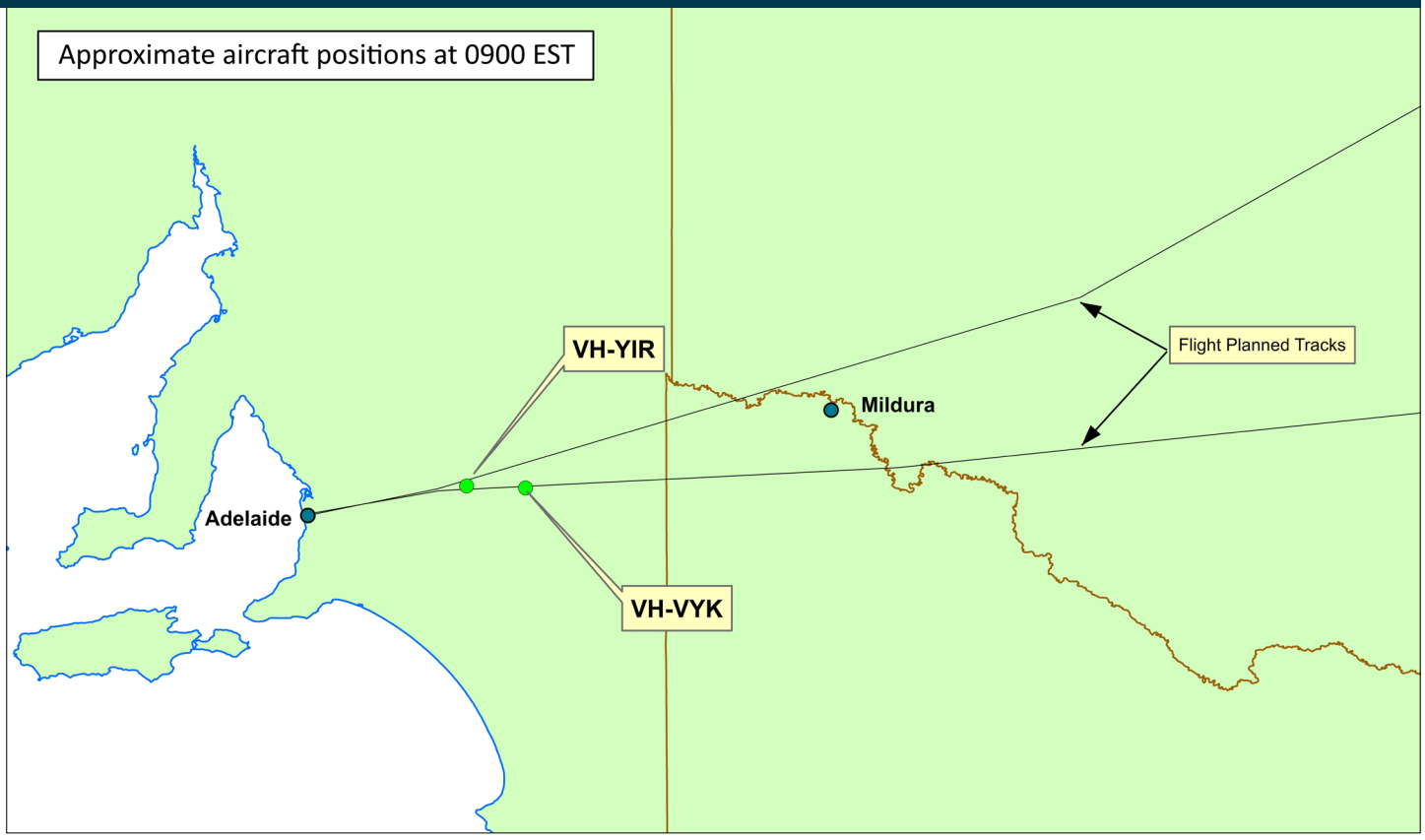
Australian Government
Australian Transport Safety Bureau

Landing below minima due to fog involving Boeing 737s, VH-YIR and VH-VYK

Mildura Airport, Victoria | 18 June 2013



Investigation

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Addendum

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Safety summary

What happened

On 18 June 2013, two Boeing 737 aircraft, VH-YIR operated by Virgin Australia Airlines Pty. Ltd. as Velocity 1384 and VH-VYK operated by Qantas Airways Ltd. as Qantas 735, were on scheduled flights to Adelaide, South Australia.

On nearing Adelaide, the forecast improvement in weather conditions had not occurred and as a result, both aircraft commenced a diversion to Mildura, Victoria. Upon arrival at Mildura, the actual weather conditions were significantly different to those forecast, in particular with visibility reduced in fog.

The flight crew of Qantas 735 conducted an instrument approach and landed below minima. The flight crew of Velocity 1384 also conducted an instrument approach and landed below minima in fog and with fuel below the fixed reserve.

What the ATSB found

The ATSB found that the weather deterioration at Adelaide did not appear on the forecast when both aircraft departed their respective ports and furthermore the forecast duration of the fog in the later, amended forecast showed a clearance time earlier than actually occurred. This meant that Qantas 735 continued to Adelaide with the expectation that the fog would clear prior to their arrival, which did not occur. It also influenced the decision making of the Virgin Australia flight watch personnel, who did not pass this weather to the flight crew of Velocity 1384.

In relation to the weather at Mildura, the ATSB found that the deterioration was significantly worse than originally forecast. This resulted in the need for both Qantas 735 and Velocity 1384 to land in conditions that were below minima. The ATSB identified that both flight crew uploaded sufficient fuel for the originally-forecast conditions in accordance with their operators' fuel policy and the Civil Aviation Safety Authority requirements.

The ATSB also found that in certain weather patterns and at certain locations, fog is both rare and difficult to forecast reliably.

In addition, the ATSB noted that the industry expectation for the provision of flight information services was not aligned with that provided by Airservices Australia (Airservices). Further, it was identified that in certain circumstances, pilots will not be made aware of a deterioration of weather at an airport that has an Automatic Weather Information Service or other Automatic Broadcast Service. These services did not provide for the recognition and active dissemination of special weather reports (SPECI) to pilots, thereby not meeting the intent of the SPECI alerting function provided by controller-initiated flight information service.

What's been done as a result

In response to this occurrence, Airservices advised that they would work with the Bureau of Meteorology to explore feasible options to provide information on significant deteriorations in weather conditions to address the very high frequency radio range limitations of the automated broadcast services. In the meantime, Airservices has updated the Manual of Air Traffic Services to ensure dissemination of weather information from locations with an Automatic Weather Information Service should that service be unavailable.

The Bureau of Meteorology advised of various system changes and improvements in response to this occurrence. This included to equipment used in forecasting.

Virgin Australia Airlines Pty. Ltd. (Virgin) advised of a review and benchmarking exercise as part of its examination of this occurrence. This resulted in enhancements to Virgin's flight planning and

flight following policies, re-organisation of the flight following section and expansion of communication infrastructure across the Virgin fleet. In addition, Virgin's pilot weather requirements have been clarified and enhanced.

In response to this occurrence the ATSB issued a safety recommendation to Airservices. This recommended that Airservices, as the issue owner, work in collaboration with the Bureau of Meteorology to instigate a system change to reinstate the alerting function of SPECI reports currently not available through an Automatic Broadcast Service.

Safety message

Pilots are reminded of their responsibility for collecting all relevant information to support in-flight decision making. This includes weather and operational information for the destination, which should be considered prior to a decision point or point of no return.

It is important that pilots understand what will be provided under Airservices' provision of flight information service and that they are also able to request weather and operational information from air traffic control. In addition, pilots should note the potential benefits of informing the controller of a non-normal situation. These include increased monitoring and support as required and the potential to reduce pilot workload in stressful situations.

Contents

The occurrence

On 18 June 2013, two Boeing 737-800 aircraft, VH-YIR operated by Virgin Australia Airlines Pty. Ltd. as Velocity 1384 and VH-VYK operated by Qantas Airways Ltd. as Qantas 735, were on scheduled passenger flights to Adelaide, South Australia.

Velocity 1384 departed Brisbane, Queensland at 0638 Eastern Standard Time[1] and had six crew and 85 passengers on board. The estimated time of arrival at Adelaide was 0920. The captain was the pilot flying and the first officer (FO) was the pilot monitoring.[2] The fuel on board at take-off from Brisbane was 8,800 kg as recorded on the flight data recorder. This comprised flight fuel to Adelaide of 6,410 kg, variable and fixed fuel reserves of 1,540 kg and additional fuel of 940 kg.

Qantas 735 departed Sydney, New South Wales at 0727 and had six crew and 146 passengers on board. The estimated arrival time at Adelaide was 0917. The captain was the pilot flying, with the FO as pilot monitoring. The fuel on board at take-off from Sydney was 7,900 kg, as recorded on operational documentation. This comprised flight fuel to Adelaide of 5,000 kg, variable and fixed fuel reserves of 1,600 kg and additional fuel of 1,300 kg. The captain reported routinely uploading additional fuel for contingencies.

At 0700, the Bureau of Meteorology (BoM) issued an updated aerodrome forecast (TAF)[3] for Adelaide, which indicated a 30 per cent probability of fog developing. For an understanding of the aircrafts' positions at this time, see Figure 1. At 0800, the BoM issued an updated trend forecast (TTF)[4], which showed that fog had reduced visibility at Adelaide and was expected to clear by 0900. See Figure 2 for the aircrafts' positions at that time.

At this stage, the crew of Qantas 735 were aware of the changes to the TTF and continued to Adelaide on the basis that the fog would clear prior to their arrival. In addition, they had sufficient fuel to hold for about 45 minutes should the fog last longer than forecast and land with required fuel reserves. The crew of Velocity 1384 were not aware of the changes to the forecast. They were advised of fog at Adelaide by Air Traffic Control (ATC) at 0844, once they changed to the en route sector frequency immediately prior to the Adelaide terminal area airspace. Figure 3 shows the aircraft's approximate positions at 0900.

The crew of Qantas 735 elected to hold at waypoint BLACK, which was 48 NM (89 km) from Adelaide, rather than continue their descent to the airport, which was still affected by fog. The crew of Velocity 1384 had commenced their descent to Adelaide and gathered further information about the conditions from the Adelaide tower controller.

Based on the report from the Adelaide tower controller that conditions were not suitable for landing, and that there had been no successful landing attempts, the crew of Velocity 1384 elected to divert to Mildura, Victoria at 0904. The observation reports issued by BoM at that time indicated that the conditions at Mildura were above the alternate minima for the aircraft, despite the TAF for Mildura indicating a temporary deterioration during the forecast period. The crew's estimated arrival time at Mildura was 0932.

The crew of Qantas 735 heard Velocity 1384 broadcast their decision to divert to Mildura. On being informed by ATC that the latest trend forecast for Adelaide predicted a delay in the fog

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1 Eastern Standard Time (EST) is Coordinated Universal Time (UTC) + 10 hours. Unless otherwise indicated, all times in this report are quoted in EST.

2 Pilot flying (PF) and pilot monitoring (PM) are procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances; such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and aircraft flight path.

3 Aerodrome Forecasts are a statement of meteorological conditions expected for a specific period of time, in the airspace within a radius of 5 NM (9 km) of the aerodrome.

4 A trend forecast is defined as an aerodrome weather report to which a statement of trend is appended.

clearing of 30 minutes, and after gathering observation reports for Mildura, the crew of Qantas 735 also elected to divert there at 0913. Their estimated arrival time at Mildura was 0942.

In making the decision to divert to Mildura, the captain of Qantas 735 reported that they were aware that they had the capability to conduct an autoland at Adelaide Airport (see the section titled *Low visibility/autoland capability*). However, based on the reports of significantly better weather at Mildura, a diversion to that airport was assessed as preferable to continuing to Adelaide.

The captain of Velocity 1384 similarly reported that they considered the option of an autoland at Adelaide. However, given the observations of significantly better weather at Mildura, they also concluded a diversion was a better option at that time.

Arrival at Mildura

At 0916, the pilot of an air ambulance flight departing Mildura made a call to ATC that conditions were deteriorating, with a cloud base at 400 ft. The pilot did not specify the cloud datum, but a comparison of the reported cloud base with the observed cloud base from the Mildura Airport automated station, which was generated 2 minutes later, identified that the reported cloud base was probably with reference to mean sea level. At the time, neither Velocity 1384 nor Qantas 735 were on this frequency and so did not hear this transmission. At 0918, just after Velocity 1384 transferred to this frequency, the controller for this sector informed them of four other aircraft due to arrive at Mildura around their arrival time, which included Qantas 735. At 0922, Qantas 735 transferred to the same frequency and was also advised of the arriving traffic.

Also at 0918, the BoM issued a SPECI[5] observation for Mildura, showing cloud at 200 ft above ground level (AGL) but visibility in excess of 10 km. The area GPS-based navigation Global Navigation Satellite System (RNAV GNSS) instrument approach to runway 27 at Mildura required pilots to be clear of cloud at a minima of 660 ft (493 ft AGL), reducing to 560 ft (393 ft AGL) using an actual aerodrome QNH[6] (see the sections titled *Area navigation Global Positioning System navigation system* and *Airport information*). As the conditions had deteriorated below this minima, the RNAV GNSS approach could not be conducted in normal operations. The aerodrome forecast for Mildura, valid at that time, contained a temporary deterioration with cloud at 600 ft AGL.

Between 0928 and 0932, three further SPECI's were issued for Mildura, indicating that visibility was decreasing in mist. In line with Airservices Australia (Airservices) procedures, as Mildura broadcast weather information via an Aerodrome Weather Information Service (AWIS)[7], the controller responsible for this sector was not automatically-provided with the SPECI reports at their console. However, they could request it through The Australian Advanced Air Traffic System.[8] As the AWIS for Mildura was not broadcasting due to an unserviceability, the inbound aircraft could not obtain this information from the AWIS (see the section titled *Aerodrome weather information service*).

At 0936 the controller made a broadcast on the area frequency to traffic at Mildura, informing them of the details of the 0932 SPECI. This SPECI indicated broken[9] cloud at 200 ft and that the visibility was now 2,100 m in mist. A review of data from the cockpit voice recorder of Velocity 1384 identified that, for the duration of the controller's broadcast of the SPECI, the crews

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5 A SPECI is a special weather observation report that is triggered by a significant change in a set of parameters, including cloud and visibility.

6 Altimeter barometric pressure subscale setting to provide altimeter indication of height above mean seal level in that area.

7 An AWIS provides actual weather conditions, via telephone or radio broadcast, from an automatic weather station.

8 An advanced hardware and software system that is used by Airservices Australia to help manage domestic and international flights in Australian airspace.

9 Cloud cover is normally reported using expressions that denote the extent of the cover. The expression few indicates that up to a quarter of the sky was covered, scattered indicates that cloud was covering between a quarter and a half of the sky, broken indicates that more than half to almost all the sky was covered, while overcast means all the sky was covered.

of Qantas 735 and Velocity 1384 were busy communicating on the Mildura common traffic advisory frequency.[10]

At 0937 the crew of Qantas 735 contacted the crew of Velocity 1384 to discuss the arrival and the crew of Velocity 1384 stated that they were tracking to the initial waypoint to commence the RNAV GNSS approach to runway 27. At 0939 the crew of a Qantaslink Bombardier DHC-8 aircraft (Dash-8) broadcast to traffic at Mildura that they were conducting a go-around. The crew of Velocity 1384 asked for an appreciation of the weather and were told by the Dash-8 crew that at the minima, they 'couldn't see anything'.

At 0940 the crew of Qantas 735 contacted Velocity 1384 to advise that they were commencing the RNAV GNSS approach 'due fuel'. The Velocity 1384 FO replied that they were 'in the same boat' but, after discussion between the captain and FO of Velocity 1384, they elected to hold and allow Qantas 735 to continue with the approach. This decision was passed to the crew of Qantas 735.

The crew of Qantas 735 applied a revised minimum to the approach that was 200 ft lower than that published. This was based on the knowledge that the cloud base would preclude becoming visual via a normal approach. The crew reported that as they descended toward the revised minimum, the extent of the cloud reduced and they gained sufficient visual reference of the runway environment to continue the approach. At 0946 the crew of Qantas 735 broadcast that they had landed at Mildura. The aircraft landed on runway 27 with the required fuel reserves intact and the crew reported that the runway was visible once they descended below the cloud.

At 0948 the crew of the Dash-8 asked Qantas 735 for their assessment of the weather. The crew replied that the cloud base was at 150 ft AGL and that they had landed off the approach 'due fuel'. At this time, a SPECI was issued for Mildura, showing visibility was now 900 m in fog and that the cloud was overcast at 100 ft AGL.

At 0950, Velocity 1384 sought an update on the weather from Qantas 735, who stated that the fog had appeared to be getting thicker but was now clearing, although the cloud was still below minima. At 0952, Velocity 1384 updated ATC that they were still holding due to the low cloud at Mildura. ATC asked them to nominate a latest divert time to proceed to a suitable airport. The FO replied that they did not have the fuel to proceed anywhere else. After obtaining further information from the crew, ATC initiated an alert phase and at 0958, after contacting the crew again, ATC activated the Mildura Airport emergency procedures.

At 0954, the controller made another 'all stations' broadcast with the latest TAF issued for Mildura, valid from 1000. This forecast predicted:

- visibility as 3 km in mist
- scattered cloud at 300 ft AGL
- an improvement in both visibility and cloud base in the hour from 1000
- a 30 per cent probability of the visibility reducing to 500 m in fog for the period between 1000 and 1200.

Given their available fuel, the crew of Velocity 1384 determined that they needed to commence an approach just after 1000 to allow for a second approach if needed. They discussed the conduct of a 'sighting' approach to ensure the aircraft was aligned with the runway from the RNAV GNSS approach. The captain was still the pilot flying; however, they briefed that if at any time during the approach the FO sighted the runway, then the FO was to take control and land.

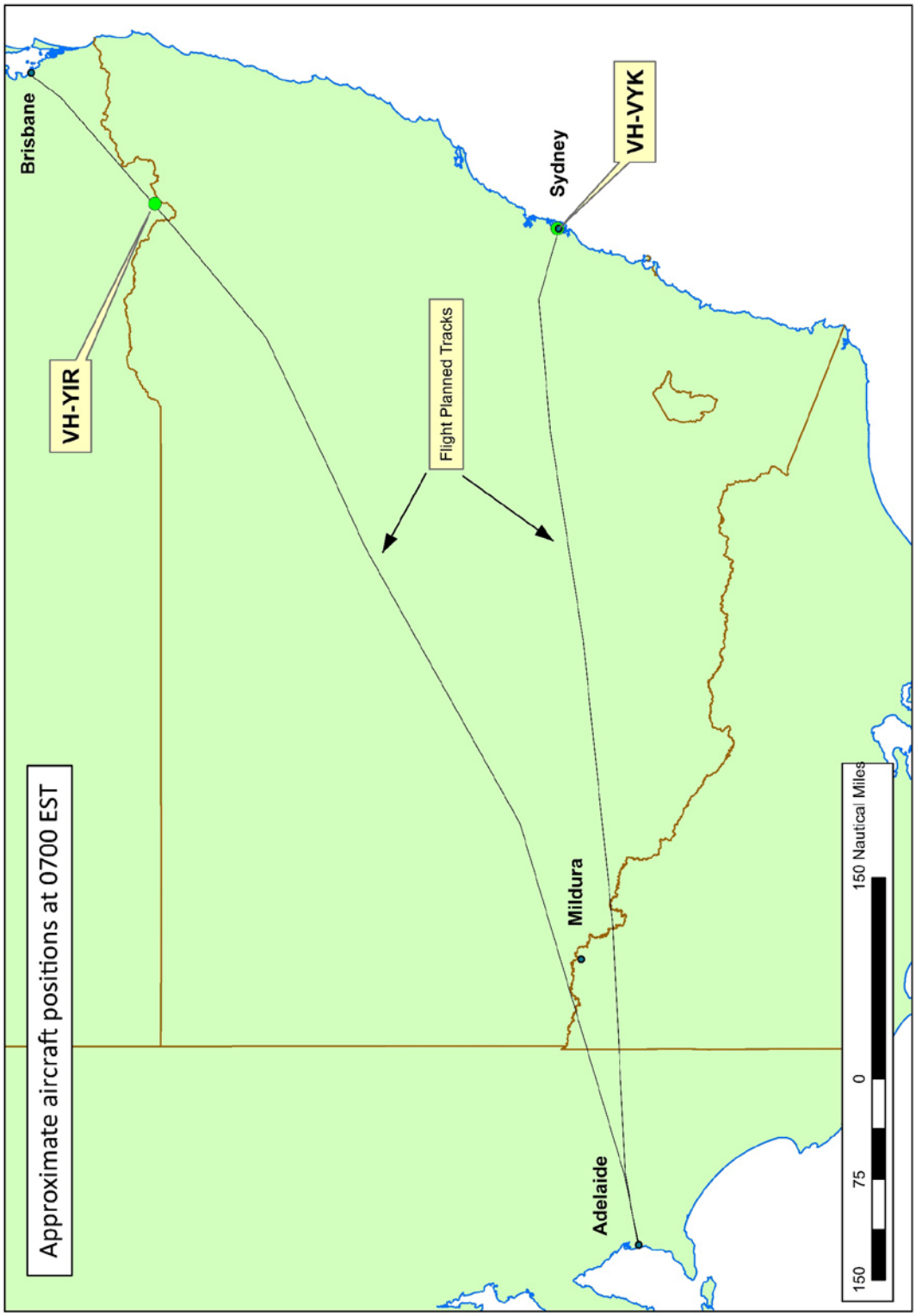
At 1002, Velocity 1384 transmitted that they were on a 4 NM (7 km) final for the RNAV GNSS approach. At 1004, as they were not visual with the runway, the crew initiated a missed approach from 132 ft AGL. The FO reported that as they commenced the missed approach, it was possible

[10] Common Traffic Advisory Frequency is the frequency on which pilots operating at a non-towered aerodrome should make positional radio broadcasts.

to confirm that they were aligned with the runway by looking directly down. At 1012, ATC initiated a distress phase.

