil (Brasil)) certification.

**II - SUBJECT: ENGINE FAILURE ABNORMAL PROCEDURE**

**III - REASON:**

This Operational Bulletin is being issued to provide the EMB-120 operators under ANAC certification with a revised engine failure abnormal procedure.

**IV - BACKGROUND INFORMATION:**

Instances have been reported to EMBRAER of difficulties to perform a one engine inoperative go-around after an engine failure during final approach. Such difficulties are related to the fact that the propeller of the affected side had not been confirmed feathered before the airplane was commanded to perform the go-around.

Current ANAC approved EMB-120 Airplane Flight Manual (AFM) Engine Failure abnormal procedure already addresses the event of an engine failure. Nevertheless, since the mentioned engine failure event may require flight crew action before the level-off altitude is reached, case in which the checklist is consulted by the flight crew, EMBRAER understands that the current ANAC approved EMB-120 AFM Engine Failure abnormal procedure needs to be revised in order to include memory item steps.

It is EMBRAER recommendation that all EMB-120 operators do adequate flight crew update training regarding this revision to the Engine Failure abnormal procedure.

**V - OPERATING INFORMATION:**

If an engine failure occurs, the following procedure must be observed:

**ENGINE FAILURE**

- |   |
|---|
| 1. Power Lever (affected engine) .....FLT IDLE                    |
| 2. Condition Lever (affected engine) .....FEATHER, AND THEN CHECK |
| 3. ELEC FEATHER Switch.....ON, THEN CHECK                         |
| PROPELLER FEATHERING  |

Precautionary Engine Shutdown .....PERFORM

**CAUTION:** IF DET INOP ENG/WW OR DET INOP PIPE ZONE LIGHT ILLUMINATES SIMULTANEOUSLY WITH ENGINE FAILURE, APPLY ENGINE FIRE PROCEDURE.

**VI - TECHNICAL PUBLICATION INFORMATION:**

The Airplane Flight Manual (AFM-120/813) and the Quick Reference Handbook (QRH-120/1023) will be revised to incorporate this information.

## **4.5 Ansett Aviation Training**

### **4.5.1 No EMB-120 flight simulator training facility in Australia**

Although not identified as a safety issue, as a result of this investigation, on 15 April 2009, the following advice was received from Ansett Aviation Training in regard to the availability of an EMB-120 flight simulator training facility in Australia:

Until recently it was cost prohibitive for many operators to consider full flight simulator training for their flight crew, as most of the simulator devices were located overseas. The owners of Ansett Aviation Training recently invested in excess of 35 million dollars creating the largest pilot training and simulator centre in the Southern Hemisphere. During the development stage of the new centre, CASA indicated that there would be legislation introduced that would require operators to utilize full flight simulators for pilot training should these devices be located in Australia. The selection of full flight simulators for the centre was driven by this planned requirement together with the subsequent commercial viability of each device. The Embraer 120, Fokker F100 and the King Air 200 full flight simulators were purchased and CASA certified the devices for endorsement and other pilot training requirements.

It is evident looking at the Australian regional airline industry and aerial work operators, that following the pilot shortage of the previous few years, the experience level of the pilot work force is low. Experience pilots flowed through to the major airlines and young inexperienced pilots were taken on by the regional airlines. Our experience has been that most of these young pilots have never been inside a full flight simulator and are not aware of the training advantages of these devices. In some instances, the chief pilot and training managers have never trained in a full flight simulator and have not experienced the level of training that can be achieved.

This situation resulted in Ansett Aviation Training programming educational workshops for operators of aircraft types applicable to our full flight simulators. A successful workshop was held some time ago to promote full flight simulator training in the Metro III/23 simulator and this resulted in many operators now using this device for their pilot training needs. A workshop and discussion forum is planned for Embraer 120 aircraft operators and is scheduled for the 28th April 2009. The workshop will introduce the full flight simulator over a number of sessions over the two days demonstrating some of the 225 separate malfunctions possible on the device. We will be looking at standardization of training and syllabus and to look at identifying those check and training personnel who need to be familiar with the operation of the simulator for their own needs. All EMB 120 operators have indicated that they will take part and each operator will be sending several key training personnel for the two day forum. We have also included the Embraer aircraft representative for the Asia Pacific region and are endeavouring to acquire the attendance of representatives from operator insurance companies. [A] CASA Internal Audit and Standards Officer will be attending and addressing the forum...