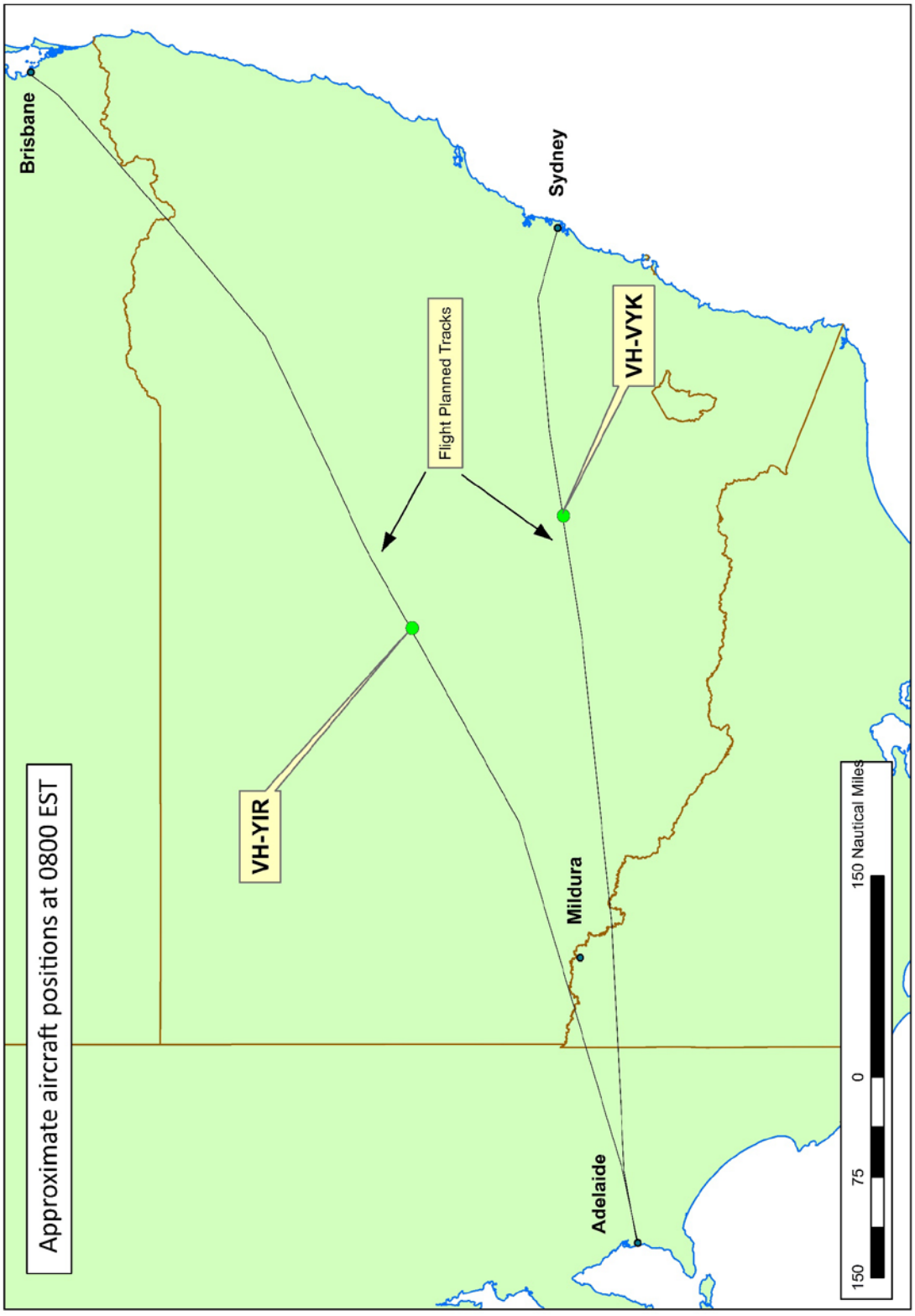
The aircraft was positioned for a second approach, during which the cabin crew were briefed and prepared for an emergency landing, briefing the passengers to brace accordingly. At 1014, Velocity 1384 landed at Mildura in foggy conditions with fuel below the required reserves. As they taxied in, the captain told the cabin crew to stand down and normal arrival procedures resumed.

Figure 1: Approximate aircraft positions at 0700, when the amended forecast for Adelaide was issued with a 30 per cent probability of fog



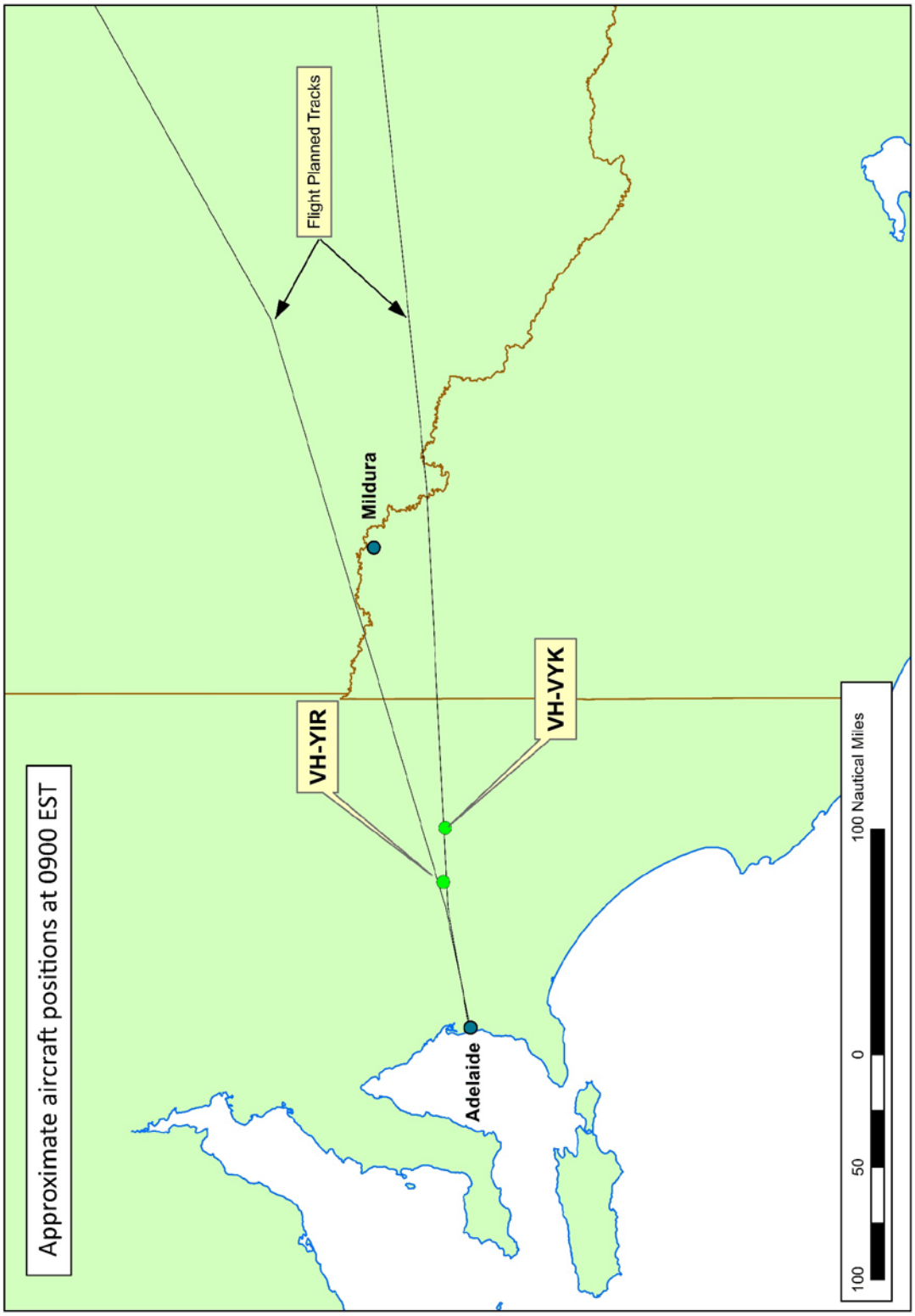
Source: ATSB

Figure 2: Approximate aircraft positions at 0800, when the trend forecast for Adelaide was issued with fog conditions forecast to lift at 0900



Source: ATSB

Figure 3: Approximate aircraft positions at 0900, just prior to initiating the diversion to Mildura



Source: ATSB

Context

Personnel information

Virgin Australia Airlines Pty. Ltd.

Captain

The captain held an Air Transport Pilot (Aeroplane) Licence with a Boeing 737-300 to -800 endorsement and a current Class 1 Aviation Medical Certificate with various conditions. These included the need for distance vision correction to be worn. The captain had also held Training Captain/Approved Testing Officer approvals since April 2003. The captain's relevant aeronautical experience is outlined in Table 1.

Table 1: Captain's aeronautical experience

Total flying hours	19,966
Total flying hours on the B737-800	9,111
Total flying last 90 days	135 hours
Total flying last 30 days	54 hours
Total flying last 7 days	0 hours
Last proficiency check	13 March 2013

The captain reported their recent sleep as normal. For the 3 days preceding the occurrence, they advised going to bed by 2000. The captain reporting obtaining about 6.5 hours sleep the night prior to the occurrence and being well rested. Prior to this flight, the captain was on stand-by on 17 June 2013 without being called out and had a rostered day off on 16 June 2013. It is considered likely that fatigue was not a factor in the captain's performance in the occurrence.

First officer

The first officer (FO) held a held an Air Transport Pilot (Aeroplane) Licence with a Boeing 737-300 to -900 endorsement and a current Class 1 Aviation Medical Certificate with no restrictions. The FO's relevant aeronautical experience is outlined in Table 2.

Table 2: FO's aeronautical experience

Total flying hours	7,100
Total flying hours on the B737-800	1,120
Total flying last 90 days	132 hours
Total flying last 30 days	14 hours
Total flying last 7 days	14 hours
Last proficiency check	1 April 2013

The FO had recently come off a month of leave and reported their recent sleep as normal. The FO reported obtaining about 7 hours sleep the night prior to the occurrence and felt well rested. The day previously (17 June 2013), the FO was on stand-by without being called out. The FO reported a duty day on 16 June 2013 that included flying Brisbane–Melbourne and return with approximately 7 hours duty time. Taking into account their recent duty and rest opportunities, it is considered that FO fatigue was not a factor in the occurrence.

Flight dispatch

The team leader dispatch oversaw the flight planning and flight watch functions of the operations centre. The team leader on the day was a qualified dispatcher with over 20 years of experience.

The flight watch dispatcher was responsible for maintaining flight watch services, either by actively monitoring, or passively following various assigned flights (see the section titled *Flight dispatch and following*). The dispatcher on duty for 18 June 2013 was appropriately-qualified and had over 4 years of experience, most of that with Virgin Australia Airlines Pty. Ltd. (Virgin).

Operations control centre

The operations controller was responsible for overseeing the Virgin flight network, including coordinating air traffic control (ATC) slot times for arrivals. This role included liaison with flight dispatch to update flight plans and manage diversions as applicable. The controller on duty on 18 June 2013 had 9 years of experience in the operations department at Virgin.

The meteorologist on duty had over 35 years of experience, including 30 years as a forecaster with the Bureau of Meteorology (BoM). They had been situated within Virgin's operations control centre, initially as a BoM employee, before joining a private company providing the same service to Virgin. The meteorologist had worked in the Virgin operations control centre for a total of about 8 years.

Qantas Airways Ltd.

Captain

The captain held an Air Transport Pilot (Aeroplane) Licence with a Boeing 737-300 to -800 endorsement and a current Class 1 Aviation Medical Certificate with a restriction that distance correction was to be worn, and reading correction be available while exercising the privileges of the licence. The captain's relevant aeronautical experience is outlined in Table 3.

Table 3: Captain's aeronautical experience

Total flying hours	17,069
Total flying hours on the B737-800	7,590
Total flying last 90 days	167 hours
Total flying last 30 days	71 hours
Total flying last 7 days	18 hours
Last proficiency check	1 May 2013

The captain reported their recent sleep as normal and that they obtained about 7.5 hours sleep the night prior to the occurrence. The captain reported flying Sydney–Adelaide and return on 17 June 2013 with about a 6.5 hour duty time. The captain had a day off on 16 June 2013. Given the sleep obtained and rest opportunities available, it is not considered likely that fatigue was a factor in the captain's performance in the occurrence.

First officer

The FO held an Air Transport Pilot (Aeroplane) Licence with a Boeing 737-300 to -900 endorsement and a current Class 1 Aviation Medical Certificate with no restrictions. The FO's relevant aeronautical experience is outlined in Table 4.

Table 4: FO's aeronautical experience

Total flying hours	7,714
Total flying hours on the B737-800	3,982
Total flying last 90 days	172 hours
Total flying last 30 days	57 hours
Total flying last 7 days	11 hours
Last proficiency check	1 February 2013

The FO reported their recent sleep as normal and that they obtained about 7.5 hours sleep the night before the occurrence. The FO's roster showed that 16 and 17 June 2013 were rostered days off. Given the sleep obtained and rest opportunities available, it is not considered likely that FO fatigue was a factor in the occurrence.

Flight dispatch

The dispatch duty manager was a qualified dispatcher with over 36 years' experience in dispatch. Twenty of those years were as duty manager. The dispatch duty manager had oversight of the dispatch and flight watch functions at Qantas Airways Ltd. (Qantas).

Airservices Australia

The Tailem Bend[11] and Mallee[12] en route sector controllers were appropriately-endorsed and current for their respective sectors. The controllers were supported by aisle supervisors and a systems supervisor.

The aisle supervisors were appropriately-endorsed and current for their role, which included oversight of the en route sector controllers.

The systems supervisor was completing the final day of a 2-day endorsement check for the position, and operating under supervision at the time of the occurrence.

Aircraft information

Fuel system

Overview

The B737-800 is equipped with three fuel tanks. The No. 1 tank is integral with the left main wing, the No. 2 tank is integral with the right main wing and the centre fuel tank is located within the fuselage and extends into each wing. Fuel tank capacity is indicated in Table 5.

During normal operations both engines are pressure fed from the centre tank until it is empty and then each engine is pressure fed from its respective wing tank.

When opened, a crossfeed valve located in the centre tank and controlled by a switch on the cockpit forward overhead panel allows both engines to be supplied from one wing tank.

[11] The Tailem Bend en route sector comprised the airspace from 36 NM (67 km) to 140 NM (259 km) to the east of Adelaide Airport.

[12] The Mallee en route sector comprised the airspace from 140 NM (259 km) to about 270 NM (500 km) to the east of Adelaide Airport and included the en route airspace above Mildura.

Table 5: Usable fuel capacity

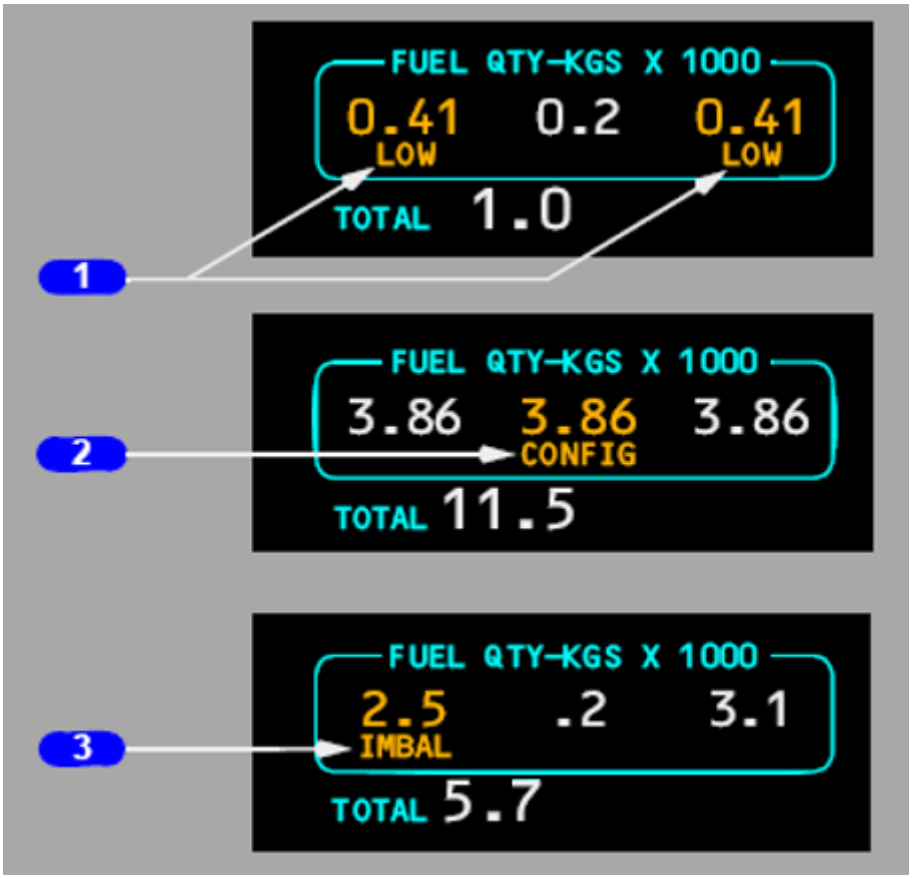
Tank	Volume (US Gallons)	Volume (litres)	Weight (kg)
No. 1	1,288	4,876	3,852
No. 2	1,288	4,876	3,852
Centre	4,299	16,273	12,856
Total	**6,875**	**26,025**	**20,896**

The fuel quantity remaining is indicated in tonnes on the upper display unit (Figure 4). This display, together with an explanation of the LOW FUEL, FUEL CONFIGURATION and FUEL IMBALANCE indications, is expanded at Figure 5.

Figure 4: Location of the fuel quantity indication on the upper display unit (circled in yellow)

Source: Boeing, modified by the ATSB

Figure 5: Fuel quantity display in detail with an explanation of the LOW FUEL, FUEL CONFIGURATION AND FUEL IMBALANCE indications



1. LOW FUEL INDICATION
   - Occurs when fuel quantity is less than 907 kg (2,000 lbs) in the related main wing tank.
   - Digits on tank(s) with low fuel quantity turn amber.
   - Displayed until quantity is increased to 1,134 kg (2,500 lbs).
2. FUEL CONFIGURATION (CONFIG) INDICATION
   - Occurs when the centre tank quantity is greater than 726 kg (1,600 lbs), both centre tank pumps are producing low or no pressure and either engine is running.
   - Digits on the centre tank turn amber.
   - Inhibited when centre tank quantity is less than 363 kg (800 lbs).
3. FUEL IMBALANCE (IMBAL) INDICATION
   - Occurs when the main wing tanks differ by more than 453 kg (1,000 lbs).
   - Digits on the tank with the lower fuel quantity turn amber.
   - Inhibited on the ground.
   - Inhibited by a LOW fuel indication when both indications exist.
   - Displayed until any imbalance is reduced to 91 kg (200 lbs).

Source: Boeing, modified by the ATSB

Fuel-related Non-normal procedures

A LOW fuel indication and/or fuel IMBAL indication would normally result in the flight crew actioning the appropriate non-normal checklist in the aircraft's Quick Reference Handbook (QRH).

This typically involves the pilot monitoring (PM) locating the correct checklist in the QRH and reading the title and condition to the pilot flying (PF) to confirm selection of the correct checklist. The PM would then read out the steps and point towards the appropriate cockpit switch for the PF to confirm before actioning by the PM. Non-normal procedures that are deemed time critical contain memory items for actioning by the crew before referencing the QRH. This prevents further degradation of these types of abnormal situations. The low fuel and fuel imbalance checklists did not contain any memory Items.

Recorded information – Velocity 1384

Data from the aircraft's flight data recorder (FDR) showed that at 0933, as Velocity 1384 was on descent to Mildura, a fuel imbalance developed between the main wing tanks (No.1 and No. 2). Three minutes later, the FO was heard on the cockpit voice recorder (CVR) as being happy to 'leave those pumps off'.

At 0938, a 'LOW FUEL QTY Tank 2' message was recorded on the FDR, with 880 kg remaining in the No. 2 main wing tank and 1,054 kg in the No. 1 main wing tank. This imbalance was likely the result of the crossfeed valve being opened by the crew. Differences in pump outputs between the tanks would then result in the No. 2 tank supplying the majority of the fuel to both engines and therefore being used at a higher rate. This scenario is explained in the Flight Crew Training Manual (FCTM) (see appendix A).

At about 0951 the fuel imbalance reached a maximum of 573 kg, before reducing as the fuel quantity in the No. 2 main wing tank remained constant. This was likely the result of the fuel pumps in the No. 2 tank being selected OFF, leaving the No. 1 tank to supply both engines.

The FDR recorded a LOW FUEL QTY message for both main wing tanks at about 0955. At that stage, the No. 1 tank had 887 kg and the No. 2 tank 433 kg remaining. From this time, the imbalance began to increase again. It is likely that the fuel pumps for the No. 2 tank were selected back to ON, with the crossfeed valve open. The CVR recorded discussion between the crew about the position of the fuel pumps and crossfeed valve. That discussion did not result in a change to the valve position and it remained open. When the aircraft touched down, the No. 1 tank had 594 kg and the No. 2 tank 18 kg remaining, with an imbalance of 576 kg. Had the 18 kg of fuel in the No. 2 main wing tank been consumed, the position of the crossfeed valve at OPEN would have ensured fuel was supplied to both engines from the No. 1 main wing tank.

Data from the CVR indicated that the crew actioned the low fuel and fuel imbalance checklists from memory. Discussion with operators indicated that while that was not considered unusual in the circumstance, they would expect crew to then reference the non-normal checklists to ensure nothing was missed. They further noted that they would not expect crew to conduct a fuel imbalance check during a fuel low situation, such as the occurrence flight, unless a fuel leak was suspected or identified. Completing the fuel imbalance checklist with low fuel on board would have resulted in the closure of the crossfeed valve (see appendix B). In this instance, that would have increased the risk of the starvation of fuel to the No.2 engine late in the approach or on landing due to the low fuel level in the No.2 main wing tank at that time.

It should be noted that while these actions were being carried out, the crew were also managing air traffic and making decisions relating to the occurrence of fog at the airport. The FCTM cautioned against conducting fuel balancing activities 'during approach or times of high workload' and further states that fuel balancing is 'to reduce wear and tear on the airframe and landing gear, and not for controllability reasons'.

Low visibility/autoland capability

An autoland is a precise, repeatable landing that can be conducted in poor weather conditions where insufficient visual cues are available to the pilots. It uses a number of automatic flight

control systems on board the aircraft, combined with specific ground-based instrument landing system (ILS)[13] and runway environment requirements (Table 6).

Table 6: Categories of ILS and required minimum cloud ceiling and visibility in which:

- cloud ceiling is measured from landing wheel height above the threshold and expressed as a decision height in feet
- visibility is the average distance that distinguishing obstacles can be seen around the aerodrome. Alternatively runway visual range (RVR) is the electronically-recorded visibility at some aerodromes as measured from various stages of the runway - touchdown zone (TDZ), middle of the runway (MID) or end of the runway (END).

Category of ILS	Minimum decision height (ft)	Minimum visibility/RVR (m)
I	200	800 m visibility or 550 m RVR
II	100	• 300 m TDZ • 125 m MID or • 125 m END if MID RVR is not available • (that is, sufficient visual reference for a manual landing and verification that the aircraft will land in the TDZ)
IIIA	50	• 175 m TDZ • 125 m MID or • 125 m END if MID not available • that is, insufficient visual reference to permit manual landing; however, sufficient to allow the pilot to determine if the aircraft will land in the TDZ
IIIB	Not applicable	• 75 m TDZ • 75 m MID • 75 m END

The low visibility/autoland capability can be divided into two levels, defined as ‘fail passive’ or ‘fail operational’. These levels depend on the:

- number of redundancies available in the event of a system component failure
- effect such a failure would have on the aircraft’s ability to continue with an autoland approach.

A system component failure in a fail passive system will not result in significant deviation of the aircraft’s flight path but will mean that the aircraft can no longer be landed automatically. Fail passive capability is the minimum required aircraft capability to conduct a Cat II and some CAT IIIA ILS approaches.

A fail operational system is a higher capability. It allows for completion of the ILS and autoland following failure of any single system component after a specified alert height as determined by a number of safety parameters. Fail operational capability is the minimum capability to conduct Cat IIIB, and some Cat IIIA ILS approaches.

[13] A standard ground aid to landing, comprising two directional radio transmitters: the localizer, which provides direction in the horizontal plane; and the glideslope, for vertical plane direction, usually at an inclination of 3°. Distance measuring equipment or marker beacons along the approach provide distance information.

At the time of this occurrence, runway 16 at Melbourne Airport, Victoria was the only location in Australia with:

- promulgated low visibility procedures for the conduct of CAT III ILS approaches
- the necessary runway and ground infrastructure approved for autoland procedures in weather conditions resulting in reduced visual cues.

At the time of the occurrence, Adelaide Airport was certified for CAT I ILS with autoland. Certification for various levels of autoland is dependent on a number of factors. In this respect, Adelaide Airport did not meet all of the regulatory and redundancy requirements for a higher certification. However, the airport and equipment had demonstrated the ability to support emergency landings below CAT I meteorological conditions during practice approaches. Those practice approaches were carried out in conditions equal to or better than the CAT I minima.

While runway 16 at Melbourne Airport met the requirements of flight instrument procedures requiring autoland capability, on the morning of the occurrence, the forecast for Melbourne was for low cloud and a 30 per cent chance of fog until 1000. In addition, a notice to airmen (NOTAM)[14] listed holding requirements for Melbourne. Taking into account the forecast fog and these holding requirements at Melbourne, neither Velocity 1384 nor Qantas 735 had sufficient fuel to proceed to Melbourne from Adelaide.

Both aircraft had the necessary equipment to conduct at least a CAT II (fail passive) autoland at Adelaide and both flight crews were trained and approved in Cat II/III autoland procedures. However at the time of the occurrence, only Qantas had the appropriate approval from the Civil Aviation Safety Authority (CASA) to conduct autoland operations in B737 aircraft.

Potential safety benefit of CAT III B autoland facilities at all Australian major airports

As a result of stakeholder input during the report review process, the ATSB considered the potential safety benefit of the installation of CAT III B autoland facilities at all Australian major airports. However, appropriate meteorological data was not available at the time to support such an examination and potential safety recommendation for the widespread installation of equipment of this magnitude and complexity.

In response to this occurrence, the ATSB also initiated research into the reliability of weather forecasts in Australia, initially at Adelaide and Mildura Airports (see the section *ATSB research investigation*). On completion of this initial research, the ATSB will progressively examine the weather forecast reliability at all Australian major airports. It could be expected that the results from this ongoing research effort may assist regulators and industry make informed decisions about the need for further infrastructure at major Australian airports.

Area navigation Global Positioning System navigation system

The B737 is equipped to conduct area navigation Global Navigation Satellite System (RNAV GNSS) approaches, which are classified as non-precision approaches. However, the accuracy of the onboard equipment meant that Qantas 735 and Velocity 1384 were aligned with the runway centre-line during the final part of their respective approaches. Given the nature of the emergency, this allowed the crew to land despite the low visibility conditions.

Additional equipment

VH-VYK

VH-VYK was fitted with a very high frequency (VHF)/ aircraft communications addressing and reporting system (ACARS), which was routinely used by Qantas flight operations and flight crew. It

[14] A Notice To Airmen advises personnel concerned with flight operations of information concerning the establishment, condition or change in any aeronautical facility, service, procedure, or hazard, the timely knowledge of which is essential for safe flight.

was also fitted with a Head-up Guidance System (HGS), which is located on the captain's side. The HGS displays certain aircraft parameters such as altitude and airspeed, and is useful during low visibility operations as it allows the captain to scan the outside environment while also viewing relevant parameters on the HGS.

VH-YIR

VH-YIR was fitted with satellite communications (SATCOM) equipment that supported telephone and ACARS equipment. At the time of the occurrence, Virgin had not yet commenced using ACARS routinely in their B737 fleet, although it was available for use by the crew. The aircraft was not fitted with HGS.

Meteorological information

Bureau of Meteorology

The Bureau of Meteorology (BoM) is the designated meteorological authority in Australia for the provision of a meteorological service for international air navigation in accordance with International Aviation Civil Organization (ICAO) Annex 3 – *Meteorological Service for International Air Navigation.* The objective of this service is to contribute towards the safety, regularity and efficiency of air navigation.

To achieve that objective, the BoM produces and supplies relevant operational meteorological information to operators, flight crew, air traffic services units, search and rescue services, airport management and others concerned with the conduct of air navigation. In accordance with the core standards and recommended practices outlined in Annex 3, the BoM had implemented a quality management system that was certified in accordance with the standards contained in AS/NZ ISO 9001:2008.

Forecasting priorities

The BoM Aeronautical Services Handbook (ASH), which is available as guidance for staff, lists the priorities for the provision of services. In relation to forecasts and warnings, the ASH outlined a framework for prioritising tasks. The priority reflects the need to create forecasts and warnings in relation to time critical activities, such as ditching reports and search and rescue activities. Under the forecast priority guidance, issuing an amended aerodrome forecast (TAF) for Category B airports, such as Mildura, is ranked below the need to create information concerning en route weather phenomena that may affect the safety of aircraft operations (SIGMET).[15] Generation of a routine TAF for Mildura Airport is also secondary to issuing trend forecasts (TTF) and amended TAFs for major international airports and category A airports (such as Canberra).

[15] A weather advisory service issued to warn of potentially hazardous (significant) or extreme meteorological conditions that are dangerous to most aircraft, such as thunderstorms or extreme turbulence.

Forecasting fog

Forecasting fog for aviation purposes is known to present a number of challenges. A number of these challenges have been identified by the Centre of Australian Weather and Climate Research and include that:

- the development of fog depends on factors that are not well understood
- fog is relatively uncommon at most airports
- the required accuracy of the forecast is high
- the potential consequences of an unforecast fog are high.

At interview, the BoM similarly stated that as fog is a very rare event for most airports, it is difficult to accurately forecast. This was the case for Adelaide Airport, which is affected by fog about four or five times a year. In addition, it was possible for fog to exist at nearby locations, such as at Edinburgh Airport, without operations at Adelaide Airport being affected.

For regional airports, such as Mildura, the BoM relied on satellite imagery, in addition to other data, to provide indications of fog. However, it can be difficult to differentiate between fog and low cloud when using satellite imagery. The BoM reported that their review of the forecasting used for Mildura on the day of the occurrence showed that the conditions (including wind direction) were not conducive to fog developing at that time of day and were more consistent with the possibility of low cloud. As such, the TAF that was valid at the time reflected a temporary period of low cloud that was expected to last between 30 and 60 minutes (TEMPO), rather than fog.

Forecasts and observations

Adelaide Airport

The 0303 TAF for Adelaide on the morning of the occurrence forecast scattered cloud and light winds. This was the forecast that was available to the crews of Velocity 1384 and Qantas 735 at their times of departure and used for flight planning.

At 0700, an amended TAF for Adelaide was issued effective from that time. This TAF predicted similar conditions as the 0303 forecast, but with the addition of a 30 per cent probability of fog developing. Concurrently, the TTF for Adelaide showed light winds with few clouds with no significant changes expected over the forecast period. However, a TTF conveys the most likely sequence of meteorological events and as such, does not contain forecast probabilities that are included in TAFs.

At 0800, the TTF for Adelaide showed visibility had reduced to 1 km to the north-west and that patches of fog and shallow fog were present. The trend was for visibility to decrease to 500 m in fog before clearing at 0900 to a visibility in excess of 10 km and few cloud.

Subsequent TTFs were issued for Adelaide, each extending the predicted time for the fog to clear. The first TTF with no fog present was issued at 1230.

The BoM reported that the fog forecasting procedure for Adelaide Airport used various inputs, including a computer model, observed wind speed and direction at 2,000 ft, surface wind speed, recent precipitation, dew point depression, the position of high pressure systems, and dew point as a function of time of year. The BoM also advised that ‘the forecast for the airport was recalculated twice overnight using the observed 2,000 ft wind speed and direction from the upper wind balloon flights’ at 2100 on 17 June and 0300 on 18 June.

On the morning of the occurrence, the ‘upper air wind flight’ at 0300 measured the 2,000 ft wind as being outside the fog formation envelope of the fog forecasting procedures. The 0303 TAF was computed on that basis.

At about 0630 on 18 June, ATC at Parafield and Edinburgh Airports, to the north of Adelaide, began to advise BoM forecasters that visibility was reducing in fog. The forecasters then decided

to amend the Adelaide TAF at 0700 to include a 30 per cent probability of fog. BoM observations, together with reports from Adelaide Airport tower controllers placed the fog well to the north of Adelaide Airport.

The BoM reported that fog was not included in the 0700 TTF as the surface winds did not support the formation of fog. As a TTF does not include probability forecasts, only the 0700 amended TAF could include the 30 per cent probability of fog. The 0800 TTF indicated fog as it was considered imminent and formed at 0804, which was reflected in a SPECI issued at 0805.

Mildura Airport

The 0358 amended TAF for Mildura that morning forecast light winds and scattered cloud at 3,000 ft and broken cloud at 6,000 ft. The TAF also included TEMPO periods between 0500 and 1000 in which the cloud base was forecast to reduce to 600 ft AGL.

A new routine TAF was issued for Mildura at 0902 that was valid from 1000. This TAF forecasted visibility in excess of 10 km and scattered cloud at 3,000 and 5,000 ft. No significant weather was listed on the TAF and no indication of low cloud or fog was given. Neither crew were aware of this TAF nor would they have been able to use this forecast in support of their decision to divert. This was because the Aeronautical Information Publication (AIP) Australia stated that a TAF that is valid for 30 minutes prior to the arrival must be used for flight planning purposes. As such, it could not be used for arrivals at Mildura prior to 1000.

A further amended TAF was issued for Mildura at 0952 and covered the period 1000–2200. This TAF forecasted a visibility of 3,000 m in mist, with scattered cloud at 300 ft AGL and broken at 4,000 ft AGL. In addition there was a 30 per cent probability of 500 m visibility in fog and broken cloud at 200 ft AGL between 1000 and 1200.

The METAR observation reports issued for Mildura at 0830 and 0900 showed light winds, visibility in excess of 10 km and the cloud lifting from broken at 3,400 to broken at 3,900 ft. These were the reports obtained by the crew of Velocity 1384 and Qantas 735 to assist their decision making about diverting to Mildura.

The BoM reported that their assessment of Mildura at around 0830 showed that low cloud was more likely to occur than fog. In addition, improved conditions could be expected from 1000 as the wind was forecast to tend southerly and both fog and low cloud were rare in a southerly flow at Mildura. Based on this information, the forecast for TEMPO conditions was continued.

At around 0900, weather recording instrumentation at Mildura started to indicate patches of low cloud at around 400 ft. A visual satellite image indicated a bank of low cloud south of Mildura indicating that the prediction of temporary (TEMPO) deteriorations was still appropriate.

At 0918, a special weather report (SPECI) observation was issued for Mildura, listing the cloud as broken at 200 ft, and visibility in excess of 10 km. Subsequent SPECIs at 0928, 0930 and 0932 showed the visibility decreasing from 5,000 m to 2,100 m in mist, with broken cloud at 200 ft. The first SPECI indicating the presence of fog was issued at 0948, showing visibility as 900 m in fog and cloud overcast at 100 ft.

Between 0925 and 0931, the visibility at Mildura abruptly decreased from about 28 km to 1,000 m. In addition to the recorded indications, the BoM forecaster received a phone call from ATC asking about the conditions. In response the forecaster contacted the BoM observer located at Mildura Airport. The observer advised the forecasting office that the mist and subsequent fog arrived rapidly from the south. Given the speed in which it developed, the fog was forecast to dissipate in about 1–2 hours.

As a result of this development, the forecaster issued an amended TAF for Mildura at 0952 that was valid from 1000. This TAF included a forecast for mist and a 30 per cent probability of fog, a forecast visibility of 500 m and broken cloud at 200 ft AGL for 2 hours.

After the amended TAF was issued, the BoM meteorologist located within the National Operations Centre at Airservices Australia (Airservices) rang the relevant BoM forecaster to discuss the conditions at Mildura Airport. The BoM reported advising Airservices that the deterioration was unlikely to improve in the next 15 minutes.

Subsequent SPECIs show that the visibility at Mildura reached a low of 200 m in fog at 1011. Cloud remained overcast at 100 ft. The visibility then started to increase, with the first SPECI showing no fog, but with mist and overcast cloud at 100 ft being issued at 1048. At 1130, the visibility had increased to greater than 10 km and the cloud was now listed as few at 300 ft.

Further information on the Adelaide and Mildura forecasts and observations is in appendix C.

Code grey forecast

The ICAO *Annex 3 – Meteorological Service for International Air Navigation* does not permit the inclusion in a TAF of a probability of less than 30 per cent that a weather phenomenon, such as fog, may occur during the forecast period. In order to provide some airline operators an advance notice about such low probability weather conditions that may interrupt flight operations, the BoM issues an aerodrome weather briefing (AWB) product and, if applicable, a 'code grey' forecast. When a TAF is issued that is valid for the period 1800 to 2400 UTC (0400–1000 EST), any current 'code grey' forecast is superseded by that TAF.

The availability of a code grey forecast is unique to Australia, and is used to highlight the possibility of weather conditions that airline operators may wish to consider in terms of flight planning. They are typically used in long haul operations due to the extended flight time between departure and arrival. There is no regulatory requirement to carry alternate aerodrome fuel in the case of a code grey forecast and they are not routinely referred to by short haul flight crew or in the construction of flight plans for short haul domestic operations. As such, there was no requirement for the crews of Velocity 1384 or Qantas 735 to obtain or account for a code grey forecast in their fuel planning for Adelaide. Additionally, the AWB for Adelaide included the potential for fog by way of a code grey, but the TAF issued at 1800 did not forecast fog. Based on the procedure that any current code grey is superseded by the 1800 to 2400 UTC TAF, the TAF issued at 1800 UTC for Adelaide would normally cancel the code grey forecast.

Automatic weather stations

Automatic weather stations (AWS) provide data to the BoM that is used to generate observation reports and forecasts at various locations throughout Australia. At locations where there is no authorised observer, or where the observer is not available, the observation generated has the word 'AUTO' preceding the observation.

AIP GEN 3.5 paragraph 4.1 defined aerodrome weather reports as:

> …reports of observations of meteorological conditions at an aerodrome. The reports are generated by electronic recording devices called automatic weather stations (AWS) and may have manual input from approved observers. Manual input of visibility, weather and cloud is for an area within a radius of approximately 5 NM of the ARP [aerodrome reference point].

A routine weather report (METAR) is issued at fixed times, hourly or half hourly. Special reports (SPECI) are issued by the BoM whenever weather conditions fluctuate about or are below specified criteria, including significant weather, temperature, QNH or wind changes. SPECI reports are also issued when stipulated conditions begin, end or change in intensity. These conditions include thunderstorms, hail storms and fog.

The 1-minute AWS visibility data for Mildura Airport on 18 June 2013 recorded a reduction in visibility from greater than 10 km to around 1,500 m at 0927. The visibility then fluctuated before dropping below 1,000 m at 0947. There was a slight improvement before it again reduced below 1,000 m at 0959, remaining there until 1026 when there were further fluctuations. An improvement in visibility was recorded from 1042, when the visibility increased above 3,000 m.

The 1-minute AWS cloud data for Mildura Airport showed that the lowest layer of cloud was below 200 ft at 0837, with increased cloud detected below 200 ft at 0918. The visibility and cloud detected by the AWS was broadly consistent with the SPECIs that were available at that time as both were generated from the same data source.

Aerodrome weather information service

At certain airports, an Aerodrome Weather Information Service (AWIS) provides actual weather conditions via telephone or broadcast on VHF radio. This information is sourced from the airport's AWS and is generally broadcast continuously and updated every minute. The distance at which flight crew can access the relevant AWIS is limited by the range of VHF but is typically within about 30 minutes flight time for large jet aircraft at normal cruising altitudes.

Mildura Airport had an AWIS that was normally capable of broadcasting on VHF. However, on the day of the occurrence, a NOTAM was in place advising that the broadcast function of the Mildura AWIS was unserviceable. Despite this limitation, the data was still being received from the AWS and could be obtained by telephone, or on request from ATC. Only one caller was able to access the AWS via phone at any one time.

Airport information

Mildura Airport had a number of non-precision instrument approaches available for landing and, in terms of its facilities, was a suitable alternate for the Boeing 737-800. These included a RNAV GNSS approach to runway 27 with a minima of 660 ft and a Distance Measuring Equipment (DME)[16] or GNSS arrival, to be used with the Mildura non-directional beacon (NDB)[17] or VHF omni-directional radio range (VOR)[18] ground-based navigation aids. The DME or GNSS arrival had a circling minima of 980 ft for large jet aircraft.

In order to use Mildura Airport as an alternate, the forecast cloud and visibility were required to be above the alternate minima. The alternate minima for runway 27 at Mildura for large jet aircraft were 1,233 ft and 6 km if the forecast QNH was used. This could be reduced to 1,133 ft if the actual aerodrome QNH was used (see below), although the visibility requirement remained at 6 km.

While the RNAV GNSS approach had a minima of 660 ft, if the actual aerodrome QNH was obtained from an approved source, this could be reduced to 560 ft. AIP ENR 1.5 section 5.3.2 defines approved sources of actual QNH as 'ATC and ATIS except when the aerodrome forecast QNH is provided [such as when the actual aerodrome QNH is not available], AWIS and CASA-approved meteorological observers'. The validity time for the actual aerodrome QNH is listed as 15 minutes from the time of receipt. There is also a note stating 'METAR QNH does not meet this requirement'. As the Mildura AWIS was not broadcasting, application of the lower minima could only be applied if the actual QNH was obtained from ATC.

The lower minima for the RNAV GNSS approach was based on the higher accuracy possible with GPS (GNSS) tracking. This approach also offered the benefit of a runway-aligned approach that did not require significant manoeuvring once visual. This was the approach conducted by both Velocity 1384 and Qantas 735.

At 0953, Velocity 1384 informed ATC that they would have to declare a fuel emergency in 10 minutes. In response, at 0958, the ATC operations room manager in Melbourne Centre contacted the Victorian Police coordination centre to activate the Mildura Airport emergency plan.

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[16] A ground-based transponder station. A signal from an aircraft to the ground station is used to calculate its distance from the ground station.

[17] A radio transmitter at a known location, used as a navigational aid. The signal transmitted does not include inherent directional information.

[18] A navigation aid that emits a signal that can be received by appropriately-equipped aircraft and represented as the aircraft's bearing (called a 'radial') to or from that aid.

This resulted in local emergency services being contacted to initiate a response to the arrival of Velocity 1384.

Operational information

Fuel policy

Virgin and Qantas each had a fuel policy within their operations manual, which specified the minimum fuel required, including the necessary fixed fuel reserves. Both allowed aircraft to be dispatched without carrying alternate fuel if the weather forecast for the destination did not require an alternate. Alternate fuel is calculated as sufficient fuel to approach the destination, conduct a missed approach and proceed to the nominated alternate airport for landing.

In the case of the occurrence flights, as the TAF for Adelaide that was used for flight planning did not require an alternate, each aircraft departed with sufficient fuel to reach Adelaide and land with the stipulated fuel reserves intact. In this case, the captain of Qantas 735 chose to load additional fuel prior to departure, however this was not in response to a forecast weather condition. Discretionary loading of additional fuel by an aircraft captain was allowed under each operator's fuel policy.

Flight dispatch and following

Virgin

In relation to the use of specific meteorological products for flight planning, the Virgin operations manual for flight dispatch stated:

> If required to plan a flight which reflects weather requirements (i.e. a 'live' flight plan), the TTF shall be used in the first instance, providing the flight's scheduled ETA [estimated time of arrival] is within the validity time of the TTF. If the ETA is outside the validity of the TTF, then the weather requirements shall be determined from the current TAF.
>
> METAR/SPECI are observations, not forecasts, and as such cannot be used for Flight Planning purposes, other than as a reference to determine temperature for performance purposes.

When planning for an alternate aerodrome, the policy reflected the requirements of the AIP in that the aerodrome had to be suitable for the flight and had to not itself require an alternate. Flight planning was required to take into account the requirements for holding fuel in lieu of the requirement to nominate an alternate. In this instance, if the aircraft could carry sufficient fuel to hold until 30 minutes beyond any specified time of improvement in the weather conditions at the destination, an alternate was not required.

Flight dispatch and flight following consisted of two modes. For long haul operations and those flights to islands, Asia and from the east to the west coast of Australia, flights were 'actively' followed. This meant that flight following personnel provided relevant updates to the flight crew on weather and operational matters. For all other short haul domestic flights, this service was not guaranteed, and was provided as workload permitted. At interview, the first officer (FO) of Velocity 1384 confirmed that this was their understanding of the flight following service for domestic operations.

In relation to the provision of this service, Virgin's documented guidance stated that:

> The service requires the Flight Dispatcher to continually monitor relevant operational information as it is received and to evaluate it in terms of its impact on the progress of all flight watched flights.

Qantas

Qantas's Flight Dispatch manual stated that information to prepare a flight plan included various sources of weather and operational information, including TAFs. At interview, a dispatch duty manager reported that flight plans are calculated using the relevant TAF rather than a TTF.

Flight dispatch and following was similar to Virgin in that only international and selected short haul flights were actively flight followed. These flights were always provided with relevant updates regarding weather and operational information. Short haul domestic operations, particularly those under 90 minutes duration, were provided with updated weather and operational information on a workload permitting basis.

In-flight decision making

Weather information

The AIP ENR 1.10 paragraph 1.1 had a requirement for a pilot in command to consider forecasts and observation reports during their pre-flight planning. There was no corresponding guidance for application to crews' in-flight planning. As a result, the ATSB sought clarification from CASA on the extent to which pilots are able to use observation reports for in-flight planning decisions, such as to continue to the destination or initiate a diversion.

CASA, in their response stated that 'ultimately the decision [to continue to the destination or initiate a diversion] rests with the pilot in command, but only can be based on available forecasts (TAF), Aerodrome Weather Reports (METAR/SPECI), Aerodrome Weather Information Service (AWIS) or observations'. In addition, CASA clarified that there was no 'strategic difference between an in-flight scenario and a pre-flight plan' in relation to the use of forecasts.