We have completed analysis into the real cost of aircraft training verses full flight simulator training. It is easy to show that even when taking into account airfares, accommodation and allowances for aircrew, simulator training is the cheaper option. Often an operator will only look at initial operating costs such as fuel etc to determine the viability of aircraft training verses simulator training. This is not a true determination when all aircraft operating costs, including maintenance, insurance, depreciation, air navigation charges and aircraft re-scheduling and crew costs are taken into consideration. I believe that any legislation requiring simulator training for aircrew will not be an added financial burden to operators.

On 28, 29 April 2009, a workshop and discussion forum to introduce the new Embraer Brasilia simulator involving all Australian operators of EMB-120 aircraft was held at the Ansett Aviation Training facility. Subsequently, flight crew training on the EMB-102 simulator began. Flight crew from the operator of XUE were among the first crews to undertake training in the EMB-120 simulator.

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## APPENDIX A: FUEL LOW LEVEL WARNING SYSTEMS: PREVIOUS OCCURRENCES AND RECOMMENDATIONS

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The EMB-120 aircraft was designed under Part 25 of the US Federal Aviation Regulations (FARs). Although fuel low level warning systems are not specifically required for Part 25 aircraft, many aircraft in that category are equipped with those systems. In some cases, however, the design of those systems has been questioned following fuel quantity indicating systems being implicated in air safety occurrences.

For example, in an investigation into a British Aerospace J-31 accident (21 May 2000)<sup>21</sup>, the US National Transportation Safety Board (NTSB) noted that the aircraft was equipped with low fuel quantity lights for each tank on the instrument panel. However, the position and characteristics of the lights meant that they could be easily overlooked, even when illuminated.

An Irish Air Accident Investigation Unit (AAIU) report into an ATR-42 incident (8 August 2003)<sup>22</sup> found that, although that aircraft had fuel low level warning, the warning was not independent of the fuel gauges. The final investigation report (August 2005) included the following recommendation:

The European Air Safety Agency (EASA) should review the certification criteria for public transport aircraft low fuel contents warning systems, with a view to requiring such systems to be independent of the main contents gauging systems.

The Italian safety investigation agency, Agenzia Nazionale per la Sicurezza del Volo (ANSV), issued a similar recommendation to EASA following the accident involving an ATR-72 offshore of Palermo Airport (6 August 2005).<sup>23</sup>

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21 NTSB Accident No. DCA00MA052, Executive Airlines, British Aerospace J-31, N16EJ, Bear Creek Township Pennsylvania, 21 May 2000. The right engine stopped due to fuel starvation and there was intermittent stoppage of the left engine due to fuel starvation. Due to communication problems, the crew probably thought more fuel had been added to the tanks prior to the last flight than was actually added. The 19 people on board were fatally injured.

22 AAIU Formal Report No: 2005-014, Serious Incident to ATR 42, EI-CBK, near Dublin, 8 August 2003. During a regular passenger flight, the right engine stopped due to fuel starvation. The crew declared an emergency and diverted the flight for an uneventful single-engine landing. The fuel gauge had been providing erroneous indications for several weeks prior to the incident.

23 The final report for this accident has not been released. The ATR-72 aircraft ditched after both engines ceased operating due to fuel exhaustion. At the time, the fuel quantity indicator (FQI) was indicating 1,800 kg even though the fuel tanks were empty. That situation arose because the FQI had been replaced with one applicable to ATR-42 model aircraft. Of the 39 people on board, 16 were fatally injured.

Following an incident involving an Airbus Industrie A340 aircraft (8 February 2005)<sup>24</sup>, the UK Air Accident Investigation Branch (AAIB) issued four recommendations relating to low fuel level warning systems. These were:

AAIB Safety Recommendation 2005-108: It is recommended that the European Aviation Safety Agency introduces into CS-25 the requirement for a low fuel warning system for each engine feed fuel tank. This low fuel warning system should be independent of the fuel control and quantity indication system(s).

AAIB Safety Recommendation 2005-109: It is recommended that the European Aviation Safety Agency should review all aircraft currently certified to EASA CS-25 and JAR-25 to ensure that if an engine fuel feed low fuel warning system is installed, it is independent of the fuel control and quantity indication system(s).

AAIB Safety Recommendation 2005-110: It is recommended that the USA's Federal Aviation Administration should introduce into FAR-25 a requirement for a low fuel warning system for each engine feed fuel tank. This low fuel warning system should be independent to the fuel control and quantity indication system(s).

AAIB Safety Recommendation 2005-111: The Federal Aviation Administration should review all aircraft currently certified to FAR-25 to ensure that if an engine fuel feed low fuel warning system is installed, it is independent of the fuel control and quantity indication system(s).

EASA responded to the AAIB, stating that it agreed with the recommendations and was developing plans to amend the relevant legislation by 2009. The AAIB accepted EASA's responses.

In its response to AAIB recommendation 2005-110, the FAA stated<sup>25</sup>:

As noted within the Discussion section of the AAIB Safety Recommendation (File Ref:EW/C2005/02/03): "It could be argued that the need to indicate fuel system failures to the crew on complex aircraft is covered by EASA CS-25 1309 para c." The AAIB goes on to state that: "Indeed, when the fuel control system is operating normally on the A340-600 this is true, but this incident demonstrated a need for more specific requirements for certain warnings such as low fuel level in an engine feeder tank".

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24 AAIB Report on the incident to Airbus A340-642, registration G-VATL en-route from Hong Kong to London Heathrow on 8 February 2005. The number one engine lost power and ran down due to fuel starvation. A few minutes later, the number four engine started to lose power. Fuel had not been transferring from the centre, trim and outer wing tanks to the inner wing tanks due to a computer problem. Although transfer was partially achieved, the expected indications of fuel transfer in progress were not displayed so the commander decided to divert to Amsterdam where the aircraft landed safely on three engines.

25 AAIB, Progress Report 2007: Responses to Air Accidents Investigation Branch (AAIB) Safety Recommendations, pp.8-9.

Compliance with 25.1309 (c) is just as relevant during any anticipated failure condition as it is when the system is operating normally. Traditional designs may not have effectively met the intent of 25.1309 (c)<sup>26</sup> for certain "unsafe system operating conditions", including "low fuel level in an engine feeder tank". As evidenced by the Notice of Proposed Rulemaking (NPRM) (NO. 87-3) published in the Federal Register on May 12, 1987 (52 FR 17890), titled "Low Fuel Quantity Alerting System Requirements for Transport Category Airplanes" the FAA once agreed with the AAIB that this "demonstrated a need for more specific requirements".

While adding a more specific rule may focus special attention and unique provisions onto a particular "unsafe system operating condition" , it will not relieve an applicant of the obligation of complying with 25.1309 (c) for that condition. After considering the comments from NPRM 87-3 and reviewing all the relevant service history, the FAA has concluded that there is no need for any new regulatory provisions in this case. The addition of a more specific requirement will be redundant to those regulatory objectives already covered by 25.1309 (c). Furthermore, promulgation of a more specific requirement could inadvertently impede future design innovation and would not be an efficient use of our limited rulemaking resources.

The FAA now intends to develop clearer 25.1309 (c) compliance guidance in the form of an interpretive policy on this issue. Successful completion of that action would effectively address FAA Safety Recommendation 06.006.

The AAIB classified this response, and the FAA response to recommendation 2005-111, as 'Rejected'.

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<sup>26</sup> US Federal Aviation Regulation 25.1309 (Equipment, systems, and installations), paragraph (c) stated: Warning information must be provided to alert the crew to unsafe system operating conditions, and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors which could create additional hazards.



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## **APPENDIX B: FUEL STARVATION-RELATED OCCURRENCES INVOLVING AUSTRALIAN REGISTERED AIRCRAFT OTHER THAN EMB-120 AIRCRAFT SINCE JANUARY 2005**

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### ***Fairchild Metro III, 23 September 2005 (BO/200504768)<sup>27</sup>***

At 1910 Eastern Standard Time on 23 September 2005, a Fairchild Industries Inc. Model SA227-AC (Metro III) aircraft, registered VH-SEF, departed Thangool on a scheduled flight to Brisbane, Qld. There were two pilots and 16 passengers on board. Approaching overhead Gayndah, the L XFER PUMP (left fuel transfer pump) amber caution light illuminated, indicating low fuel quantity. The fuel quantity indicator showed substantial fuel in the tanks. The crew completed the checklist actions but the light remained on so they diverted the flight to Bundaberg. About 18 km from Bundaberg, the left engine stopped. The crew subsequently completed a single-engine landing at Bundaberg.

Four pounds (2 L) of fuel was subsequently drained from the left tank, indicating that the left engine stopped because of fuel starvation. There was 49 lbs (28 L) of fuel in the right tank, sufficient for about 10 minutes flight.