In relation to the use of observation reports for in-flight planning, CASA noted that 'weather observations are not a legal instrument to determine if an alternate should be held or for fuel planning, unless the observation has a trend appended to it (eg TTF…)…'. However, they further stated that '…a pilot is able to use both a valid forecast and observation information'.

Further to the use of observation reports, CASA's advice noted:

> The usefulness of the observation is dependent directly on how far away the aircraft is from the aerodrome. For example, a report showing an improvement in the weather may be useful to an aircraft in the holding pattern directly overhead the aerodrome, to decide on whether or not to fly the approach or not. Conversely, if the aircraft is a distance away (eg one hour) the observation should be viewed with caution.

Applicable to this occurrence, where the valid TAF indicated weather below landing minima at the destination, and a recent observation report indicated weather above the minima (without a trend specified, that is no TTF), CASA reported that:

> …for in-flight planning considerations the decision making must be based on the forecast element so a pilot must hold an alternate and applicable fuel but is able to make a decision to attempt an approach at the destination should the flight crew calculate additional fuel is available to do so. Specific operator procedures and fuel policies may also need to be considered.

Weather awareness

Velocity 1384

At the time that Velocity 1384 departed Brisbane, the TAF current for their arrival into Adelaide forecast fine conditions. As such, they were not required to carry fuel to reach an alternate.

At 0700, when the amended TAF for Adelaide was issued, Velocity 1384 was established at flight level (FL) 400 in the cruise.[19] At that time, they were about 150 NM (278 km) south-west of Brisbane. Virgin flight watch personnel reported receiving and reviewing this TAF when it was issued. As the TAF had a 30 per cent chance of fog and the TTF issued at the same time forecast no deterioration, they elected not to pass the amended TAF to the crew of Velocity 1384 through ACARS.

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[19] At altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 400 equates to 40,000 ft.

When the TTF for Adelaide was issued at 0800 and showed fog, flight watch again reviewed the situation for applicability to Velocity 1384. The TTF predicted that the fog would clear at 0900 and the company meteorologist called the BoM to determine the forecaster's confidence that the fog would clear at 0900. The BoM forecaster replied that they believed the fog would clear as stated in the TTF. In addition, the Virgin meteorologist reviewed other information sources to determine the probable impact of fog on the arrival of Velocity 1384. The arrival time of Velocity 1384 was planned for 0920, which was after the forecast clearance of the fog. On this basis, and the additional information gathered by the meteorologist, flight operations did not pass the 0800 TTF to the crew of Velocity 1384.

There were two additional opportunities for the crew of Velocity 1384 to become aware of the deteriorating weather at Adelaide while en route. A review of the relevant ATC recorded radio communication identified that the first opportunity was at 0816, when the crew of Qantas 735 requested further information from ATC regarding conditions in Adelaide. This was in response to their receipt of the 0800 TTF showing fog and the crew nearing their diversion point (see the following section titled *Qantas 735*). The crew of Qantas 735 asked ATC if the forecast improvement was likely to occur as expected. In response, the en route controller contacted Adelaide Tower to ascertain the current conditions. These conditions were reported back to Qantas 735 as including a visibility of 700 m in fog. The controller then offered to gather further information for the crew of Qantas 735 but indicated there would be a slight delay in doing so. A review of recorded radio communication between Qantas 735 and ATC identified that this frequency was also being monitored by the crew of Velocity 1384 at this time. The exchange between ATC and Qantas 735 was not captured on Velocity 1384's cockpit voice recording as it only recorded the 2 hours preceding engine shutdown. Engine shutdown was at about 1019.

The second opportunity occurred at 0838, when ATC updated Qantas 735 on the conditions at Adelaide. This transmission was captured on Velocity 1384's cockpit voice recording. In this update, ATC stated that the visibility was now 500 m in fog, with no landing attempts having been made for a while. Another Virgin aircraft then asked ATC to clarify if that report was for Melbourne, to which ATC replied 'negative, Adelaide'. At this time, the Velocity 1384 FO was out of the flight deck. The captain reported hearing this transmission while preparing for the approach into Adelaide. However, this information was not communicated to the FO upon the FO's return to the flight deck.

The Virgin operations manual, volume 1A, section 9.1.3 outlined the post-dispatch fuel requirements for flight crew. This included that 'At any time after dispatch, it is the PIC's [pilot in command] responsibility to ensure the fuel on board is sufficient to allow for the safe operation of the aircraft to an adequate aerodrome'.

The manual gave the following guidance to crew in order to ensure compliance:

> Once airborne, the amount of fuel onboard the aircraft at any point inflight should not be less than:
>
> - Fuel required to enable the aircraft to fly from that point to 1500 ft above an adequate aerodrome, make an approach and land; and
> - Variable Reserve based on the point above but not more than the Maximum Variable Reserve; and
> - Fuel to provide for WX [weather] holding, if the weather at the selected adequate aerodrome is forecast to be below the applicable alternate minima or a probability of thunderstorms is forecast; and
> - Fuel to provide for any required TFC [traffic] holding at the selected adequate aerodrome; and
> - Fixed Reserve.

In relation to in-flight fuel checks, it further stated:

> If sufficient fuel does not remain on board at the PNR [Point of No Return] to allow continued flight to the destination in accordance with the inflight fuel requirements, a diversion shall be made to an aerodrome which satisfies the inflight fuel requirements.

Section 9.2, Inflight fuel management, section 9.2.1 *Procedures*, stated:

> The captain shall ensure that the fuel situation is continually monitored by inflight fuel checks. Changes in operational status of the aerodrome of intended landing, alternate aerodromes and deviations from the original flight plan, shall be taken into account.

This section also provided guidance on what actions to carry out if an in-flight fuel check indicated the expected fuel remaining on arrival at the destination was insufficient. This guidance identified the need to 'take into account the traffic and weather conditions expected' for the destination, along the diversion route and at the alternate (if applicable).

Information was sought from Virgin on their level of assurance that flight crew were complying with the above requirements. Virgin advised that after a review of various information sources, including audit data and internal occurrence reports, they were satisfied there was no indication of systemic non-compliance.

The crew of Velocity 1384 reported that the first time they became aware of the fog at Adelaide was on initial contact with the Tailem Bend sector controller at 0844. At this time the aircraft was about 156 NM (289 km) to the east-north-east of Adelaide Airport.

Qantas 735

Qantas 735 had not departed Sydney when the amended TAF for Adelaide was issued at 0700; however, they had entered the 'sterile cockpit'[20] phase of flight. As a result, and in accordance with the Qantas procedures in such situations, flight watch did not pass the amended TAF via ACARS until Qantas 735 had reached top of climb and the sterile cockpit period had ended. In addition to the TAF, flight operations also passed the 0800 TTF to the crew at the top of climb.

The crew of Qantas 735 had started collecting weather information proactively prior to this point. About 5 minutes after take-off, the crew sent a request through ACARS for the current Automatic Terminal Information Service (ATIS)[21] at Adelaide. These requests are actioned automatically and do not require flight following staff input. The flight crew continued collecting weather updates for various ports as the flight progressed, including Mildura, Melbourne, Canberra, Sydney and Adelaide. These requests for forecasts and observations ceased when Qantas 735 reached holding waypoint BLACK.

At 0816, the crew of Qantas 735 received information about the current conditions at Adelaide. This included the 0800 TTF, which indicated fog that was predicted to clear at 0900. At 0820, the aircraft reached its latest point of safe diversion back to Sydney. By this time, the flight crew had gathered the latest information about the conditions at Adelaide from multiple sources, which continued to state a forecast improvement from 0900. As their planned arrival time was 0917, the crew elected to continue to Adelaide. They also had sufficient fuel to hold for about 45 minutes beyond their planned arrival time.

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[20] Employed to minimise unnecessary distractions during critical phases of flight. Qantas maintained a sterile cockpit from push back until established above 10,000 ft above mean sea level in the climb.

[21] An automated pre-recorded transmission indicating the prevailing weather conditions at the aerodrome and other relevant operational information for arriving and departing aircraft.

The Qantas Flight Administration Manual, section 16.5.1, mandated the minimum fuel requirements for all engines operations. These included that 'at all times inflight onboard fuel shall not be less than':

- Fuel to proceed to a Suitable Airport;
- 10% of the above;
- Approach Fuel;
- Fixed Fuel Reserve; and
- Special Holding Fuel (when required).

  Note: A 'Suitable Airport' may be, in order of priority:

- the Destination Airport;
- an Alternate Airport, following an approach and missed approach at destination, if the destination requires an alternate; or
- any other Suitable Airport to which an enroute diversion can be made.

A further note specified that:

> The Pilot In Command is required to assess, prior to DPA [Designated Point All Engines Operating] based on a Suitable Airport, that the above Minimum Mandatory requirements will be met at DPA. The Pilot in Command may adjust the DPA to be a geographical point, other than a position on the Fuel Flight plan (i.e. a PNR [Point of No Return]), if necessary.

In relation to a change in weather conditions after DPA, the manual contained the following note:

> It is recognised that there are occasions when a flight may pass DPA with the required fuel on board and a subsequent deterioration in forecast weather may then result in the minimum mandatory requirements above not being met.

The action by the crew of Qantas 735 at 0816 to seek additional information from ATC in relation to the clearance of the fog at Adelaide was to inform their decision-making as they approached the DPA. In this occurrence, the forecast extension of the fog at Adelaide occurred after DPA, which limited the available options.

ATC

As the actual conditions deteriorated in Adelaide, the en route controllers in Melbourne Centre responsible for the surrounding airspace started informing inbound flight crew of these changes. This ATC-initiated flight information service (FIS) (see the section titled *Airservices Australia*) extends to aircraft within 60 minutes of the condition or destination. In this case, controllers in adjacent sectors informed flight crew of the amended TAF and SPECIs for Adelaide from the time that the fog was included on the TTF at 0800.

At 0844, when Velocity 1384 and Qantas 735 were both on the Tailem Bend sector frequency, the controller provided the following information:

> Qantas seven-thirty-five and Velocity thirteen-eighty-four you are probably both aware of the weather in Adelaide at the moment. Latest SPECI from two-two-three-zero [0830 EST], wind zero four zero degrees at five knots, visibility one five zero metres in fog, cloud overcast at one hundred, temperature is six, dewpoint is zero five.

Various supervisors in Melbourne Centre advised that they were aware that the weather in Adelaide was deteriorating. The supervisors were also aware that the weather was similarly deteriorating and, in some cases, additional traffic holding requirements were affecting other ports such as Melbourne, Canberra and Albury. These deteriorations resulted in an increase in the number of in-flight diversions and therefore ATC workload.

In relation to Mildura, the first time the systems supervisor became aware that the conditions were deteriorating was on receipt at around 0930 of a telephone call from the Mildura aerodrome

reporting officer (ARO). The ARO was calling to query why aircraft were diverting to Mildura given the conditions. As a result, the systems supervisor contacted the BoM to advise them of the unexpected deterioration and that the current Mildura TAF did not reflect the severity of the conditions. At around 0957, the systems supervisor again called BoM for an appreciation of the weather as Velocity 1384 was compelled to land at Mildura.

The BoM meteorologist at the Airservices National Operations Centre (NOC), located in Canberra, contacted the BoM after the amended TAF was issued at 0952. The NOC was responsible, in part, for liaison with the airlines and the meteorologist was querying the conditions at Mildura in relation to Velocity 1384. The BoM advised the NOC that conditions were unlikely to improve in the next 15 minutes.

Diversion to Mildura

As the crews of Velocity 1384 and Qantas 735 became aware that the fog at Adelaide was not dissipating as initially forecast, they both started collecting weather and operational information for alternate airports. The other airports in the area reporting suitable weather were Mildura, Broken Hill and Woomera. Boeing 737-800 aircraft were unable to use Broken Hill due to runway pavement limitations. Woomera was not considered by either crew as there were no company facilities at that airport, nor was it a routine destination for the airlines.

The flight plan provided to the crew of Velocity 1384 included the weather and NOTAMs for Mildura, as Mildura was listed as a diversion port in the event of an en route depressurisation. This information included the current TAF at the time the crew diverted to Mildura, which forecast a TEMPO period of low cloud covering their planned arrival time. In order to proceed to an airport with a TEMPO for deterioration of weather conditions below the alternate criteria, crews must ensure they have sufficient fuel to hold for the duration of the deterioration and land with fuel reserves intact, or provide for flight to an alternate destination. The FO mentioned the TEMPO during the crew's discussion of the diversion to Mildura; however, at that time the captain was conducting a separate calculation and the crew did not discuss the TEMPO requirements any further.

To supplement the information already provided, the crew asked ATC for the latest observation reports for Mildura. They were provided with two routine (METAR) reports for Mildura, which indicated conditions were suitable for an approach, with cloud above the landing minima and visibility in excess of 10 km.

The crew of Qantas 735 had been monitoring the Mildura weather through ACARS and heard the transmission by ATC of the METAR information to Velocity 1384. They also obtained the TAF showing a TEMPO and reported calculating that they could meet this additional fuel requirement for Mildura. Due to limited information, the ATSB was not able to validate the crew of Qantas 735's calculations. However, fuel uplift records from Sydney and Mildura, as well as flight plan fuel figures adjusted for taxi and auxiliary power unit fuel burn, enabled the ATSB to calculate if this requirement could be met. This showed that Qantas 735 could hold until about 1020, 10 minutes short of the requirement.

Shortly after both crew initiated a diversion to Mildura, the BoM released an amended TAF for Mildura, removing the TEMPO requirement. However, neither crew had access to this TAF and, even if they had, they would not have been able to use it for flight planning purposes at that stage as it was not valid for use before 1000.

The crews of Velocity 1384 and Qantas 735 reported having placed a greater weight on the observation reports for Mildura, given the ongoing forecast issues for Adelaide. This decision was further influenced by the fact that the observation reports for Mildura showed an improving trend in conditions.

The ATSB calculated that, at 0918 when the first SPECI associated with the low cloud at Mildura was issued, Qantas 735 had sufficient fuel to hold at cruise altitude until about 0955 then return to Adelaide and complete an emergency autoland with the fixed fuel reserve intact. However, once

Qantas 735 commenced descent towards Mildura, the divert time of 0955 would have reduced by about 20 minutes due to the increasing distance from Adelaide and additional fuel required to climb back to cruise altitude and effect a return.

Additionally, the workload associated with preparing for and conducting a diversion and approach could generally be expected to affect the crew's capacity to determine whether they had sufficient fuel to conduct a further diversion.

Similar calculations for Velocity 1384 indicated that the fuel on board at 0918 permitted the aircraft to hold for about 5 minutes before diverting to Adelaide and landing with the fixed fuel reserve intact. The captain of Velocity 1384 reported that the required decision making and associated actions to return to Adelaide could be achieved in this timeframe.

Landing below minima

Civil Aviation Regulation 1988 (CAR) subregulation 257(4) specified that if an element of the meteorological minima for landing is less than that determined for the aircraft operation at the aerodrome, the aircraft must not land at that aerodrome. However, CAR 257(5) specified that 'if an emergency arises that, in the interests of safety, makes it necessary for an aircraft to land at an aerodrome where the meteorological minima is less than that determined for that aircraft operation at that aerodrome' then CAR 257(4) did not apply.

The flight crews of Velocity 1384 and Qantas 735 had insufficient fuel to divert to another airport once they arrived at Mildura. Given the meteorological conditions were less than the landing minima for a Boeing 737, this constituted an emergency. As such, both crews were able to land under the provisions of CAR 257(5).

Airservices Australia

The ATSB examined the training and guidance material available to air traffic controllers relating to the provision of air traffic services. In addition to training in core ATC competencies, controllers received training in the classroom and simulator that covered aircraft operational aspects including, but not limited to:

- flight planning
- alternate requirements
- meteorology
- aircraft performance.

Additionally, assessment was made in simulators and on-the-job in relation to controllers' management of non-routine events. Specifically, this included responding to changing conditions, passing operational information and responding to pilot requests. Particular emphasis was placed on prioritising and disseminating information, including the need to document these actions to ensure an accurate record and a common understanding between controllers and supervisors.

Airservices advised that monitoring of a flight will increase if flight crew declare an emergency. The declaration of an emergency, including due to insufficient fuel, enables ATC to understand the nature and extent of the situation. Without this, the diversion of an aircraft to an alternate due to poor weather at the destination will not trigger increased monitoring. Airservices advised that this was because diversions are common and controllers are encouraged not to become involved in pilot decision making.

Flight information service

The AIP Australia detailed the various elements of flight information service (FIS), including that 'pilots are responsible for obtaining information necessary to make operational decisions'. It also noted that:

> To ensure that accurate information is obtained in adequate time, pilots must take into consideration that ATC initiated FIS is limited to aircraft within one hours flight time of the condition or destination at time of receipt of the information by ATC. The only exception to this is SIGMET information, which shall cover a portion of the route up to two hours flying time ahead of the aircraft.

For in-flight FIS, the service consisted of three elements:

- ATC-initiated FIS
- the Automatic Broadcast Services (ABS)
- an On-request service.

ATC-initiated FIS allowed for the provision to crews by ATC of pertinent operational information. This included 'meteorological conditions and the existence of non-routine met products'. AIP GEN 3.3 section 2.5.2 stated that:

> When providing FIS, ATC will not alert pilots to the availability of aerodrome weather reports that are available from an automatic broadcast service.

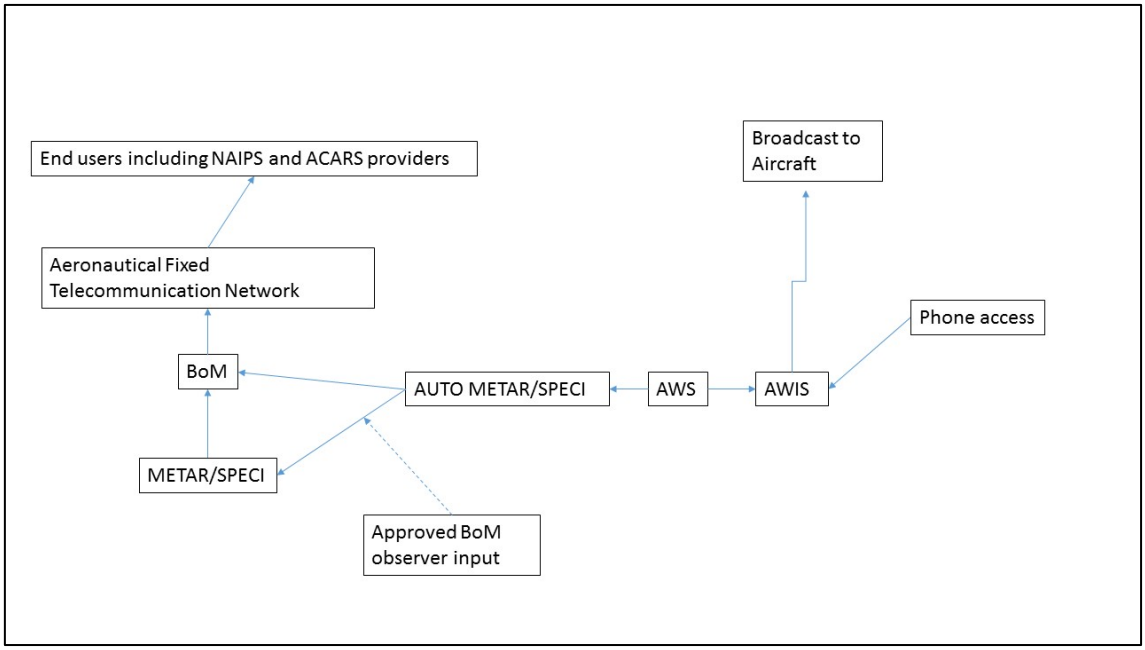
The ABS consist of:

- Automatic Terminal Information Service (ATIS). An ATIS provides normal operational information for the airport terminal area. It is broadcast automatically and continuously and contains information required for take-off and landing. It provides weather observations as well as relevant operational information, such as the requirement for additional holding fuel and the unavailability of facilities or services.
- Automatic En Route Information Service (AERIS). This service continuously broadcasts routine meteorological reports (METAR) on a network of VHF transmitters. It caters predominately for aircraft operating in control areas within VHF range of the facility.
- Aerodrome Weather Information Service (AWIS). AWIS allows for the actual weather conditions at suitably-equipped locations to be accessed by telephone and, at some locations, the information is also broadcast on VHF. Most broadcasts are continuous and the information is updated every minute. At a number of the AWIS locations, the broadcast is pilot-activated via radio.
- Meteorological Information for Aircraft in Flight (VOLMET). VOLMET provides meteorological information for Australian major international airports and Townsville via high frequency (HF) radio transmission.

As with the broadcast of weather observations via ATIS, an AWIS does not append the words 'METAR' or 'SPECI' to weather observations that are broadcast via AWIS. However, the information provided by an AWIS is generated from the associated automatic weather station (AWS), which is the same data source used by BoM to create a METAR or SPECI report (Figure 6).

Many non-major airports in Australia have an AWIS and, as this is classified as an ABS, ATC will generally not alert pilots to significant deteriorations or improvements in specified weather condition (SPECIs) at those locations. In this case, pilots can still access the source weather data from the AWIS, although there is no verbalisation in the respective weather observations of the trigger term 'SPECI'. Instead, pilot awareness of the implications for the flight of the reported weather conditions is crucial to effective in-flight decision making.

Figure 6: Overview of the Automatic Weather Station outputs and end user products. Note that the approved BoM observer input is optional and, if not actioned, will result in an 'AUTO' METAR or SPECI



If there is no AWIS, or it is a major airport, ATC will advise the availability of a SPECI report as FIS, workload permitting. These reports:

- are generated by the AWS
- offer the potential that an approved observer may amend the source data
- have the term 'METAR' or 'SPECI' appended to the report by the BoM before their distribution, including to ATC, via the Aeronautical Fixed Telecommunication Network.

The on-request service is available to all aircraft in all classes of airspace on VHF or HF. To access the on-request service, pilots are to use a standard radio call comprising the prefix of the ATC unit applicable and the call sign 'Flightwatch' (for example 'Melbourne Centre Flightwatch request actual weather (location)'). There is the potential that due to workload considerations, pilot requests may be redirected to another VHF frequency or Flightwatch HF.

Hazard alert

AIP GEN 3.3 sections 2.5.4 and 2.5.5 detailed the hazard alert service provided by ATC as part of ATC-initiated FIS. This alert is used to notify flight crew of a 'sudden change to a component of FIS, not described in a current MET product or NOTAM, having an immediate and detrimental effect on the safety of an aircraft…'. The transmission is prefixed by 'Hazard Alert'.

When the change is anticipated to be prolonged, the 'Hazard Alert' prefix continues to be used in broadcasts repeated at H+15 and H+45 in the hour following the initial transmission. These broadcasts normally cease either after 1 hour or after an updated MET product or NOTAM is available, whichever occurs earlier.