Faults were found in a number of components of the fuel quantity indicating system. The maintenance manual procedures for calibration of the fuel quantity indicating system had not been followed correctly on two occasions in the previous 10 days. The result was that the fuel quantity indicating system was over-reading. The crew relied on the fuel quantity indicator to determine the quantity of fuel on the aircraft before the flight. That practice was common to most of the operator's crews. The fuel quantity management procedures and practices within the company did not ensure validation of the aircraft's fuel quantity indicator reading. There was also no system in place to track the aircraft's fuel status during and after maintenance. The aircraft type was fitted with dripsticks.

### ***Boeing Co B747-338, 5 February 2007 (BO/200700368)<sup>28</sup>***

On 5 February 2007, the crew of a Boeing Co 747-338, registered VH-EBY, shutdown the number 3 engine in flight, due to a fuel-related problem, approximately 256 km from the destination airport.

Approaching the top of descent, the crew noticed that the number 3 main fuel tank quantity indicator was reading zero, and that both fuel-boost pump low pressure lights had illuminated. The crew then shut down the number 3 engine, declared a PAN and the flight continued for an uneventful landing at Melbourne.

The subsequent investigation by engineering personnel found that the number 3 main fuel tank was empty. An 'over read' malfunction in the number 3 fuel quantity

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27 The final safety investigation report is available at [http://www.atsb.gov.au/publications/investigation\\_reports/2005/AAIR/air200504768.aspx](http://www.atsb.gov.au/publications/investigation_reports/2005/AAIR/air200504768.aspx)

28 The final safety investigation report is available at [http://www.atsb.gov.au/publications/investigation\\_reports/2007/AAIR/air200700368.aspx](http://www.atsb.gov.au/publications/investigation_reports/2007/AAIR/air200700368.aspx)

indicator system (FQIS) had caused the crew to believe there was a greater quantity of fuel remaining in that tank than was actually present. The planned quantity of fuel for arrival at Melbourne for the number 3 tank was 2,500 kg. The investigation determined that the malfunction was caused by either an electrical malfunction, water contamination or a combination of both.

The FQIS system fault was rectified and the aircraft returned to service.

Investigation by the operator's safety group found that the refuelling procedures current at the time were not able to accurately verify the base line quantity of fuel on board, or to alert the flight crew or line engineers to the consequences of an erroneous FQIS indication. The investigation also reviewed the refuelling procedures for all other of the company fleet types to ensure serviceability of those installations. As a consequence a series of recommendations were made requiring amendments to the published refuelling procedures and including revision of the risk management process, intended to prevent a possible recurrence of the incident events.

### ***Cessna Aircraft Company C404 Titan, 18 October 2007 (AO-2007-049)<sup>29</sup>***

On 18 October 2007, the pilot of a Cessna Aircraft Company C404 Titan aircraft was conducting a charter flight from Adelaide Airport, SA to Parafield Airport, Beverley airstrip, and return to Adelaide. The pilot had commenced descent into Adelaide on the final sector of the flight when the right engine lost power. There were no apparent anomalies and the fuel quantity gauges were showing adequate fuel in each tank. After securing the right engine, the pilot continued to Adelaide Airport and landed without further incident.

Aircraft maintenance engineers who inspected the aircraft reported that 3 L of fuel was drained from the right tank and 90 L was drained from the left tank. The fuel quantity gauge was indicating 150 lbs (95 L) in the right tank. An engineer found that one of the electrical circuits in the right fuel quantity indicating system had a high resistance. After wiring in the circuit was repaired, the fuel quantity gauge correctly indicated zero fuel in the right tank. Calibration of the fuel quantity indicating system was carried out and during that process, the left and right signal conditioners were found to be unreliable and were replaced or repaired.

The operator amended its fuel documentation and fuel planning procedures to include a secondary means of verification of fuel on board to cross check the electric fuel indication system.

### ***Fairchild Metro III, 20 December 2007***

The pilot in command submitted the following report to the ATSB:

After my arrival it was discovered that the aircraft had been refuelled twice and by fuel records alone 3,500 lbs of fuel should have been on board. The fuel flow totaliser indicated that 200 lbs of fuel had been used. It was assumed that this amount was used during engine ground running for maintenance purposes. As a result the fuel on board should have been 3,300 lbs.