During the investigation, the ATSB became aware that the En Route Supplement Australia (ERSA), which is a supplement to the AIP, and the Jeppesen Australian Airways Manual contained incomplete information on hazard alerting. Specifically, ERSA section 4 *Hazard alerts (GEN-FIS-2)* and Jeppesen *Meteorology reports and advisories* section 4.4, *Hazard alerts* defined hazard alerts without specifying that they were 'limited to a sudden change to a component of FIS not described in a current MET product or NOTAM'. However, Jeppesen *Air traffic rules and services,* section 8.5 *ATC initiated FIS* did contain this advice.

Changes to FIS

The Manual of Air Traffic Services (MATS) is a joint document of Airservices and the Department of Defence. The manual contains the rules that relate to the provision of air traffic services. In 2009 the MATS was amended to reflect changes to the AIP, in that pilots were not to be alerted to the availability of a SPECI that could be obtained from an ABS. This change came about, in part, due to the introduction of more automatic weather stations, which increased the amount of data available for various airports. While the increase in data was a benefit to BoM, an unexpected outcome was the production of numerous AUTO SPECI reports. These were triggered by a change in one of the recorded parameters meeting the requirements for a SPECI (see the section titled *Automatic weather station*).

The increased number of automatically-generated weather observations increased the amount of weather being delivered to controllers' consoles for various airports. All required review and, if pertinent, broadcast to relevant traffic. This resulted in a significant increase in controller workload. Often the reports were consistent with the forecast, or were triggered by an improvement in conditions. As such, they did not always represent a significant or unforecast deterioration.

In response, in December 2008, Airservices conducted a *Safety Case Assessment and Reporting Determination* (SCARD), which was required whenever:

> …changes to service levels, procedures or equipment, which will affect the performance, functional or technical specification of a system or service; and organisational changes affecting safety accountabilities.

The SCARD assessed changes to FIS, including that SPECIs that can be obtained from an ABS do not need to be 'directed' or 'broadcast' to aircraft by ATS.

The SCARD determined that a safety case was not required as there was no change to the Air Traffic Services Provider Certificate. The size of the change was assessed as 'small' and the magnitude of the change as 'reasonable'. In assessing the magnitude of the change, Airservices identified a potential failure of 'the pilot does not obtain in-flight information', with the effect that the 'pilot is not aware of significant weather information'. The overall assessment was considered 'minor' and approved by the relevant managers.

As a result of this process, Airservices amended the AIP and MATS to reflect that SPECIs would no longer be broadcast to pilots if an ABS (such as AWIS) was available. In addition, The Australian Advanced Air Traffic System was amended so that controllers were no longer automatically provided with weather for an airport that had an ABS. They could, however, access the weather if requested by flight crew or for their own information.

Although only one component of ABS, AWIS is the most prevalent ABS supporting non-major airports in Australia. In order to access information from an AWIS, an aircraft needs to be within VHF range. For a large jet aircraft, this position is typically within 30 minutes flight time of the AWIS and occurs during a period of increased crew workload associated with the descent.

For further information on the history of the changes to FIS and hazard alerting, see appendix D.

Air reports

The AIP GEN 3.5 section 11 contained information for pilots in relation to broadcasting an air report (AIREP). This included that a special AIREP should be made 'when requested, or as soon as practicable after encountering a condition which is likely to affect the safety or markedly affect the efficiency of other aircraft'. In the climb out, such as the air ambulance pilot departing Mildura Airport on the morning of the occurrence, the AIP specified that a pilot 'must report meteorological conditions, not previously advised, which are likely to affect the safety of aircraft operations'.

A short AIREP should be provided by pilots when requested and ATS should be advised when a pilot encounters:

a. Cloud – unexpected significant variations to amount, base or tops (by reference to QNH);

b. Visibility – reduced due fog, mist, hail, rain, snow or dust, improvement observed;

c. Wind – significant variation to forecast;

d. Other Phenomena – incidence of severe or moderate turbulence, thunderstorms, moderate or severe icing, hail, line squalls, standing waves or winds of 40 KT or more within 2,000FT of ground level.

In respect of the distribution of short AIREPs, MATS section 3-10-930 required controllers to:

Distribute short AIREPs originated by general aviation pilots to:

a) the MET office responsible for MET watch over the area

b) the briefing office associated with the area

c) other aircraft and ATS units, if considered of operational significance.

The pilot of the air ambulance aircraft who departed Mildura at 0916 did not use the term 'AIREP'. However, the information that was passed to ATC in that report did meet the conditions listed in AIP for broadcast by a pilot.

The Mallee controller who was responsible for the airspace above Mildura did not pass this information on, either internally or directly to BoM. They reported to Airservices that this was due to high workload at the time, and a consideration that the information in the pilot's report did not differ significantly to the forecast TEMPO conditions. Supervisors at Melbourne Centre indicated that the BoM would often ask for more than one report of deteriorating weather to inform their decision making in relation to amending a forecast. This is particularly the case if the sole report is consistent with the current forecast, as in this instance, when the low cloud at Mildura as reported by the air ambulance pilot was already forecast.

The BoM subsequently advised the ATSB that there was no procedure in place to require a forecaster to request multiple reports of deteriorating weather before amending a forecast. The BoM further stated that forecast amendments are based on a number of factors and not limited to aerodrome weather reports.

International provision of flight information service

United States

The United States (US) AIP that was current at the time of the occurrence listed the various areas of FIS that were provided to pilots in the US. AIP GEN 3.5 section 6 outlined the in-flight weather broadcasts available to pilots, including weather advisory broadcasts. These covered SIGMET and weather advisory information, such as moderate/severe icing. In addition, the US Hazardous Inflight Weather Advisory Service is an automated, continuous broadcast providing in-flight weather advisories. These included the following products:

- Alert Severe Weather Watch bulletins
- SIGMETs
- Convective SIGMETs
- Centre Weather Advisories
- AIRMETs (advisories of significant weather phenomena)
- urgent pilot weather reports.

US AIP GEN 3.5 section 7 described two basic types of FIS, 'broadcast only', which was called FIS-B and 'two-way request/reply'. Broadcast system components comprised a ground- or space-based transmitter, an aircraft receiver and a portable or installed cockpit display device.

In the US, FIS is available from four types of service providers and operates independently of ATC, but in some cases will be a Federal Aviation Administration (FAA)-operated service. FIS in this context is:

> …a method of receiving aviation weather and other operational data in the cockpit that augments traditional pilot voice communication with FAA's Flight Service Stations (FSS), ATC facilities, or Airline Operations Control Centers.

Subsequent cautions in section 7 stated that:

> To ensure airman compliance with Federal Aviation Regulations, manufacturer's operating manuals should remind airmen to contact ATC controllers, FSS specialists, operator dispatchers, or airline operations control centers for general and mission critical aviation weather information and/or NAS [national airspace system] status conditions (such as NOTAMs, Special Use Airspace status, and other government flight information).
>
> FIS should not serve as the sole source of aviation weather and other operational information. ATC, FSSs and, if applicable, AOCC [airline operations control center] VHF/HF voice remain as a redundant method of communicating aviation weather, NOTAMs, and other operational information to aircraft in flight.

Weather avoidance assistance was also available from ATC in the US. AIP GEN 3.5 Section 10.2.1 stated that 'to the extent possible, controllers will issue pertinent information of weather and [stipulated] areas and assist pilots in avoiding such areas if requested'. Section 10.2.4 contained the caveat that:

> It should be remembered that the controller's primary function is to provide safe separation between aircraft. Any additional service, such as weather avoidance assistance, can only be provided to the extent that it does not derogate the primary function. It is also worth noting that the separation workload is generally greater than normal when weather disrupts the usual flow of traffic. ATC radar limitations and frequency congestion may also be factors in limiting the controller's capability to provide additional service.

The provision of FIS in the US has more components than the system in Australia and is supported by greater infrastructure, both ground-based and in-aircraft. Nevertheless, the underpinning principle that the primary function of ATS is the safe separation of aircraft, with weather avoidance as an additional service subject to workload, is consistent with the system in Australia.

Canada

Transport Canada, in their document *Aeronautical Information Manual – RAC – Rules of the Air and Air Traffic Services* section 1.1.1 *ATC and Information Services* stated that:

> Flight information service is provided by ATC units to assist pilots by supplying information concerning known hazardous flight conditions. This information will include data concerning unfavourable flight conditions and other known hazards; which may not have been available to the pilot prior to takeoff or which may have developed along the route of flight.

The section went on to state the 'prevention of collisions and expediting of traffic' will take precedence over this service. In addition, it was noted that:

> …Flight information will be made available, whenever practicable, to any aircraft in communication with an ATC unit, prior to takeoff or when in flight, except where such service is provided by the aircraft operator. Many factors (such as volume of traffic, controller workload, communications frequency congestion and limitations of radar equipment) may prevent a controller from providing this service.

Section 1.1.2 of the Transport Canada manual was titled *Flight Advisory and Information Services* and outlined the elements of the in-flight information service. In part, these included:

> (b) *FISE*: the exchange on the FISE [flight information service en route] frequency of information pertinent to the en-route phase of flight. Air traffic information is not provided. Upon request from an aircraft, a FIC [flight information centre] provides:
>
> (i) meteorological information: SIGMET, AIRMET, PIREP [pilot report], aviation routine weather report (METAR), aviation selected special weather report (SPECI), aerodrome forecast (TAF), altimeter setting, weather radar, lightning information and briefing update;
>
> (ii) aeronautical information: NOTAM, RSC [runway surface condition], CRFI [Canadian runway friction index], MANOT [missing aircraft notices] and other information of interest for flight safety; and
>
> (iii) relay of communications with ATC: IFR clearance and SVFR [special VFR] authorization.

The provision of FIS under this system is similar to that provided by Airservices, in that it is primarily pilot-initiated (or 'upon request'). While the provision of FIS for 'known hazardous flight conditions' is supplied to pilots, this is dependent on many factors, including controller workload. This arrangement is consistent with the service provided by Airservices.

New Zealand

The AIP New Zealand, in GEN 3.3 outlined the services provided by New Zealand ATC in relation to FIS. In New Zealand, FIS is defined as:

> 3.3.7 FIS will include the provision of available and relevant information concerning:
>
> (a) SIGMET;
>
> (b) weather conditions reported or forecast, at departure, destination, and alternative aerodromes;
>
> (Table GEN 3.3-3 lists aerodrome MET information available in-flight on request from ATS)
>
> (c) changes in the serviceability of navigation aids;
>
> (d) changes in the condition of aerodromes and associated facilities, including information on the state of the aerodrome movement areas when they are affected by snow, ice, or water;
>
> (e) unmanned free balloons;
>
> (f) pre-eruption volcanic activity, volcanic eruptions, and volcanic ash clouds;
>
> (g) release into the atmosphere of radioactive materials or toxic chemicals;
>
> (h) traffic to aircraft likely to be affected; and
>
> (i) other activities likely to affect safety.

AIP GEN Section 3.3.1 stated that 'FIS will be provided whenever practicable to all aircraft that are known to be affected by the information'. Additionally, subsequent sections stated:

> 3.3.4 For aircraft in flight, flight information is normally confined to information concerning the route being flown up to and including the next attended aerodrome. This includes available information regarding nominated alternate aerodromes and unattended aerodromes enroute at which a landing is planned.
>
> 3.3.5 FIS does not diminish the responsibilities normally vested in the pilot of an aircraft, including that for making a final decision regarding any suggested alteration to flight plan.
>
> 3.3.6 Where ATC units provide both FIS and ATC service, the provision of ATC service will take precedence over the provision of FIS whenever the provision of ATC service so requires.

The provision of flight information service by New Zealand ATC and the precedence afforded the provision of ATC services over FIS are consistent with the service provided by Airservices.

Tests and research

ATSB research investigation

In support of this occurrence investigation, the ATSB initiated a research investigation into the reliability of aviation weather forecasts at Adelaide and Mildura Airports between 2009 and 2013 (AR-2013-200 that will, on completion, be available at www.atsb.gov.au). At the time of writing, the results of this research for Mildura Airport were available and are summarised below.

Exposure to weather conditions below the landing minima at Mildura was found to be very unlikely during the period studied. Specifically, weather conditions were observed below the landing minima 0.99 per cent of the time, and below the alternate minima about 2.6 per cent of the time at Mildura Airport between 2009 and 2013. Additionally, a review of forecast retrievals for the period up to 2 hours prior to arrival found that 0.09 per cent of the time weather predicted above the alternate minima actually deteriorated below the landing minima. In other words, considering the forecasts that did not predict conditions below the alternate minima (0.09 per cent), and all observations below the landing minima (0.99 per cent), in the period 2009–2013, 10 per cent of the time that the observations were below the landing minima at Mildura Airport, those conditions were not forecast (0.09/0.99). Taking into account aircraft traffic arrival patterns at Mildura, these events, which would not have required crews to have planned for an alternate, resulted in the potential for an average of four aircraft per year being affected by unforecast weather conditions that were below the landing minima.

The ATSB also found that the forecasting process at Mildura Airport appeared to be conservative, with a high false alarm rate. That is, conditions that were forecast to be below the alternate minima, were actually observed to be above those minima.

Significant fluctuations in forecast accuracy and the resulting risk to safety were observed over time. Additionally, aspects such as aircraft holding time and the number of traffic movements also need to be taken into account to determine the operational effect and risk of any inaccuracy. These, and other factors, are investigated in detail in ATSB research report AR-2013-200.

ATSB industry safety forum

On 31 March 2014, the ATSB hosted a safety forum in Canberra, with representatives from Airservices, the Australian Federation of Air Pilots, the Australian and International Pilots Association, the BoM, CASA, CivilAir (Australia's ATC union), Qantas, Virgin and the Virgin Pilot's Association.

During the forum, it was apparent that there was an expectation by pilots that they would be told of any significant deterioration in weather by ATC. In particular, in relation to this occurrence, it was noted that pilots would have expected the crews of Velocity 1384 and Qantas 735 to have been told of the fog at Adelaide prior to changing to the Tailem Bend sector frequency. That is, there was an expectation that the crew would have been told about the fog in Adelaide when the condition commenced.

Given that at 0800 neither aircraft was within 60 minutes flight time of Adelaide, a potential misinterpretation of FIS by industry was indicated. It should be noted that ATC will only provide FIS to aircraft within 1 hours flight time of the destination or condition and, as the provision of FIS is workload dependent, pilots should not rely on this service in order to become aware of changes at their destination.

It was also noted at the forum that, while ACARS equipment is widely fitted and used on large jet aircraft, not all Australian airline fleets are equipped with ACARS. It is also not necessarily fitted in smaller jet and non-jet aircraft. As such, there is still a reliance on services such as FIS to provide pilots with an appreciation of deteriorations in weather at certain airports.

Notwithstanding this industry view, there is a requirement for pilots to obtain all relevant weather information in-flight to aid operational decision making. Primarily this will be achieved through the on-request service, supplemented by the ATC-initiated FIS when possible.

Related occurrences

A number of reviews of the ATSB occurrence database were carried out in an effort to understand the potential operational and other factors in this occurrence. These included in the areas of:

- the number of unforecast weather occurrences reported since the changes to the provision of FIS in Australia were introduced in 2009
- the level of assistance provided by ATC to flight crew in response to a number of non-routine events
- similar occurrences to that at Mildura in June 2013.

Unforecast weather occurrences reported since the changes to the provision of FIS in Australia in 2009

A review of the ATSB occurrence database was conducted for the period January 2009–March 2015 in order to determine the number of unforecast weather occurrences reported in this time. This period was chosen to reflect the system after the changes to the provision of FIS in Australia were introduced in 2009. The search identified 160 occurrences, and that in 117 of these occurrences the crew received an alert of the deterioration from either ATC or the operator's flight watch service.

It should be noted that there was insufficient detail in some of the reports to identify if the crew was alerted to the unforecast weather. Therefore, crews may have been alerted on more than the 117 occurrences identified. In addition, some of these unforecast deteriorations were observed during approach, meaning the deterioration was only just prior to the arrival of the aircraft.

Of the 160 occurrences, 36 resulted in the declaration of a PAN or other emergency by the crew to facilitate either a diversion (particularly to a military airport) or priority landing. In almost all cases, the landing was made with fuel above the fixed reserve.

Four occurrences were identified in which the weather change was forecast but the crew were not alerted.

Assistance provided by ATC to flight crew in response to non-routine events

A second review of the ATSB occurrence database was conducted to examine the level of assistance provided by ATC to flight crew and identify any systemic issues. The following non-routine events were examined:

- engine issues
- lost or unsure of position
- encounter with unforecast weather, including VFR flight into instrument meteorological conditions[22]
- low fuel situations
- inadvertent flight below the minimum permitted altitude.

[22] Instrument meteorological conditions (IMC) describes weather conditions that require pilots to fly primarily by reference to instruments, and therefore under Instrument Flight Rules (IFR), rather than by outside visual references. Typically, this means flying in cloud or limited visibility.

The time period for this review was July 2008 to December 2013. This encapsulated the pre-2009 FIS change through to the occurrence at Mildura. This was to examine the typical level of assistance provided by ATC around the time of the occurrence for any systemic issues.

By filtering the above occurrences for those making some reference to ATC in the reporter's text (870 occurrences), the ATSB found 171 occurrences with evidence that ATC provided assistance to the pilot, some of which was at pilot request. There was only one occurrence found where the pilot believed they should have received greater assistance from ATC, however that occurred in the context of high controller workload and potential miscommunication between the pilot and ATC about the situation.

Similar occurrences to that at Mildura in June 2013

A further review of the ATSB occurrence database identified five occurrences that had happened since 1999 and were similar to this occurrence. These occurrences were investigated by the ATSB and are detailed below (available at www.atsb.gov.au).

ATSB investigation 199904029

On 20 August 1999, as the Airbus A320 aircraft, registered VH-HYO, approached runway 23 at Adelaide Airport, South Australia for landing, the crew observed a bank of fog drifting toward the aerodrome from the north-east. By the time the aircraft arrived at the airport, the runway threshold was obscured by the fog. As a result, the crew elected to conduct a missed approach.

During the missed approach, the crew noticed that the threshold area of runway 05 was clear and requested an immediate visual approach to runway 05 before the fog drifted further to the south-west. Due to other instrument flight rules traffic, ATC could not issue an immediate clearance for the approach. By the time that clearance was available, the remainder of the runway was obscured by fog.

A Boeing 737 aircraft had been able to land on runway 05 following a VOR/DME approach, so the A320 crew attempted to conduct a similar approach. However, that attempt resulted in a second missed approach. The aircraft tracked to the north-east of the aerodrome and the crew informed ATC that they would conduct an instrument landing system (ILS) approach to runway 23 and then land using the aircraft's autoland system. With 1,500 kg of fuel remaining, the aircraft landed without incident in the fog with 250–350 m visibility.

The aircraft was certificated for autoland approaches, but the ground equipment was not. The ILS transmitter was a Category 1 unit with a minimum visibility of 1,200 m required for landing. The crew decided to conduct an autopilot-coupled approach with automatic landing, as fog was also present at Edinburgh Airport, rendering that airport unsuitable as an alternate.

Fog had not been forecast for Adelaide when the crew submitted their flight plan. Consequently, the aircraft did not carry fuel for holding at Adelaide or for diversion to an alternate airport. However, fog had been forecast for both Edinburgh and Parafield airports. The BoM reported at the time that this was not unusual, as records showed that in the previous 20 years, fogs formed at both Adelaide and Edinburgh on about 50 per cent of occasions that it was forecast, with Edinburgh proving to be the greater risk. On the day of the A320 occurrence, moisture levels were higher to the north of Adelaide, with fog forming at Edinburgh at 0730. What was unusual about the occurrence involving the A320 was that the advection of fog moved in from the north at a greater speed than the surface wind. In addition, the onset time of fog at Adelaide Airport that day was 40 minutes later than any recorded onset time at that location in the preceding 30 years.

BoM records at the time showed that Adelaide Airport averaged 4.9 fog events per annum. The highest annual total for such events was nine, as recorded in 1956 and 1983. At the time of the

A320 occurrence on 20 August 1999, there had been 11 fog events recorded at Adelaide Airport during 1999.

ATSB investigation 200401270

On 6 April 2004 an Airbus A330 aircraft landed on runway 34L at Sydney Airport in weather conditions that were below the applicable landing minima. During the latter stage of the flight, unforecast fog developed at Sydney, which resulted in the deterioration of visibility to below the landing minima.

The flight had been planned using a valid TAF for Sydney, which predicted conditions above the alternate minima for the flight's arrival. As there were no operational requirements due to the forecast weather, the flight departed Perth without fuel for a diversion to an alternate airport after an approach at Sydney.

Unforecast fog developed at Sydney Airport after the aircraft passed the flight planned last point of safe diversion, which had been based on a diversion to Melbourne. By the time the crew became aware of the fog, the aircraft did not have sufficient fuel to proceed to an alternate airport categorised by the operator as suitable for normal operations. While the crew was manoeuvring the aircraft for an approach to runway 34L at Sydney, the fog moved across the threshold of that runway reducing visibility to below the landing minima.

ATSB investigation 200605473

On 16 September 2006 an Airbus A330 landed on runway 21 at Perth Airport in weather conditions that were below the applicable landing minima.

Before departure from Singapore, the TAF for Perth Airport predicted a 30 per cent probability of fog after 0200 Western Standard Time[23]. The aircraft was due at Perth at 0020 WST so in accordance with the operator's fuel policy, fuel was not specifically carried for a diversion to an alternate aerodrome. While the aircraft was in cruise, the TAF was revised to forecast fog from 2400 WST, but the TTF which superseded the TAF trended fog from 0030 WST.

At about 2350 WST, when the flight crew commenced descent, the aircraft passed the point where it had sufficient fuel to divert to Learmonth, Western Australia. About 10 minutes later, the TTF was amended to forecast fog to occur before the aircraft's arrival time. The fog occurred at about 0015 WST. The crew attempted two ILS approaches before using autoland to land on runway 21 in weather conditions that were below the prescribed landing minima for the ILS.

ATSB investigation AO-2012-073

At 0027 WST on 1 June 2012, the flight crew of a Boeing 717 aircraft, registered VH-NXO, were conducting an instrument approach to land on runway 03 at Perth Airport after a flight from Paraburdoo, Western Australia. The approach was being conducted in instrument meteorological conditions. When the aircraft was at the decision altitude, the crew initiated a missed approach procedure as they had not obtained visual reference with the runway. Almost immediately, the crew obtained visual reference with the runway, discontinued the missed approach procedure and landed.

The onset of fog at Perth Airport at the estimated time of arrival was not forecast until after the aircraft had passed the point in the flight when it had insufficient fuel remaining to divert to a suitable alternate airport. Before that point, there had been no requirement for the aircraft to carry fuel to continue to a suitable alternate.

[23] Western Standard Time (WST) was UTC + 8 hours.