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29 The final safety investigation report is available at [http://www.atsb.gov.au/publications/investigation\\_reports/2007/AAIR/aair200706444.aspx](http://www.atsb.gov.au/publications/investigation_reports/2007/AAIR/aair200706444.aspx)

The serviceable left tank fuel gage indicated 1,100 lbs of fuel [the right fuel gauge was unserviceable as per the aircraft MEL], well short of the expected value of 1650lbs. Both tank fuel quantities were checked utilizing the Magna-stick which indicated that at least a total of 2,100 lbs of fuel was in the fuel tanks. (The magna-sticks are only accurate between 130 and 1,050 lbs of fuel/tank) Endurance was planned on 2,100 lbs of fuel, performance was planned on the fuel record value of 3,300 lbs and the flight conducted without incident.

After landing, the magna-sticks revealed that 1,100 lbs of fuel remained in the tanks. Based on the fuel used for the flight of 1,300 lbs and the fuel remaining, we had departed Brisbane with 2,400lbs of fuel some 900 lbs of fuel less than the flight record sheet suggested.

I contacted ... to enquire if any maintenance had been performed on the fuel tanks ... and was told that both tanks had been drained into... to enable fault finding on the unserviceable right fuel gauge.

As the fuel remaining figure of 1,000 lbs on flight record sheet 59278 [from the previous flight] had been drained this explains the discrepancy of 900 lbs of fuel.

It appears that we have no system in place to track the aircrafts fuel status during and after maintenance.



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## APPENDIX C: RECENT SERIOUS OCCURRENCES INVOLVING TRANSPORT CATEGORY TURBOPROP AIRCRAFT IN AUSTRALIA WHERE AIRCRAFT HANDLING WAS A FACTOR

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### *Fairchild Industries Inc SA227-AC, VH-NEJ, Tamworth, NSW 16 September 1995*

The flight was the second Metro III type conversion training flight for the copilot. Earlier that night, he had completed a 48-minute flight.

During the briefing prior to the second flight, the check-and-training pilot indicated that he would give the copilot a  $V_1$  cut during the takeoff. The copilot questioned the legality of conducting the procedure at night. The check-and-training pilot indicated that it was not illegal because the company operations manual had been amended to permit the procedure. The crew then proceeded to brief the instrument approach, which was to be flown following the  $V_1$  cut. There was no detailed discussion concerning the technique for flying a  $V_1$  cut.

The copilot conducted the takeoff. Four seconds after the aircraft became airborne, the check-and-training pilot retarded the left engine power lever to flight idle. The landing gear was selected up 11 seconds later. After a further 20 seconds, the aircraft struck the crown of a tree and then the ground about 350 m beyond the upwind end of the runway and 210 m left of the extended centreline. It caught fire and was destroyed. The copilot and another trainee on board the aircraft were killed while the check-and-training pilot received serious injuries.

The investigation found that the performance of the aircraft was adversely affected by:

- the control inputs of the copilot; and
- the period the landing gear remained extended after the simulated engine failure.

The check-and-training pilot had flown night  $V_1$  cut procedures in a Metro III flight simulator, but had not flown the procedure in the aircraft at night. He did not terminate the exercise, despite indications that the aircraft was not maintaining  $V_2$  and that it was descending. There were few external visual cues available to the crew in the prevailing dark-night conditions. This affected their ability to maintain awareness of the aircraft's position and performance as the flight progressed.

A number of organisational factors were identified which influenced the aviation environment in which the flight operated. These included, on the part of the operating company:

- an inadequate Metro III endorsement training syllabus in the company operations manual;
- inadequate assessment of the risks involved in night  $V_1$  cuts; and
- assigning the check-and-training pilot a task for which he did not possess adequate experience, knowledge, or skills.

Organisational factors involving the regulator included:

- a lack of enabling legislation prohibiting low-level night asymmetric operations;
- deficient requirements for copilot conversion training;
- inadequate advice given to the operator concerning night asymmetric operations and the carriage of additional trainees on training flights;
- deficient training and approval process for check-and-training pilots; and
- insufficient quality control of the company operations manual.

The investigation also determined that there was incomplete understanding within the company, the regulating authority, and some sections of the aviation industry of the possible effects of engine flight idle torque on aircraft performance. Inadequate information on the matter in the aircraft flight manual contributed to this.

The complete report can be viewed at:

[http://www.atsb.gov.au/publications/investigation\\_reports/1995/AAIR/air199503057.aspx](http://www.atsb.gov.au/publications/investigation_reports/1995/AAIR/air199503057.aspx)

### ***Beech 1900D Airliner, VH-NTL, Williamtown, NSW 13 February 2000***

On 13 February 2000 a Beech 1900D Airliner, VH-NTL, was on a local training flight. The pilot in command simulated a failure of the left engine shortly after takeoff by retarding the left power lever to the 'FLIGHT IDLE' position. The handling pilot applied full right rudder and right aileron to counter the resultant yaw to the left, but the yaw continued until power was restored to the left engine to regain directional control. In the 21 seconds following takeoff, the aircraft did not climb above 160 ft above ground level, and at one stage had descended to 108 ft.

The aircraft was then climbed to a height of 2,000 ft where the pilot in command simulated another failure of the left engine by retarding its power lever to the 'FLIGHT IDLE' power setting. The aircraft again lost controllability. Power was restored to the left engine, and the aircraft landed without further incident.

There was no evidence that any aircraft or systems malfunctions contributed to the controllability problems experienced by the crew during the occurrence flight.

Since 1992, it was the practice of the operator's check pilots to simulate one-engine inoperative by retarding the power lever of the 'failed' engine to 'FLIGHT IDLE'. That was contrary to the procedure prescribed in the Federal Aviation Authority-approved Beech 1900D Airplane Flight Manual, and also to that specified in the operator's Civil Aviation Safety Authority-approved Training and Checking Manual. Reducing power to 'FLIGHT IDLE' also had the effect of simulating a simultaneous failure of the engine and its propeller auto-feather system. The simulation of simultaneous in-flight failures was contrary to the provisions of the CASA-approved Training and Checking Manual. During each of the simulated one-engine inoperative sequences, control of the aircraft was not regained until the power on the 'failed' engine was advanced to the manufacturer's prescribed one-engine inoperative thrust power setting.

The operator's training and checking organisation and its check pilots were aware that the likely consequences of simulating an engine failure by retarding its power to less than zero thrust were reduced aircraft climb performance and increased air minimum control speed ( $V_{MCA}$ ). They were also aware that risk increased when

in-flight training exercises involved the simulation of multiple failures. The prescribed procedures were therefore necessary defences to minimise those risks. The circumvention of those defences significantly increased the risks associated with the operator's training and checking procedures, and was a safety-significant concern. This occurrence demonstrated the potentially serious consequences of degraded aircraft performance by setting 'FLIGHT IDLE' to simulate one-engine inoperative. The practice has the potential to jeopardise the safety of flight and should be strongly discouraged.

The ATSB's investigation established that the failure to achieve predicted performance during take-off and subsequent climb was the result of an incorrect procedure. As a result of this serious occurrence, the ATSB recommended that the Civil Aviation Safety Authority (CASA) publish information for the guidance of operators and pilots regarding the correct procedures for simulating engine failures in turbo-propeller aircraft. CASA advised that it will publish an amendment to Civil Aviation Advisory Publication 5.23-1(0) to highlight appropriate engine-out training procedures in turbo-propeller aircraft. CASA also advised that it would ensure that operators' manuals contained appropriate procedures for the conduct of multi-engine training, and that it would draw attention to those procedures during forthcoming safety promotion activities. The operator advised that it had instructed its check pilots that an engine's power lever must not be retarded below the zero thrust torque setting when simulating an engine failure on takeoff, and that those simulations were not to be carried out until the aircraft had reached 250 ft above ground level.

The complete report can be viewed at:

[http://www.atsb.gov.au/publications/investigation\\_reports/2000/AAIR/air200000492.aspx](http://www.atsb.gov.au/publications/investigation_reports/2000/AAIR/air200000492.aspx)

***Beech Aircraft Corporation King Air C90, VH-LQH, Toowoomba, Qld  
27 November 2001 (abbreviated summary)***

At about 0836 Eastern Standard Time on 27 November 2001, a Beech Aircraft Corporation King Air C90 aircraft, registered VH-LQH, took off from runway 29 at Toowoomba aerodrome, Queensland for an Instrument Flight Rules charter flight to Goondiwindi, Queensland. On board were the pilot and three passengers.

Just prior to, or at about the time the aircraft became airborne, the left engine failed. A subsequent examination of the left engine found that it probably lost thrust-producing power almost immediately. Following the engine failure, the take-off manoeuvre continued and the aircraft became airborne prior to crashing.

The aircraft was equipped with an automatic propeller feathering system, but the propeller was not feathered at impact. The reason the propeller was not feathered could not be determined. The landing gear was not retracted during the short flight. The right engine was developing significant power at impact.