ATSB investigation AO-2015-067

On the morning on 23 June 2015, the crew of a Bombardier DHC-8, registered VH-XFQ, prepared for a flight from Perth to Darlot, Western Australia. As there was no TAF service available for Darlot, the crew was required to nominate an alternate airport on the flight plan. The captain obtained the TAF for Leinster, which was about 30 NM (56 km) to the west of Darlot and, after determining it was suitable to do so, nominated Leinster as the alternate aerodrome. Given the proximity of Leinster to Darlot, the captain also carried sufficient fuel to reach Wiluna in the event that Leinster became unsuitable.

During the flight, the conditions deteriorated below those forecast for the area, requiring a diversion first to Leinster, where the conditions were worse than forecast. As a result, the crew then diverted to and landed at Wiluna. The aircraft was refuelled and the flight returned to Darlot once conditions improved.

Safety analysis

Introduction

After realising that the fog at their original destination of Adelaide Airport would not clear prior to their arrival time, the flight crews of Velocity 1384 and Qantas 735 initiated a diversion to Mildura Airport, Victoria. The diversion was based, in part, on weather observation reports at Mildura indicating the weather was better than forecast. However, on arriving at Mildura, the crew of both aircraft encountered weather conditions worse than those forecast and reported prior to the diversion.

As a result, the crews were compelled to land at Mildura in conditions below the minima permitted for landing, with Velocity 1384 also landing below their required fuel reserves. The ATSB reviewed each of the independent systems in place to support the flights, including air traffic control (ATC), the operators and the Bureau of Meteorology (BoM), as well as the actions of individuals within these systems. Overall, given the intent of the supporting systems, the individual actions were predominately reasonable for the information the individuals had at the time.

This occurrence has highlighted the effect of various factors coming together to create and influence a rare event. This analysis will examine the factors that contributed to these outcomes, including reviewing the risk controls that support in-flight decision making.

Weather conditions at Adelaide

At the time of departure for both aircraft, the forecast conditions at Adelaide Airport were such that an alternate airport was not required. As a result, neither crew was required to carry additional fuel to that calculated for the flight to Adelaide, which included the mandatory fuel reserves. The Virgin Australia Pty. Ltd. (Virgin) and Qantas Airways Ltd. (Qantas) fuel policies were approved by the Civil Aviation Safety Authority (CASA) and each flight crew uploaded sufficient fuel in accordance with their respective policies.

While Velocity 1384 was en route to Adelaide, and while Qantas 735 was in the process of departing for Adelaide, an updated forecast was issued at 0700 including a 30 per cent probability of fog. Within the hour, the weather conditions deteriorated below the landing minima at Adelaide Airport due to fog. This fog was included on the Adelaide Airport trend forecast (TTF) that was issued at 0800 but was forecast to clear by 0900. The crews of Velocity 1384 and Qantas 735 each estimated arriving at Adelaide Airport after 0900.

As the aircraft neared Adelaide, the BoM issued another TTF at 0900. This TTF forecast that the fog would now remain until 0930. Based on this revised information, the crew of Qantas 735 decided to divert to Mildura Airport, rather than holding or conducting an autoland at Adelaide. This decision took into account the observations at Mildura, which indicated the weather there was suitable for landing. The crew of Velocity 1384 (who were not authorised to conduct an autoland at Adelaide as Virgin did not have the appropriate approval from CASA to conduct an autoland) also used the observations at Mildura as the basis of their decision to divert to that airport.

The diversion of two 737 aircraft to an alternate airport due to inclement weather at the intended destination did not result in increased monitoring by ATC. Airservices Australia (Airservices) advised that a diversion in these circumstances would not generally trigger controllers or supervisors to increase their monitoring of conditions at the alternate. Additionally, in this occurrence, the observations showed the weather at Mildura was better than forecast at the time the diversion was initiated.

The BoM reported that the fog conditions at Adelaide were particularly unusual and that, based on their experience, they did not initially expect it to form. In addition, the forecaster believed that once formed, the fog would dissipate fairly rapidly. This explains the fog's predicted clearance on

the TTF of 1 hour after its formation. Given the time of day and expected temperature increase, this was a reasonable assessment. However, on the day the fog did not clear as anticipated, which resulted in the forecast end period for the fog being inaccurate. In addition, the Adelaide aerodrome forecast (TAF) valid at the time retained a 30 per cent probability that visibility would reduce in fog.

The predicted clearance of the fog at 0900 on the 0800 TTF was used by the crew of Qantas 735 to inform their decision to continue to Adelaide from the point at which they could have returned to Sydney. This predicted clearing time was also used by the flight following personnel at Virgin to inform their decision not to pass the 0800 TTF to the crew of Velocity 1384. This was on the basis that, given their arrival time, it would not affect the flight.

Weather conditions at Mildura

The 0158 amended TAF for Mildura Airport was available to both flight crew and predicted a temporary deterioration (TEMPO) of the weather. This included broken cloud at 600 ft above ground level (AGL), which was below the alternate minima for Mildura. This TEMPO meant that anyone flying to Mildura Airport required either 60 minutes of holding fuel to outlast the predicted deterioration, or needed to nominate an alternate destination airport.

The BoM reported that their assessment of Mildura Airport at around 0830 showed that low cloud was more likely than fog, and that improved conditions could be expected from 1000. As the wind was forecast to tend southerly, and fog and low cloud were rare in a southerly flow at Mildura, the decision was made to continue with the current TEMPO.

At around 0900, weather instrumentation at Mildura Airport started to indicate patches of low cloud around 400 ft AGL and a visual satellite image indicated a bank of low cloud south of the airport. The forecast TEMPO was still considered by BoM to be appropriate for the conditions; however, at around 0930, the visibility at Mildura abruptly decreased.

The BoM observer at Mildura Airport advised the forecasting office that the mist and subsequent fog arrived from the south and resulted in a rapid deterioration in conditions. Given the speed at which it developed, the fog was forecast to lift in about 1–2 hours. The forecaster then issued an amended TAF at 0952 with a 30 per cent probability of fog, visibility 500 m and broken cloud at 200 ft AGL for 2 hours. By this time, Qantas 735 had landed at Mildura and Velocity 1384 was holding after advising ATC that they intended to delay their approach to land.

After issuing the 0952 amended TAF, the BoM received a call about the weather at Mildura from the BoM meteorologist located at the Airservices national operations centre. The BoM reported advising that the weather deterioration was unlikely to improve in the next 15 minutes. Velocity 1384 landed at Mildura at 1014, in fog conditions. BoM reported that the fog was observed for approximately 20 minutes after the amended TAF was issued, with low cloud remaining for 45 minutes after the fog cleared. This supports the assessment that the fog would clear rapidly at Mildura.

As previously stated, given the forecast conditions at Adelaide Airport, the flight crews of Velocity 1384 and Qantas 735 were not required to carry fuel for an alternate. However, this reduced their options after the unexpected need to divert from Adelaide to a suitable alternate destination. Their arrival at Mildura Airport in the now deteriorated weather meant that they had insufficient fuel to divert to another airport. As such, both aircraft were committed to land in conditions below the landing minima at Mildura Airport. This contingency in the case of an emergency was permitted under Civil Aviation Regulation 257(5).

The crews' decisions to hold or attempt an immediate landing at a lower minima at Mildura Airport relied on crew judgement. Given the uncertainty about the duration and trend of the weather deterioration, the decision of the crew of Velocity 1384 to hold and of the crew of Qantas 735 to attempt a landing were both reasonable. While conditions deteriorated after Qantas 735 landed, in

different circumstances, the weather may equally have improved sufficiently to allow Velocity 1384 to hold, before landing in conditions above the minima.

Pilot airborne report

At 0916, an air ambulance pilot who was departing Mildura Airport made a call to the Mallee sector air traffic controller, who was responsible for the airspace above Mildura. The pilot reported weather conditions at the airport for the information of inbound aircraft. These included a low bank of cloud coming across the field, with a base of 400 ft. The Mallee controller acknowledged the report but, at that stage neither Velocity 1384 nor Qantas 735 were on the Mallee frequency.

The controller subsequently reported initially continuing to give priority to aircraft separation. However, at about 0934 when their workload had reduced, they obtained the latest weather for Mildura to inform their assessment of the appropriate response to the ambulance pilot's report. This assessment resulted in the controller passing the latest SPECI for Mildura to all of the aircraft on frequency at 0935, which included Velocity 1384 and Qantas 735.

The Manual of Air Traffic Services (MATS) for ATC stated that controllers should pass airborne report (AIREP) information to affected aircraft and the BoM. In this instance, the controller did not pass the AIREP to incoming aircraft nor to their supervisor, who could have informed BoM of the deterioration. This was due to the workload associated with additional traffic arriving at Mildura and was consistent with the MATS priority of giving precedence to traffic separation over the dissemination of weather information.

While the BoM had additional sources from which to obtain information about the developing deterioration at Mildura Airport, including an on-site observer, this may not be the case for all airports. As such, the dissemination of AIREP information by ATC remains a necessary source of information for BoM and should be actioned whenever possible.

In addition, dissemination of the AIREP to both Velocity 1384 and Qantas 735 when they came on frequency would have ensured they were aware of the deterioration at Mildura prior to arriving overhead the airport. As both aircraft were committed to landing at Mildura by this time this would not have influenced the occurrence. However, the timely dissemination of such information optimises the likelihood of effective flight crew planning and decision making.

A review of the ATSB occurrence database showed that in the vast majority of cases, once aware of any non-normal situation, controllers initiated appropriate action to support flight crew. This included provision of unforecast weather conditions to flight crew. This would indicate that the actions of the Mallee controller, which were reportedly influenced by workload, were not symptomatic of a systemic issue in the provision of flight information service (FIS).

Additionally, the actions of the shift supervisor to advise the aisle supervisor and BoM of the unforecast conditions at Mildura reflected the appropriate escalation of important operational information.

In-flight decision making

The Aeronautical Information Publication (AIP) Australia states that the pilot in command is responsible for in-flight fuel management. Specifically they are required to ensure the fuel available on board the aircraft is sufficient to proceed to an aerodrome where a safe landing can be made with the planned fixed fuel reserves remaining.

Ultimately the responsibility for collecting information, such as weather updates, to support in-flight decision making remains with the pilot in command. A number of information sources are available to assist this in-flight decision making in relation to assessing the weather affecting a flight and the need to divert to an alternate destination. While the infrastructure available to flight crews may vary between operators and aircraft, broadly these information sources relate to support from the operator of the aircraft (in this case the airlines) and support from ATC.

Support from operators

Virgin and Qantas each had a flight dispatch and operations facility that supported flight crew by preparing flight plan packages (including applicable weather, notices to airmen (NOTAM) and diversion information). In addition, both had a flight following (flight watch) service for long haul operations (typically international) and limited following for short haul domestic operations. In the case of short haul domestic operations, the flight watch service was typically limited to flights from the east to the west coast of Australia, to remote islands and in support of extended diversion time operations.

For the remaining short haul domestic operations, primarily under 90 minutes flight time, the flight following service was considered 'as available', and was dependent on flight watch personnel workload at the time. That is, if information about a weather deterioration was received from the BoM, and if flight watch personnel workload permitted, the information was passed to the flight crew. However, this service was not guaranteed and as such, the responsibility for checking the weather en route remained with the pilot in command but may be assisted by the operators' flight operations personnel in some cases.

Support from ATC

Flight information service

The AIP outlines the elements of ATC-initiated FIS. This included amendments to meteorological products such as:

- special weather reports (SPECI)
- amended TAFs
- en route weather phenomena that may affect the safety of aircraft operations (SIGMET).

The provision of this service is limited to aircraft within 1 hours flight time of the condition or destination, or 2 hours for a SIGMET.

The MATS that was valid at the time of the occurrence stated that if ATC is providing both controlling and FIS, precedence was to be given to the provision of air traffic control over FIS.

Provision of flight information service to the aircraft when en route to Adelaide

When the amended TAF for Adelaide Airport was issued at 0700, neither Velocity 1384 nor Qantas 735 were within 60 minutes of Adelaide. Likewise, when the 0800 TTF was issued showing fog, both aircraft were still outside this 60 minute arrival time. Evidence from the relevant ATC en route sector recorded radio communication showed that controllers were providing inbound aircraft within 60 minutes of Adelaide Airport with advice of an amended TAF and of ongoing SPECIs.

At the time that Velocity 1384 and Qantas 735 switched to the Tailem Bend frequency, the last en route frequency before Adelaide Approach, the controller queried both crews' awareness of the fog at Adelaide Airport. The crew of Velocity 1384 were unaware of the fog and from this point commenced collecting further information and planning their diversion to Mildura.

The flight crew of Qantas 735 queried the fog at Adelaide Airport with the en route controller in the sector prior to Tailem Bend, at around 0816. This was in response to the 0800 TTF that showed fog with a predicted improvement from 0900. The flight crew of Qantas 735 asked ATC if this improvement appeared likely as forecast and, as a result, the en route controller contacted Adelaide Tower to ascertain the current conditions. This information was reported back to the crew of Qantas 735 as including a visibility of 700 m in fog. The controller then offered to gather further information and get back to the flight crew of Qantas 735 but indicated there would be a slight delay. At the time Qantas 735 made this request, the flight crew of Velocity 1384 was on the same frequency, but remained unaware of the fog in Adelaide until they were alerted by the Tailem Bend controller.

Provision of flight information service to aircraft inbound to, or at Mildura

In relation to the provision of ATC-initiated FIS at Mildura, the controller responsible for the Mallee en route sector reported that workload initially precluded them from passing information on the weather deterioration at Mildura Airport. This workload was related to the five inbound aircraft, all of which required traffic information on each other, and other aircraft within the Mallee sector.

Mildura was equipped with an Aerodrome Weather Information Service (AWIS) from which pilots could normally access current weather reports. However, on the day of the occurrence, the AWIS was subject to a NOTAM stating it was not broadcasting. Despite this, it was still providing data to the BoM that was generated by the Mildura Automatic Weather Station. This data could be accessed from ATC on request, or by pilots directly via a telephone number that was provided in the NOTAM.

Consistent with the requirements of the MATS, as Mildura had an AWIS, which was an element of the Automatic Broadcast Services (ABS), the SPECI reports derived from the AWS were not sent to the Mallee controller's console. This was despite the fact that the AWIS was not broadcasting, as communicated in the NOTAM. After this occurrence, the MATS was amended to ensure dissemination responsibility for a SPECI was retained by the controller in the event the associated AWIS was not broadcasting (see the section titled S*afety issues and actions*). The recorded ATC information from the occurrence show that the Mallee controller did broadcast a SPECI to all aircraft inbound to Mildura; however, this did not occur until 0936. The 0954 amended TAF was passed to Mildura traffic by the Mallee controller once it was released by the BoM.

As MATS did not require the provision of SPECI reports at airports that have an ABS such as AWIS, in order for pilots to become aware of a deterioration, they must either access the AWIS or request those observations from ATC. The meteorological information obtained from an AWIS is operationally equivalent to that provided in routine observations (METAR) and SPECI reports. However, the calculation techniques and reporting frequency are different. For example, METARs are reported every 30 minutes, SPECI are reported when criteria are met and AWIS reports are updated every minute. Therefore, pilots are required to understand and recognise the reporting mechanism and interpret its operational significance for AWIS reports.

The broadcast range limitations of an AWIS, a function of using very high frequency radio for this service, means it can typically only be accessed about 30 minutes away from the airport. Under the provision of FIS, for major airports and airports without a broadcasting AWIS, pilots will be alerted if they are within 60 minutes of the affected destination or the relevant condition.

Given the prevalence of AWIS at many non-major airports in Australia, there remains a risk that, given this 30-minute 'gap' in the availability of weather reports, pilots will not be made aware of significant weather deteriorations at these airports in sufficient time to support their in-flight decision making. Pilots can ask ATC for any relevant weather information via the on-request service. In terms of their in-flight decision making, it is reasonable to expect that such requests would occur prior to a decision point or point of no return. However, it is also worth noting that the on-request service is workload dependent, and is therefore not guaranteed.

In addition, it is not possible for an ABS to recognise the importance of, and then actively disseminate SPECI information to pilots. As a result, significant weather deteriorations may remain unnoticed unless the pilot:

- accesses the ABS at a time when the SPECI information is available
- continuously monitors the ABS, which would be impractical and distracting.

The inherent passivity of the ABS increases the risk that potential landing options will unknowingly reduce in critical situations.

Limited options are available to crew once past their decision point, such as was the case on arrival at Mildura. However, had the 0918 SPECI been disseminated, each crew would have been informed of the developing deterioration at Mildura. Although the captain of

Velocity 1384 indicated that there was sufficient time to assess the option of returning to Adelaide, there was only a matter of several minutes available to make that decision and track towards Adelaide. In contrast, the crew of Qantas 735 had greater time to make that assessment. This additional time also meant that the crew of Qantas 735, had they been provided with the 0928 and 0930 SPECIs, would likely have had a clearer understanding of the deteriorating trend at Mildura when there was still the option for them to return to Adelaide.

Regardless, a return to Adelaide would have necessitated an automated landing by both crews in conditions that, like Mildura, were below landing minima and therefore constituted an emergency.

Anything that impacts on the provision of SPECI reports and other operational information to pilots increases the risk that pilots will not be aware of the changes at the destination in sufficient time to support in-flight planning and effective decision making. Research has shown that appropriate flight crew situation awareness relies on crew being alert to developing situations and aware of the implications of these situations (Orasanu, 1993). Good situation awareness supports effective decision making, which relies on accurate information being obtained in a timely manner (Endsley, 1997). Decision making can be influenced by such factors as workload and stress (Li, 2011; Harris & Li, 2015). By providing SPECI information proactively, the risk of it being missed as a function of pilot workload, or limitations in the range of AWIS, is reduced.

Hazard alert

The MATS section on hazard alerting required ATC to prefix an FIS call with ‘Hazard Alert’ in the case of a change to a component of FIS not described in a current meteorological product or NOTAM. Once the change appeared in an updated product, or after 1 hour, whichever was sooner, the ‘Hazard Alert’ prefix would cease.

For the deterioration at Adelaide, ATC did not need to use the ‘Hazard Alert’ prefix as the deterioration was in a current meteorological product. Similarly, once the 0918 Mildura SPECI was available showing the deterioration, there was also no need for this prefix. Given the 2-minute time period between the air ambulance pilot’s report of the deterioration and the production of a SPECI, the opportunity for a hazard alert to incoming aircraft was effectively negated. However, as the Mildura AWIS was not broadcasting the actual weather conditions, which were consistent with the SPECI, it could be considered that ATC should have provided this SPECI information to incoming aircraft as ATC-initiated FIS.

The Airservices investigation into this occurrence noted that the Mallee controller did not consider the air ambulance pilot’s report significantly different to the forecast TEMPO conditions in the 0158 TAF for Mildura. On this basis, the controller did not update the incoming aircraft of this deterioration. In addition, once the controller’s workload decreased, they commenced passing the latest SPECI and amended TAF information to aircraft at Mildura.

Flight crew awareness of the weather

Velocity 1384

When Velocity 1384 departed Brisbane for Adelaide, the TAF that was current at the time showed favourable conditions for arrival and did not require the nomination of an alternate airport. The observations for Adelaide at that time supported that forecast. At the time the amended TAF was issued at 0700, Velocity 1384 was at FL 400 in the cruise, about 150 NM (278 km) from Brisbane. Flight watch personnel at Virgin reported reviewing this TAF for applicability to Velocity 1384. The review determined that, because the TAF had only a 30 per cent chance of fog and the TTF issued at the same time forecast no deterioration, the amended TAF would not be passed to the flight crew.

At 0800, when the TTF was issued for Adelaide showing fog that was predicted to clear from 0900, Virgin’s flight watch personnel again reviewed the product for applicability to Velocity 1384. At this stage, the company meteorologist called the BoM to determine their confidence in this

clearance and also reviewed other information sources to determine the possible impact of fog on the arrival of Velocity 1384. During the telephone call with the company meteorologist, the BoM supported the content of the 0800 TTF that the fog would clear at 0900. On this basis, the decision was made that, given Velocity 1384 was planned to arrive at Adelaide at 0920, they would not be affected by the fog. As such, the TTF was not passed to the flight crew.

In support of this decision, the flight following personnel understood that as this flight was not being actively flight followed, the flight crew would, as part of their normal responsibilities, be actioning any weather updates. In addition, the assessment of the TTF was completed amongst the flight following personnel's other priorities and workload. As such, the action to not pass this information to Velocity 1384 was provided for by the Virgin dispatch manual. The FO of Velocity 1384 confirmed that this was consistent with their understanding of the Virgin flight following service for domestic operations. That was, the FO was not expecting to necessarily be sent amended weather by flight following personnel. While the 0700 amended TAF and 0800 TTF were not required to be sent to the crew under Virgin's flight following procedures, not passing the weather removed an important source of information regarding the deteriorating conditions at Adelaide. However, as the deterioration was forecast to improve prior to their arrival, it is likely that, at that stage, they would have elected to continue to Adelaide.

Despite not being passed the updated weather information from their flight operations centre, the crew of Velocity 1384 had two opportunities to become aware of the deterioration in Adelaide prior to being notified at 0844 by the Tailem Bend controller. The first was at 0816 when Qantas 735 queried the conditions in Adelaide based on the forecast of fog in the 0800 TTF. This query was made on the same frequency as was being monitored by Velocity 1384 at the time. However, this call occurred just prior to the commencement of the 2-hour, continuous loop cockpit voice recording for the flight. This precluded a full understanding of what factors may have contributed to the crew of Velocity 1384 missing this report.

The second opportunity was at 0839 when Qantas 735 was updated on the conditions at Adelaide Airport and was told the visibility was now 500 m in fog, with no landing attempts having been made for a while. Another Virgin aircraft then asked ATC to clarify if that report was for Melbourne, to which ATC responded 'negative, Adelaide'. The FO of Velocity 1384 was absent from the flight deck and the captain reported preparing for the approach into Adelaide at that time. The captain reported hearing this information but did not pass it to the FO on their return. Virgin advised that a review of their operations identified no systemic issue in relation to flight crew seeking weather information. The actions of the flight crew of the second Virgin aircraft to query ATC about the weather update for Adelaide were consistent with this advice.

As the crew of Velocity 1384 did not obtain the updated weather for Adelaide Airport while en route, they remained unaware of the deterioration until quite close to Adelaide. This limited their options and the time available to plan a diversion to a suitable alternate airport. The Virgin operations manual included a requirement for crew to check there was sufficient fuel remaining on board to continue to the destination at the point of no return. This included taking account of the traffic and weather conditions expected at the destination, along the diversion route and at the alternate (if applicable).

Despite the fact that the crew of Velocity 1384 did not seek the weather information for Adelaide Airport, it is probable that had they become aware of the fog on the 0800 Adelaide TTF and its forecast clearance from 0900, they would have elected to continue to Adelaide. Given the actions of the Qantas 735 crew (who did obtain the weather) to continue to Adelaide, this decision would have been reasonable. However, by not obtaining the weather for Adelaide while en route, the crew removed an information source that could have resulted in a better awareness of the situation at Adelaide and the opportunity to plan a diversion earlier.