The aircraft remained airborne for about 20 seconds. The aircraft's flight path was typical of an asymmetric, low speed flight situation, and it is unlikely that the aircraft's speed was ever significantly above the minimum control speed ( $V_{mca}$ ) of 90 kts. The aircraft manufacturer's specified procedures for responding to an engine failure in LQH stated that the take off should be rejected below the 'take-off speed', specified as 100 kts. After control of the aircraft was lost, and as the aircraft was rolling through about 90 degrees left bank, it struck powerlines about 10 m above

ground level and about 560 m beyond the end of the runway. It then continued to roll left and impacted the ground inverted in a steep nose-low attitude. An intense fuel-fed fire erupted upon initial impact with the ground. The aircraft was destroyed and all four occupants sustained fatal injuries. The accident was not considered to be survivable due to the impact forces and post-impact fire.

### **Flight operations issues**

The investigation determined that the pilot was appropriately licensed to conduct the flight, and that it was unlikely that any medical or physiological factor's adversely affected the pilot's performance. There was also no evidence that incorrect aircraft loading or meteorological conditions were factors in the accident.

Several factors would have contributed to the aircraft's speed not being sufficient for the pilot to maintain control of the aircraft during the accident flight. These factors included the significant loss of power from the left engine just prior to, or at about the time, the aircraft became airborne, and the substantial aerodynamic drag resulting from the landing gear remaining extended and the left propeller not being feathered. In addition, the aircraft's speed when it became airborne was probably close to  $V_{mca}$  and not sufficient to allow the aircraft to accelerate to the best one-engine inoperative rate-of-climb speed ( $V_{yse}$ ) of 107 kts with an engine failure.

With an engine failure or malfunction near  $V_{mca}$ , the safest course of action would be to reject the takeoff due to the likelihood of the aircraft not being able to accelerate to  $V_{yse}$ . Although in some cases this will mean that the aircraft will overrun the runway and perhaps sustain substantial damage, the consequences associated with such an accident will generally be less serious than a loss of control after becoming airborne.

In this case, the engine failure occurred during a critical phase of flight, in a situation that was among the most difficult for a pilot to respond to in a manner that would ensure a safe outcome. In addition to the timing of the engine failure, a number of factors could have influenced the pilot's decision to continue with the takeoff, including the nature of the operator's procedures, the length of the runway, and the visual appearance of the runway and buildings beyond the runway at the time of the engine failure.

The operator specified a rotation speed of 90 kts, which was less than the 96 kts rotation speed specified by the aircraft manufacturer for King Air C90 aircraft. The operator's specified rotation speed had the effect of degrading the one-engine inoperative performance capability of the aircraft during takeoff. In addition, the operator's procedures did not provide appropriate guidance for pilots regarding decision speeds or decision points to use for an engine failure during takeoff.

While aircraft manufacturers have provided guidance material in operating manuals regarding engine failures leading to power loss in multi-engine aircraft, CASA had not published formal guidance material. The level of training available for emergencies in this category of aircraft during critical phases of flight and at high aircraft weights was less than desirable.

Toowoomba aerodrome was licensed and met the relevant CASA standards. However, runway 29 did not meet the ICAO standard in relation to the runway end safety area (RESA).

### **Safety action**

Since the accident, CASA has made changes to the requirements of AD/ENG/5 and the processes for assessing the suitability of maintenance controllers.

As a result of this investigation, the ATSB issued six recommendations to CASA including the following:

- the provision of formal advisory material to operators and pilots about managing engine failures and other emergencies during takeoff.
- the assessment of synthetic training devices for the purpose of training pilots in making decisions regarding emergencies during critical stages of flight.

The complete report can be viewed at:

[http://www.atsb.gov.au/publications/investigation\\_reports/2005/AAIR/air200507077.aspx](http://www.atsb.gov.au/publications/investigation_reports/2005/AAIR/air200507077.aspx)

### ***Fairchild Industries SA227-AC Metro III, VH-TAG, 33km ENE Canberra, ACT 21 November 2004***

On 21 November 2004, the crew of a Fairchild Industries SA227-AC Metro III aircraft, registered VH-TAG, was conducting an endorsement training flight near Lake George, 33 km north-east of Canberra Airport. The flight included a planned in-flight engine shutdown and restart, conducted at an altitude below 4,500 ft (about 2,200 ft above ground level (AGL)). During the engine restart preparation, the instructor departed from the published procedure by moving the power lever for the left engine into the beta range and directing the pilot to select the unfeather test switch. These actions were appropriate to prepare an engine for start on the ground with a feathered propeller, but not during an airstart. As a result, the propeller on the left engine became fixed in the start-locks position. The crew lost control of the aircraft and it descended 1,000 ft, to about 450 ft AGL, before they regained control. The crew could not diagnose the source of the loss of control and proceeded to start the left engine while the propeller was fixed on the start-locks. As a result, the crew lost control of the aircraft for a second time and it descended 1,300 ft, to about 300 ft AGL, before they regained control. The SA226 / SA227 aircraft contain no lockout system to prevent pilots from intentionally moving the power lever into the beta range during flight. It was the first time the instructor had given a Metro endorsement and he was subject to time pressure to complete the endorsement. His ongoing difficulties in adapting to his employment tasks were not successfully dealt with by the operator. He had a limited understanding of the aircraft's engine and propeller systems, and had not practiced an airstart for eight years as the CASA check and training approval did not include an assessment of all flight critical exercises.

The complete report can be viewed at:

[http://www.atsb.gov.au/publications/investigation\\_reports/2004/AAIR/air200404589.aspx](http://www.atsb.gov.au/publications/investigation_reports/2004/AAIR/air200404589.aspx)



# APPENDIX D: EMBRAER SERVICE NEWSLETTER



## SERVICE NEWSLETTER

**SUBJECT:** FUEL QUANTITY INDICATION SYSTEM HARNESS

**APPLICABILITY:** To all the EMB-120 aircraft in operation.

**VALIDITY:** This SNL remains valid until it is superseded or canceled by a subsequent revision.

**SCOPE:** To inform the operators about the instructions for the FQIS in-tank harness installation, in order to avoid the possibilities of FQIS wiring chafing with other components installed in the fuel tanks.

**DESCRIPTION:**

Embraer recommends that the instructions prescribed in this Service Newsletter must be accomplished on FQIS in-tank harness inspection (Task 16 of Section 6 - "Part E: Fuel System Limitations", as shown in Temporary Revision 22-1 of the Maintenance Review Board Report for the Embraer EMB-120 aircraft) and/or installation.

In addition, for every inspection (MM 28-41-04/601 - IN-TANK UNIT HARNESS - INSPECTION/CHECK), removal and/or installation (MM 28-41-04/401 - IN-TANK UNIT HARNESS - REMOVAL/INSTALLATION) of FQIS in-tank unit harness for the EMB-120 aircraft, and in-tank maintenance that affects the adjacent systems, make sure that this recommendation is correctly followed, in order to avoid any possibility of wiring chafing.

During the detailed inspection and/or installation of the FQIS in-tank harness, avoid any possibility of wiring chafing as indicated in Figures 1 and 2 below.

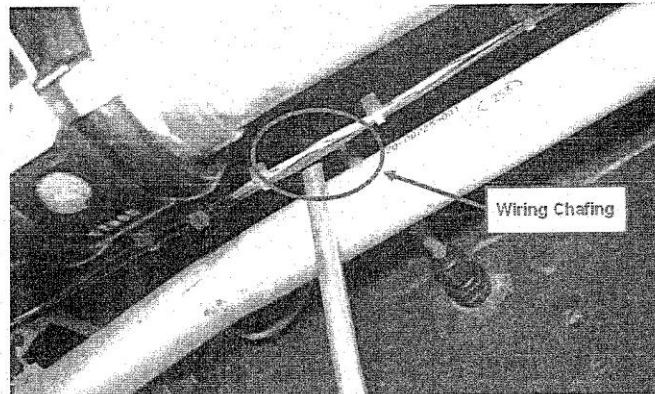


Figure 1 - Example of Wiring Chafing to be Avoided

DATE: 17/Mar/08

SNL 120-28-0008

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PAGE: 1 of 8

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## **APPENDIX E: SOURCES AND SUBMISSIONS**

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### **Sources of information**

The sources of information during the investigation included:

- the flight crew of VH-XUE
- the operator of VH-XUE
- the aircraft manufacturer
- the Civil Aviation Safety Authority (CASA)
- Ansett Aviation Training.

### **Submissions**

Under Part 4, Division 2 (Investigation Reports), Section 26 of the Transport Safety Investigation Act 2003, the Executive Director may provide a draft report, on a confidential basis, to any person whom the Executive Director considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the Executive Director about the draft report.

A draft of this report was provided to CASA, the operator, the pilots, the aircraft manufacturer, the accredited representative from the country of manufacture, and Ansett Aviation Training.

Submissions were received from the operator, the aircraft manufacturer, CASA and Ansett Aviation Training. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.