In situations where crew are primed to search for information, it is more likely that considered decision making will occur in a less stressful environment and that the associated workload will

reduce. Conversely, if crew are not aware, or primed, of a situation they may not recognise relevant information that could assist their decision making.

Qantas 735

As the flight crew of Qantas 735 was preparing to depart Sydney, just prior to leaving the gate, the 0700 amended TAF for Adelaide was issued. Given the TAF only had a 30 per cent probability of fog, and as the aircraft was in the 'sterile cockpit' phase of flight, flight watch did not pass the TAF to the crew at this point. After the aircraft reached top of climb and the sterile cockpit period ended, flight watch sent a message via the aircraft communications addressing and reporting system stating that the amended TAF now indicated a 30 per cent chance of fog, providing an overview of the conditions at Adelaide Airport and advising that the TTF forecast no significant change during its validity period.

Prior to this point, about 5 minutes after take-off, the crew of Qantas 735 sent a request via the aircraft communications addressing and reporting system for the current Aerodrome Terminal Information Service at Adelaide Airport. They then continued to collect weather updates for various ports, including Mildura, Melbourne, Canberra, Sydney and Adelaide. These included updates of forecasts and observations and occurred frequently for the remainder of the flight to waypoint BLACK (48 NM or 89 km from Adelaide).

At 0816 the flight crew received information about the current conditions at Adelaide. This included the 0800 TTF, which indicated the fog would dissipate by 0900. At 0820, Qantas 735 reached their latest point of safe diversion back to Sydney. Information gathered by the flight crew about the conditions at Adelaide from multiple sources continued to show a forecast improvement from 0900. As their arrival time was 0917, the crew elected to continue to Adelaide at this point. Supporting this decision, the flight crew had also calculated that they had sufficient fuel to hold for about 45 minutes beyond their planned arrival time without using the fixed fuel reserve. They considered this was a sufficient buffer if the fog did not clear by 0900.

Use of weather observations for decision making

The flight crews of Velocity 1384 and Qantas 735 reported assessing the Mildura weather prior to diverting from Adelaide Airport. Both reported considering the observation reports that were current at the time as a more reliable indicator of the weather at Mildura Airport than the relevant forecast. The captain of Qantas 735 reported feeling that the observation reports were more reliable given the inaccuracy of the forecast at Adelaide. The crew of Velocity 1384 reported using the observation reports to confirm their understanding of Mildura's suitability as an alternate destination.

The ATSB asked CASA for a ruling on the use of observations in-flight. CASA responded that a pilot is able to use a valid forecast and observation information. They also cautioned that observations should only be used if the arrival time was proximal to the observation and, if the forecast indicated conditions below minima, the forecast would have precedence over observations. That is, crews must carry sufficient fuel to meet the forecast requirements affecting a destination, even if the observations at that location indicate that the weather is suitable for an arrival.

While the crew of Qantas 735 reported considering the implications of the TEMPO on the 0158 Mildura TAF, and calculated that they had sufficient fuel to meet this requirement, the crew of Velocity 1384 did not complete that consideration. The FO of Velocity 1384 raised the TEMPO as an issue with the captain; however, at that time the captain's attention was on another matter and the TEMPO was not discussed. As such, when the crew of Velocity 1384 initiated the diversion to Mildura Airport, they had not confirmed sufficient fuel to meet the TEMPO requirement.

Irrespective, the extent and duration of the deterioration meant that even meeting the TEMPO fuel requirement, this would not have provided sufficient fuel to hold until the fog and low cloud at

Mildura cleared sufficiently. Unless early consideration was given to a return to Adelaide Airport for an emergency autoland approach, a landing below minima at Mildura Airport was the only option at Mildura Airport.

Summary

A review of the international aviation system identified that Australia is comparable to the international industry, particularly with regard to the provision of flight information services (FIS). Consistent with international practice, the provision of FIS relies on flight crew having a clear understanding of their role and primary responsibility to actively seek and update operational information to assure safe flight.

Critical to the assurance of safe flight is for weather services, air traffic services and aircraft operators to also have a clear understanding of their roles and responsibilities in the system. This includes the importance of controller/pilot communication to enhance situation awareness, particularly in regard to non-routine situations such as deteriorating weather or aircraft low fuel state. For example, informing ATC of a non-routine situation will increase the level of monitoring a flight will receive.

Aviation is a complex, high-reliability industry. High-reliability industries are characterised by high-consequence but very low likelihood of an adverse outcome. While such industries contain systems for managing risk, it can never be entirely eliminated.

In certain conditions, provision for flight to an alternate airport will be required. Occasionally the destination weather deteriorates, necessitating a diversion. However, it is often not practical to provide for a further alternate once a diversion has been initiated. In such cases there is a residual risk that the aircraft may be compelled to land in conditions below the landing minima. This emphasises the importance of the BoM's ongoing efforts to improve the accuracy of meteorological forecasting.

In order to better quantify the residual risk, specifically the likelihood of unforecast weather deterioration, the ATSB is examining the reliability of aerodrome forecasts as part of research investigation AR-2013-200 *Reliability of aviation weather forecasts*. This research investigation will initially examine the reliability of the aerodrome forecasts for Mildura and Adelaide Airports, before expanding to cover other major Australian airports.

Findings

From the evidence available, the following findings are made with respect to the landing below minima due to fog involving two Boeing 737s, registered VH-YIR and VH-VYK, which occurred at Mildura Airport, Victoria on 18 June 2013. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance. A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

Contributing factors

- The meteorological conditions at Adelaide Airport deteriorated below the landing minima while Velocity 1384 and Qantas 735 were en route to Adelaide.
- The inaccuracy of the forecast clearance of the fog at Adelaide Airport compelled the flight crews of Velocity 1384 and Qantas 735 to either conduct an emergency landing at Adelaide or divert to Mildura Airport.
- The actual weather conditions encountered by the flight crews of Velocity 1384 and Qantas 735 on arrival at Mildura were below landing minima and significantly worse than the aerodrome forecast and weather reports used by both flight crews to assess its suitability as an alternate destination to Adelaide.
- On arrival at Mildura, Velocity 1384 and Qantas 735 had insufficient fuel to divert to any other airport and were committed to a landing in conditions below their landing minima.

Other factors that increased risk

- The flight crew of Velocity 1384 did not obtain updated weather information for Adelaide while en route and were therefore unaware of the weather deterioration affecting the airport, limiting the options and time available to plan a diversion to an alternate destination airport.
- The flight crews of Velocity 1384 and Qantas 735 gave precedence to the aerodrome weather reports at Mildura over the aerodrome forecast when deciding to divert.
- Despite the Bureau of Meteorology (BoM) knowing of the deteriorating weather at Mildura from other sources, by not passing on the in-flight weather report of deteriorating weather from the departing air ambulance pilot, the controller removed an important source of information for use by the BoM.
- The in-flight weather report given by the air ambulance pilot was not passed to the flight crews of Velocity 1384 and Qantas 735 by the controller when they changed frequency in-bound to Mildura Airport, removing an important source of information for flight crew planning and decision making.
- **The automatic broadcast services did not have the capacity to recognise and actively disseminate special weather reports (SPECI) to pilots, thus not meeting the intent of the SPECI alerting function provided by controller-initiated flight information service. [Safety issue]**
- **For many non-major airports in Australia, flight crews of arriving aircraft can access current weather information using an Automatic Weather Information Service via very high frequency radio, which has range limitations. Where this service is available, air traffic services will generally not alert pilots to significant deteriorations in current**

weather conditions at such airports, increasing the risk of flight crew not being aware of the changes at an appropriate time to support their decision making. [Safety issue]

Other findings

- The flight crews of Velocity 1384 and Qantas 735 planned for, and uploaded, sufficient fuel for the forecast conditions at Adelaide Airport in accordance with the respective operator's fuel policies.
- The flight crew of Qantas 735 proactively sought weather information for various airports soon after departing Sydney.
- The meteorological information obtained from an Aerodrome Weather Information Service (AWIS) is operationally equivalent to that provided in routine (METAR)/special weather (SPECI) reports. However, as the AWIS broadcast doesn't contain the label 'SPECI', pilots are required to recognise and interpret its operational significance.
- Critical to the assurance of safe flight, all elements of the aviation system including weather services, air traffic services, aircraft operators and flight crews need to have a clear understanding of their roles and responsibilities in that system.

Safety issues and actions

The safety issue identified during this investigation is listed in the Findings and Safety issues and actions sections of this report. The 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 directly involved parties were provided with 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.

The initial public version of these safety issues and actions are repeated separately on the ATSB website to facilitate monitoring by interested parties. Where relevant the safety issues and actions will be updated on the ATSB website as information comes to hand.

Limited provision of flight information service for some non-major airports

Number:	AO-2013-100-SI-01
Issue owner:	Airservices Australia in consultation with the Bureau of Meteorology
Operation affected:	Aviation: Air transport
Who it affects:	All pilots operating into non-major airports accessing an Automatic Weather Information Service

Safety issue description:

For many non-major airports in Australia, flight crews of arriving aircraft can access current weather information using an Automatic Weather Information Service via very high frequency radio, which has range limitations. Where this service is available, air traffic services will generally not alert pilots to significant deteriorations in current weather conditions at such airports, increasing the risk of pilots not being aware of the changes at an appropriate time to support their decision making.

Proactive safety action taken by Airservices Australia

Action number: AO-2013-100-NSA-054

In response to this safety issue, Airservices Australia (Airservices) advised of the following proactive safety action:

> Airservices acknowledges the safety issue which highlights the VHF range limitations of automatic weather information service (AWIS) broadcast. In response to the safety issue, Airservices will work with the Bureau of Meteorology to explore feasible options to provide information on significant deteriorations in weather conditions.
>
> In the meantime or in the absence of a feasible option identified, existing avenues exist for flight crews to obtain in-flight weather information. For example in this occurrence, the Mildura SPECIs were available on the Mt William AERIS (119.75) as referenced in AIP [Aeronautical Information Package] (ERSA) [En Route Supplement Australia]. In addition, the flight crew of VOZ1384 and QFA735 had the opportunity to utilise the 'on-request' FIS [Flight Information Service] to request updated Mildura weather from ATC.
>
> To address the impact on the Automatic Broadcast Service (ABS) when out of service, Airservices has taken safety actions to update MATS [Manual of Air Traffic Services] and NAPM [National ATS Procedures Manual] to ensure the continued dissemination of weather information from locations with AWIS.

Current status of the safety issue

Issue status: Monitor

Justification: The action by Airservices will, when complete, eliminate the risk associated with the safety issue. The change to the MATS will assist in the short term when an AWIS is unavailable. The ATSB will monitor this issue until advised by Airservices that the action has been completed.

Alerting function of special weather reports (SPECI) is not met by the automatic broadcast services

Number:	AO-2013-100-SI-02
Issue owner:	Airservices Australia in consultation with the Bureau of Meteorology
Operation affected:	Aviation: Air transport
Who it affects:	All pilots operating into non-major airports accessing an automatic broadcast service

Safety issue description:

The automatic broadcast services did not have the capacity to recognise and actively disseminate special weather reports (SPECI) to pilots, thus not meeting the intent of the SPECI alerting function provided by controller-initiated flight information service.

Response to the safety issue by Airservices Australia

In response to this safety issue, Airservices advised the following:

> Airservices appreciates the opportunity to provide comment on the additional safety issue and supporting documentation in relation to ATSB Investigation A0-2013-100 provided on 26 April 2016.
>
> Airservices agrees with the safety issue and acknowledges that automatically generated SPECIs from Automatic Broadcast Service (ABS), while operating as designed, may not be readily apparent to crew in situations where weather conditions change rapidly and differ from forecast conditions.
>
> As discussed with the ATSB and Bureau of Meteorology (BoM) on 16 April 2016, just as it is not practical for pilots to continuously monitor SPECIs whilst within one hour flight time of destination, it is also not practical for ATC to continuously monitor and disseminate SPECIs. This is due to the volume and frequency of automatically generated SPECI data at locations with ABS, particularly in recent times where more sensors are available at unmanned weather stations. There is currently no mechanism as part of the ABS to filter the SPECI data to delineate that which is operationally significant to a flight.
>
> To address the safety issue Airservices considers that a meteorological system-based solution is likely to be required, and Airservices is available to support the BoM to progress the feasibility assessment work and identify suitable design and implementation options. This work could potentially be progressed in the form of a BoM-led working group including the aviation industry.

ATSB action in response

The ATSB notes Airservices agreement with the issue and intention to work with the Bureau of Meteorology to establish a solution. However the ATSB is concerned that Airservices, as the agency that provides flight information service in Australia, has not taken responsibility for the resolution of this safety issue. In addition, the indefinite nature of the proposed activity does not provide a high degree of confidence that the safety issue will be adequately addressed.

As a result, the ATSB has issued the following safety recommendation.

ATSB safety recommendation to Airservices Australia

Action number: AO-2013-100-SR-057

Action status: Released

The ATSB recommends that Airservices Australia as the safety issue owner works in collaboration with the Bureau of Meteorology to instigate a system change to reinstate the alerting function of SPECI reports currently not available through an automatic broadcast service.

Additional safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Bureau of Meteorology

Although no safety issue was identified by the ATSB, the Bureau of Meteorology advised of the following safety action in response to this occurrence:

- A review of Trend Forecast services was undertaken through a consultative process with the aviation industry and the Australian Defence Force. The reasons for reviewing Trend Forecast services include:
    - The TTF format is unique to Australia.
    - Although the TTF and TAF are forecasts for the same aerodrome, they convey different information concerning the probability and timing of meteorological phenomena.
    - Perceived conflict information between TAF and TTF as TAF can mention probabilities of 30 and 40 per cent, whereas TTF is a forecast of the most likely outcome over the next three hours.

  The report on the Review of the Trend Forecast was released for comment on the 29 September 2015. The closing date for feedback is 29 January 2016. At the time of release of this report, the BoM was progressing the action items from the report and will discuss the outcomes with CASA.
- Aviation Cameras for Forecasters (AvCam). For the 2015–16 financial year [FY] the BoM will install weather cameras at 15–20 locations at major capital city aerodromes, including Adelaide airport, and key regional aerodromes. The AvCam project [will] provide an additional tool for forecasters to assess current weather conditions, including fog, to supplement human observations or other automated present weather sensors and instrumentation.
- Trial Automation of Observations at Cairns and Canberra (TAOCC) Project. Information from the trial could be used to enhance observations and better define the capability requirement at all airports (completion expected 2017).
- Centralised Aerodrome Weather Information Service (C-AWIS) Project (completion expected 2015/16 FY). The Centralised-AWIS (C-AWIS) project aims to deliver a cost effective and reliable replacement to the current AWIB/AWIS that will centrally process AWS data.
- Aviation Verification System (AVS) 2 (due to be completed in 2017). The implementation of the next generations of TAF verification, AVS2, aims to:

  - Improve the accuracy of forecasts in relation to predicting the onset and cessation times for thunderstorms and below minima conditions at airports;
  - Result in developing a less conservative forecast approach for significant weather events (with below minima conditions);
  - Improve forecaster responsiveness in amending forecasts after weather events have passed;
- Climatology Interface Development Project. This project aims to develop a new national climatological interface for the display and interpretation of climate information at aerodromes and key aviation locations (due to be completed in 2017).
- In September 2015 the BOM implementation of Himawari 8 satellite data. Himawari-8 provides observations that enable the Bureau to create true-colour images of the Australian region, every ten minutes, based on reflected visible light. These are useful, for example, for identifying fog and low cloud, which may not be visible in thermal infrared images because it has a similar temperature to the ground below.
- The BoM's Aviation Weather Services already has a formal process in place to conduct regularly consultative meetings/workshops with key aviation stakeholders to identify improvements and current and future requirements.

Virgin Australia Airlines Pty. Ltd.

Although no safety issue was identified by the ATSB, Virgin Australia Airlines Pty. Ltd. (Virgin) advised of the following safety action in response to this occurrence:

- The flight following policy was re-written. This included clarification of the minimum requirements of the service provided (i.e. definition of notifiable updates) and removal of the differentiation between passive and active flight following such that all flights are now flight followed.
- Amended flight planning policy to apply 'worst case' of TAF or TTF forecast conditions.
- Introduction of an adverse weather flight planning policy.
- Review of Flight Watch/Following activities across several carriers to obtain best practice for this activity – Virgin America and Westjet were visited.
- Central Flight Watch desk dissolved and Flight Following introduced mid 2014 with desks split up into regions and Flight Following assigned to individual desks.
- Pilot weather updating requirements have been clarified and enhanced and ACARS [aircraft communications addressing and reporting system] equipment continues to be rolled out across the Virgin fleet.

General details

Occurrence details

Date:	18 June 2013	
Occurrence category:	Serious incident	
Primary occurrence type:	Landing below weather minima	
Location:	Mildura Airport, Victoria	
	Latitude: 34° 13.75' S	Longitude: 142° 05.13' E

Aircraft details – VH-YIR

Manufacturer and model:	Boeing 737-8FE	
Year of manufacture:	2012	
Operator:	Virgin Australia Airlines Pty. Ltd.	
Serial number:	39925	
Type of operation:	Air Transport High Capacity	
Persons on board:	Crew – 6	Passengers – 85
Injuries:	Crew – Nil	Passengers – Nil
Damage:	None	

Aircraft details – VH-VYK

Manufacturer and model:	Boeing 737-838	
Year of manufacture:	2005	
Operator:	Qantas Airways Ltd.	
Serial number:	34183	
Type of operation:	Air Transport High Capacity	
Persons on board:	Crew – 6	Passengers – 146
Injuries:	Crew – Nil	Passengers – Nil
Damage:	None	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the flight crew of Velocity 1384
- the flight crew of Qantas 735
- Airservices Australia
- the Bureau of Meteorology
- the Civil Aviation Safety Authority
- Virgin Australia Airlines Pty. Ltd.
- Qantas Airways Ltd.

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Submissions

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

A draft of this report was provided to the flight crews of Velocity 1384 and Qantas 735, Airservices Australia, the Bureau of Meteorology, the Civil Aviation Safety Authority, Virgin Australia Airlines Pty. Ltd. and Qantas Airways Ltd.

Submissions were received from the flight crew of Velocity 1384, Airservices Australia, the Bureau of Meteorology, the Civil Aviation Safety Authority, Virgin Australia Airlines Pty. Ltd. and Qantas Airways Ltd. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Appendices

Appendix A – Flight Crew Training Manual extract

Ground speed information is available from the FMC and on the instrument displays. These indications can be used as a crosscheck. Many air traffic control radars can also measure ground speed.

For airplanes equipped with an Angle of Attack (AOA) indicator, maintain the analog needle at approximately the three o'clock position. This approximates a safe maneuver speed or approach speed for the existing airplane configuration.

Descent

Idle thrust descents to 10,000 feet can be made by flying body attitude and checking rate of descent in the QRH tables. At 2,000 feet above the selected level off altitude, reduce rate of descent to 1,000 FPM. On reaching the selected altitude, establish attitude and thrust for the airplane configuration. If possible, allow the airplane to stabilize before changing configuration and altitude.

Approach

If available, accomplish an ILS or GLS approach. Establish landing configuration early on final approach. At glide slope intercept or beginning of descent, set thrust and attitude per the QRH tables and control the rate of descent with thrust.

Landing

Control the final approach so as to touch down approximately 1,000 feet to 1,500 feet beyond the threshold. Fly the airplane on to the runway, do not hold it off or let it "float" to touchdown.

Use autobraking if available. If manual braking is used, maintain adequate brake pedal pressure until a safe stop is assured. Immediately after touchdown, expeditiously accomplish the landing roll procedure.

Fuel

Fuel Balance

The primary purpose of fuel balance limitations on Boeing airplanes is for the structural life of the airframe and landing gear and not for controllability. A reduction in structural life of the airframe or landing gear can be caused by frequently operating with out-of-limit fuel balance conditions. Lateral control is not significantly affected when operating with fuel beyond normal balance limits.

The primary purpose for fuel balance alerts are to inform the crew that imbalances beyond the current state may result in increased trim drag and higher fuel consumption. The IMBAL NNC should be accomplished when the fuel balance alert is received.

There is a common misconception among flight crews that the fuel crossfeed valve should be opened immediately after an in-flight engine shutdown to prevent fuel imbalance. This practice is contrary to Boeing recommended procedures and could aggravate a fuel imbalance. This practice is especially significant if an engine failure occurs and a fuel leak is present. Arbitrarily opening the crossfeed valve and starting fuel balancing procedures, without following the checklist, can result in pumping usable fuel overboard.

The misconception may be further reinforced during simulator training. The fuel pumps in simulators are modeled with equal output pressure on all pumps so opening the crossfeed valve appears to maintain a fuel balance. However, the fuel pumps in the airplane have allowable variations in output pressure. If there is a sufficient difference in pump output pressures and the crossfeed valve is opened, fuel feeds to the operating engine from the fuel tank with the highest pump output pressure. This may result in fuel unexpectedly coming from the tank with the lowest quantity.

Fuel Balancing Considerations

The crew should consider the following when performing fuel balancing procedures:

- use of the Fuel Balancing Supplementary Procedure in conjunction with good crew coordination reduces the possibility of crew errors
- routine fuel balancing when not near the imbalance limit increases the possibility of crew errors and does not significantly improve fuel consumption
- during critical phases of flight, fuel balancing should be delayed until workload permits. This reduces the possibility of crew errors and allows crew attention to be focused on flight path control
- fuel imbalances that occur during approach need not be addressed if the reason for the imbalance is obvious (e.g. engine failure or thrust asymmetry, etc.).

Fuel Leak

Any time an unexpected fuel quantity indication, FMC fuel message, or imbalance condition is experienced, a fuel leak should be considered as a possible cause. Maintaining a fuel log and comparing actual fuel burn to the flight plan fuel burn can help the pilot recognize a fuel leak.

Significant fuel leaks, although fairly rare, are difficult to detect. The Engine Fuel Leak NNC assumes the leak is between the front spar and the engine. This is the most common type of fuel leak since fuel lines are exposed in the strut. Most other fuel lines, such as a crossfeed manifold, are contained within the tanks. A significant fuel leak directly from a tank to the outside is very rare due to the substantial wing structure that forms the tanks.

There is no specific fuel leak annunciation on the flight deck. A leak must be detected by discrepancies in the fuel log, by visual confirmation, or by some annunciation that occurs because of a leak. Any unexpected change in fuel quantity or fuel balance should alert the crew to the possibility of a leak. If a leak is suspected, it is imperative to follow the NNC.

The NNC leads the crew through steps to determine if the fuel leak is from the strut or the engine area. If an engine fuel leak is confirmed, the NNC directs the crew to shutdown the affected engine. There are two reasons for the shutdown. The first is to close the spar valve, which stops the leak. This prevents the loss of fuel which could result in a low fuel state. The second reason is that the fire potential is increased when fuel is leaking around the engine. The risk of fire increases further when the thrust reverser is used during landing. The thrust reverser significantly changes the flow of air around the engine which can disperse fuel over a wider area.

Low Fuel

A low fuel condition exists when the fuel LOW indication is displayed.

Approach and Landing

In a low fuel condition, the clean configuration should be maintained as long as possible during the descent and approach to conserve fuel. However, initiate configuration changes early enough to provide a smooth, slow deceleration to final approach speed to prevent fuel from running forward in the tanks.

A normal landing configuration and airspeed appropriate for the wind conditions are recommended.

Runway conditions permitting, heavy braking and high levels of reverse thrust should be avoided to prevent uncovering all fuel pumps and possible engine flameout during landing roll.

Go-Around

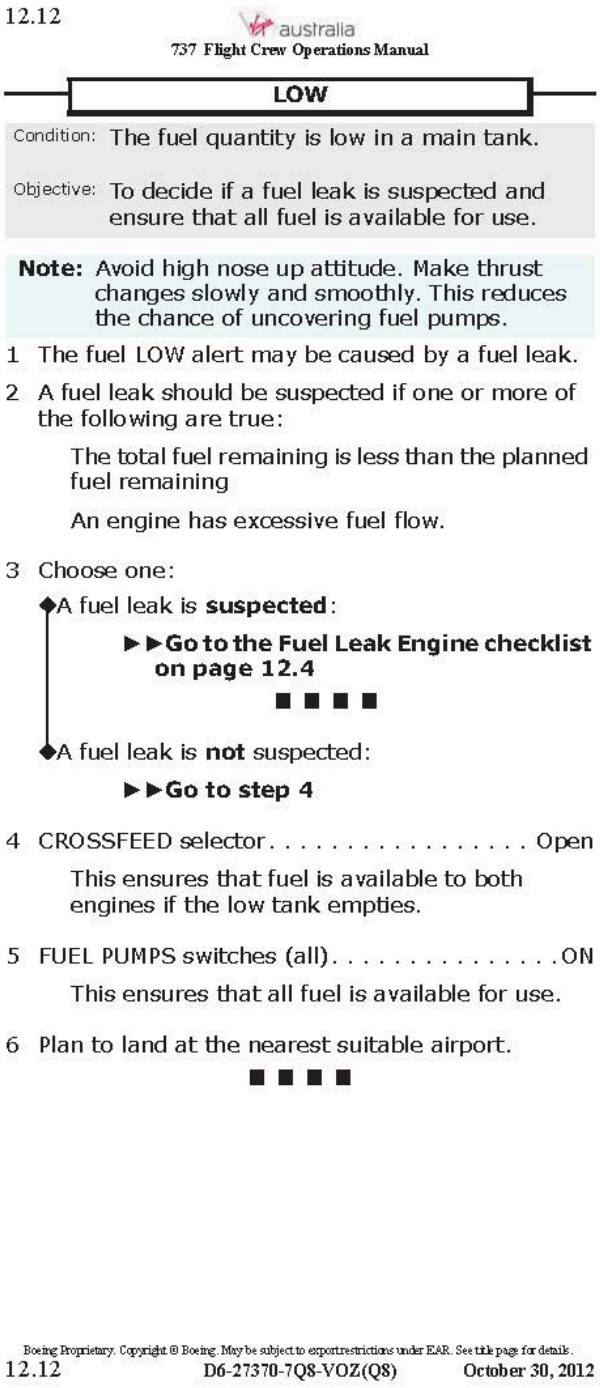
If a go-around is necessary, apply thrust slowly and smoothly and maintain the minimum nose-up body attitude required for a safe climb gradient. Avoid rapid acceleration of the airplane. If any wing tank fuel pump low pressure light illuminates, do not turn the fuel pump switches off.

Hydraulics

Proper planning of the approach is important. Consideration should be given to the effect the inoperative system(s) has on crosswind capabilities, autoflight, stabilizer trim, control response, control feel, reverse thrust, stopping distance, go-around configuration and performance required to reach an alternate airfield.

Appendix B – Fuel low and fuel imbalance checklists

Boeing 737 fuel low checklist (Virgin Australia Airlines Pty. Ltd.)



12.12

737 Flight Crew Operations Manual

LOW

Condition: The fuel quantity is low in a main tank.

Objective: To decide if a fuel leak is suspected and ensure that all fuel is available for use.

Note: Avoid high nose up attitude. Make thrust changes slowly and smoothly. This reduces the chance of uncovering fuel pumps.

1 The fuel LOW alert may be caused by a fuel leak.

2 A fuel leak should be suspected if one or more of the following are true:

The total fuel remaining is less than the planned fuel remaining

An engine has excessive fuel flow.

3 Choose one:

◆A fuel leak is **suspected**:

►►**Go to the Fuel Leak Engine checklist on page 12.4**

■ ■ ■ ■

◆A fuel leak is **not** suspected:

►►**Go to step 4**

4 CROSSFEED selector. . . . . Open

This ensures that fuel is available to both engines if the low tank empties.

5 FUEL PUMPS switches (all). . . . . .ON

This ensures that all fuel is available for use.

6 Plan to land at the nearest suitable airport.

■ ■ ■ ■

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Boeing 737 Fuel imbalance checklist (Virgin Australia Airlines Pty. Ltd.)

IMBAL

Condition: There is a fuel imbalance between the main tanks.

Objective: To decide if a fuel leak is suspected. To balance fuel if a fuel leak is not suspected.

1 If an engine has low fuel flow and unusual engine indications, the IMBAL alert may show due to an engine malfunction.

2 The IMBAL alert may be caused by a fuel leak, an inoperative crossfeed valve or a fuel imbalance.

3 A fuel leak should be suspected if one or more of the following are true:

The total fuel remaining is less than the planned fuel remaining

An engine has excessive fuel flow.

4 Choose one:

◆A fuel leak is **suspected**:

►►**Go to the Fuel Leak Engine checklist on page 12.4**

■ ■ ■ ■

◆A fuel leak is **not** suspected:

►►**Go to step 5**

5 CROSSFEED selector . . . . . Open

Verify that the VALVE OPEN light illuminates bright, then dim. This indicates that the crossfeed valve is operating correctly.

6 Choose one:

◆Crossfeed valve is operating **correctly**:

►►**Go to step 7**

◆Crossfeed valve is **not** operating correctly:

►►**Go to the CROSSFEED SELECTOR INOPERATIVE checklist on page 12.2**

■ ■ ■ ■

▼ Continued on next page ▼

▼IMBAL continued▼

7 Choose one:

◆**Main tank 1** quantity is low:

Main tank 1 FUEL PUMPS switches (both) . . . . . OFF

This allows fuel from the higher quantity tank to feed both engines.

►►**Go to step 8**

◆**Main tank 2** quantity is low:

Main tank 2 FUEL PUMPS switches (both) . . . . . OFF

This allows fuel from the higher quantity tank to feed both engines.

►►**Go to step 8**

8 **When** fuel balancing is complete:

Main tank FUEL PUMPS switches (all) . . . . . ON

CROSSFEED selector . . . . . Close

■ ■ ■ ■

Appendix C – Weather forecasts and reports

The weather forecasts and reports tabulated below do not indicate whether the applicable weather information was passed to the aircraft. More particularly, they indicate specific times when weather information was issued by the Bureau of Meteorology or Airservices Australia.

Time: 0525 EST – Velocity 1384 crew at flight briefing	
Adelaide TAF	TAF YPAD 171703Z 1718/1824 VRB05KT 9999 FEW030 SCT045 FM181000 VRB05KT CAVOK RMK T 06 06 11 14 Q 1018 1018 1020 1020
Adelaide TTF METAR	METAR YPAD 171900Z 07004KT 9999 FEW022 05/04 Q1018 RMK RF00.0/000.0 TTF: NOSIG
Mildura TAF	TAF AMD YMIA 171758Z 1718/1812 24005KT 9999 SCT030 BKN060 BECMG 1718/1720 21006KT 9999 SCT006 SCT030 BECMG 1800/1802 18010KT 9999 SCT030 SCT050 BECMG 1807/1809 16008KT 9999 SCT040 TEMPO 1719/1724 BKN006 RMK T 06 05 07 13 Q 1016 1018 1020 1019
Mildura METAR	METAR YMIA 171900Z AUTO 29005KT 9999 SCT048 06/05 Q1017 RMK RF00.0/000.0

Time: 0600 EST – Qantas 735 crew at flight briefing	
Adelaide TAF	TAF YPAD 171703Z 1718/1824 VRB05KT 9999 FEW030 SCT045 FM181000 VRB05KT CAVOK RMK T 06 06 11 14 Q 1018 1018 1020 1020
Adelaide TTF METAR	METAR YPAD 172000Z 06004KT 9999 FEW022 05/04 Q1019 RMK RF00.0/000.0 TTF: NOSIG
Mildura TAF	TAF AMD YMIA 171758Z 1718/1812 24005KT 9999 SCT030 BKN060 BECMG 1718/1720 21006KT 9999 SCT006 SCT030 BECMG 1800/1802 18010KT 9999 SCT030 SCT050 BECMG 1807/1809 16008KT 9999 SCT040 TEMPO 1719/1724 BKN006 RMK T 06 05 07 13 Q 1016 1018 1020 1019
Mildura METAR	METAR YMIA 172000Z 26003KT 9999 FEW042 06/05 Q1017 RMK RF00.0/000.2

Time: 0638 EST – Velocity 1384 departs Brisbane	
Adelaide TAF	No change from previous
Adelaide TTF METAR	METAR YPAD 172030Z 08005KT 9999 FEW022 05/05 Q1019 RMK RF00.0/000.0 TTF: NOSIG
Mildura TAF	No change from previous

Mildura METAR	METAR YMIA 172030Z 27003KT 9999 FEW038 05/05 Q1017 RMK RF00.0/000.2

Time: 0700 EST – Velocity 1384 approaching top of climb, Qantas 735 at gate loading last passengers at Sydney

Adelaide TAF	TAF AMD YPAD 172100Z 1721/1824 05005KT 9999 FEW025 FM180000 VRB05KT 9999 FEW030 SCT045 FM181000 VRB05KT CAVOK PROB30 1721/1724 0500 FG RMK T 05 10 14 15 Q 1019 1020 1020 1020
Adelaide TTF METAR	METAR YPAD 172100Z 05004KT 9999 FEW022 05/05 Q1019 RMK RF00.0/000.0 TTF: NOSIG
Mildura TAF	No change from previous
Mildura METAR	METAR YMIA 172100Z 28005KT 9999 FEW042 05/05 Q1018 RMK RF00.0/000.2

Time: 0707 EST – Velocity 1384 in cruise, Qantas 735 preparing to pushback from Sydney

Adelaide ATIS	ATIS YPAD S 172107 RWY: 23 WND: 050/5, MAX DW 5 KTS. VIS: GREATER THAN 10 KM CLD: FEW022 TMP: 5. QNH: 1020

Time: 0711 EST – Velocity 1384 in cruise, Qantas 735 taxiing at Sydney

Adelaide TTF SPECI	SPECI YPAD 172111Z 06005KT 9999 MIFG FEW022 SCT058 05/05 Q1020 RMK RF00.0/000.0 TTF: NOSIG

Time: 0730 EST – Velocity 1384 in cruise, Qantas 735 on initial climb from Sydney

Adelaide TTF SPECI	SPECI YPAD 172130Z 06004KT 9999 MIFG FEW022 05/04 Q1020 RMK RF00.0/000.0 TTF: NOSIG
Adelaide ATIS	ATIS YPAD T 172130 RWY: 23 WND: 050/5, MAX DW 5 KTS. VIS: GREATER THAN 10 KM, REDUCED TO 4000 M TO THE NORTH IN FOG. CLD: FEW020 TMP: 5. QNH: 1020
Mildura METAR	METAR YMIA 172130Z 27004KT 9999 FEW040 05/05 Q1018 RMK RF00.0/000.2

Time: 0748 EST – Velocity 1384 and Qantas 735 in cruise

Amended TAF for Adelaide issued at 0700 EST passed to the crew of Qantas 735 via ACARS.

Time: 0756 EST – Velocity 1384 and Qantas 735 in cruise

Adelaide ATIS	ATIS YPAD U 172156 RWY: 23 WND: 360/5, MAX DW 5 KTS. VIS: GREATER THAN 10 KM, REDUCED TO 1500 M IN FOG. CLD: FEW015 TMP: 5. QNH: 1020

Time: 0758 EST – Velocity 1384 and Qantas 735 in cruise

Adelaide ATIS	APCH: EXP INST APCH RWY: 23 OPR INFO: HIAL ON WND: 360/5, MAX DW 5 KTS. VIS: GREATER THAN 10 KM, REDUCED TO 1500 M IN FOG. CLD: FEW015 TMP: 5. QNH: 1020

Time: 0800 EST – Velocity 1384 and Qantas 735 in cruise

Adelaide TTF SPECI	SPECI YPAD 172200Z 01006KT 1000NW 9999 PRFG MIFG FEW022 05/05 Q1020 RMK RF00.0/000.0 TTF: FM2200 01005KT 0500 FG FM2300 05005KT 9999 FEW025
Mildura METAR	METAR YMIA 172200Z 28005KT 9999 SCT034 05/04 Q1019 RMK RF00.0/000.2

Time: 0804 EST – Velocity 1384 and Qantas 735 in cruise

Adelaide ATIS	ATIS YPAD W 172204 APCH EXP INST APCH RWY 23 OPR INFO HIAL ON. LOW VIS PROCS WND 360/5, MAX DW 5 KTS. VIS 700M IN FOG CLD FEW015 TMP 5. QNH 1020

Time: 0805 EST – Velocity 1384 and Qantas 735 in cruise

Adelaide TTF SPECI	SPECI YPAD 172205Z 01006KT 0500N 2000 FG FEW022 04/04 Q1020 RMK RF00.0/000.0 TTF: FM2205 01005KT 0500 FG FM2300 05005KT 9999 FEW025
Mildura METAR	No change from previous

Time: 0815 EST – Velocity 1384 and Qantas 735 in cruise, Qantas 735 approaching diversion point

Adelaide TTF SPECI	SPECI YPAD 172215Z 02006KT 0250N 0500 FG BKN001 04/04 Q1020 RMK RF00.0/000.0 TTF: FM2300 05005KT 9999 FEW025
Mildura METAR	No change from previous

Time: 0830 EST – Velocity 1384 and Qantas 735 in cruise

Adelaide TTF SPECI	SPECI YPAD 172230Z 04005KT 0150 FG BKN001 06/05 Q1020 RMK RF00.0/000.0 TTF: FM2300 05005KT 9999 FEW025
Mildura METAR	METAR YMIA 172230Z 27004KT 9999 BKN034 06/05 Q1019 RMK RF00.0/000.2
Adelaide ATIS	ATIS YPAD X 172230 APCH EXP INST APCH RWY 23 OPR INFO HIAL ON. LOW VIS PROCS WND 360/5, MAX DW 5 KTS. VIS 500M IN FOG CLD FEW015 TMP 6. QNH 1020

Time: 0900 EST – Velocity 1384 and Qantas 735 on descent to Adelaide

Adelaide TTF SPECI	SPECI YPAD 172300Z 04006KT 0150 FG BKN000 06/06 Q1021 RMK RF00.0/000.0 TTF: FM2330 05005KT 9999 FEW025
Mildura METAR	METAR YMIA 172300Z 23004KT 9999 BKN039 07/06 Q1019 RMK RF00.0/000.2

Time: 0902 EST – Velocity 1384 and Qantas 735 on descent to Adelaide

Adelaide TAF	TAF YPAD 172302Z 1800/1906 VRB05KT 9999 FEW030 SCT045 FM181000 VRB05KT CAVOK FM190000 04008KT CAVOK RMK T 11 14 15 11 Q 1020 1020 1020 1021
Mildura TAF	TAF YMIA 172302Z 1800/1812 20008KT 9999 SCT030 SCT050 RMK T 08 12 13 10 Q 1020 1019 1019 1020

Time: 0911 EST – Velocity 1384 diverting to Mildura, Qantas 735 holding to east of Adelaide

Adelaide ATIS	ATIS YPAD Y 172311 APCH: EXP INST APCH RWY: 23 OPR INFO: HIAL ON. LOW VIS PROCS WND: 360/5, MAX DW 5 KTS. VIS: 500M IN FOG CLD: FEW015 TMP: 7. QNH: 1021

Time: 0918 EST – Velocity 1384 and Qantas 735 en route to Mildura

Mildura SPECI	SPECI YMIA 172318Z 22004KT 9999 BKN002 SCT041 08/06 Q1019 RMK RF00.0/000.0

Time: 0928 EST – Velocity 1384 and Qantas 735 on descent to Mildura

Mildura SPECI	SPECI YMIA 172328Z 21006KT 5000 BR BKN002 07/07 Q1019 RMK RF00.0/000.0

Time: 0930 EST – Velocity 1384 and Qantas 735 approaching Mildura

Mildura SPECI	SPECI YMIA 172330Z 21006KT 3300 BR BKN002 07/07 Q1019 RMK RF00.0/000.0

Time: 0932 EST – Velocity 1384 overhead Mildura, Qantas 735 approaching Mildura

Mildura SPECI	SPECI YMIA 172332Z 20007KT 2100 BR BKN002 07/07 Q1019 RMK RF00.0/000.0

Time: 0948 EST – Velocity 1384 overhead Mildura, Qantas 735 landed at Mildura

Mildura SPECI	SPECI YMIA 172348Z 19007KT 0900 FG OVC001 07/07 Q1019 RMK RF00.0/000.0

Time: 0952 EST – Velocity 1384 overhead Mildura, Qantas 735 shutdown at Mildura

Mildura TAF	TAF AMD YMIA 172352Z 1800/1812 20007KT 3000 BR SCT003 BKN040 BECMG 1800/1801 19006KT 9999 SCT030 SCT050 PROB30 1800/1802 0500 FG BKN002 RMK T 07 11 13 10 Q 1019 1019 1019 1020

Time: 0956 EST – Velocity 1384 overhead Mildura

Mildura SPECI	SPECI YMIA 172356Z 21007KT 0400 FG OVC001 07/07 Q1020 RMK RF00.0/000.0

Time: 1000 EST – Velocity 1384 overhead Mildura

Mildura SPECI	SPECI YMIA 180000Z 20006KT 0300 FG OVC001 07/07 Q1020 RMK RF00.0/000.0

Time: 1011 EST – Velocity 1384 on final approach to runway 27 Mildura, lands at 1014 EST.

Mildura SPECI	SPECI YMIA 180011Z 20006KT 0200 FG OVC001 07/07 Q1020 RMK RF00.0/000.0

Appendix D – Aeronautical Information Publication Australia and Manual of Air Traffic Services amendments

Aeronautical Information Publication Australia

Provision of flight information service

Aeronautical Information Publication (AIP) Australia GEN 3.3, Section 2 *FLIGHT INFORMATION SERVICE* contained information about the provision of a flight information service (FIS). This service was 'structured to support the responsibility of pilots to obtain information in-flight on which to base operational decisions relating to the continuation or diversion of a flight.'

During the period prior to the occurrence involving VH-YIR and VH-VYK, there were several amendments to the AIP regarding the provision of FIS. These included a number of amendments in June 2007 and another in March 2009, which are discussed below.

AIP of 15 March 2007

The version of the AIP that was current on 15 March 2007 stated that, in relation to FIS, pilots were responsible for requesting information necessary to make operational decisions. However, there was also scope for the provision of air traffic control (ATC)-initiated FIS.

The AIP also indicated that the FIS comprised three elements:

a. Automatic Broadcast Services;

b. On Request Service; and

c. Hazard Alert Service.

The automatic broadcast services (ABS) consisted of:

a. Automatic Terminal Information Service (ATIS),

b. Automatic En Route Information Service (AERIS),

c. Aerodrome Weather Information Service (AWIS), and

d. Meteorological Information for Aircraft in Flight (VOLMET).

An automatic terminal information service (ATIS) is an automated pre-recorded transmission indicating the prevailing weather conditions at an airport and other relevant operational information for arriving and departing aircraft. An AERIS is a continuous broadcast of routine aerodrome weather reports (METAR[24]) from selected airports around Australia. It operates from specific very high frequency (VHF) transmitters and the contents of the broadcast from each transmitter cater for the needs of aircraft operating in control areas within the broadcast range of each transmitter.

An AWIS is a transmission of actual weather conditions, as measured by automatic weather stations (AWS),[25] via either telephone or radio broadcast from selected sites. The broadcast is usually continuous with updates available on a minute by minute basis.

VOLMET broadcasts provide meteorological information for Australian major international airports and contain METAR/SPECI or trend forecast (TTF) information and the availability of SIGMETs[26]. The broadcasts are of 5 minutes' duration and occur at times 00–05 and 30–35 (commencing on the hour and half hour).

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[24] Routine aerodrome weather report issued at fixed times, hourly or half-hourly.

[25] These conditions can be determined by BoM or other AWSs.

[26] A weather advisory service issued to warn of potentially hazardous (significant) or extreme meteorological conditions that are dangerous to most aircraft, such as thunderstorms or extreme turbulence.

The on-request service is provided by FLIGHTWATCH, the generic call sign of the service. This service responds to in-flight requests for operational information from pilots operating in all classes of airspace on air traffic control VHF frequencies or high frequencies (HF).

The Hazard Alerting service is provided by ATC and provides pilots with information that is assessed by ATC to be of an unexpected and critical nature, and could assist pilots to avoid hazardous situations. The AIP indicated that a hazard alert would be broadcast on appropriate ATC frequencies during the 60-minute period following the onset of the hazardous conditions, or would be directed to those aircraft in continuous communications with ATC within 60 minute's flight time of the hazardous condition.

The AIP defined hazard alerts to include:

a. SIGMET,

b. AIRMET,

c. observations, pilot reports, or amended forecasts indicating that weather conditions at the destination have unexpectedly deteriorated below the IFR or VFR alternate minima, and

d. any additional information that could assist the pilot in the avoidance of hazardous situations.

Amendment 51 of 7 June 2007

On 7 June 2007, amendment 51 of the AIP redefined the elements of an FIS by adding an ATC-initiated FIS and removing the Hazard Alert Service. The ABS and the on-request service remained as described in the previous version of the AIP.

The AIP stated that ATC-initiated FIS provided pertinent operational information including meteorological conditions and the existence of non-routine meteorological products. It also indicated that the provision of ATC-initiated FIS would be generally limited to aircraft within 60 minutes flight time of the condition or destination at the time of the receipt of the information by ATC. It cautioned that pilots must consider that time period when complying with the requirement to obtain information on which to base their operational decisions.

Hazard alerting was removed from the list of FIS elements and the definitions of what constituted a hazard alert were removed from the AIP. The only section in the AIP that defined hazard alerting procedures stated:

> A sudden (not forecast NOTAMed) change to a component of FIS having an immediate and detrimental effect on the safety of an aircraft will be communicated by ATC using the prefix "Hazard Alert".

Amendment 58 of 12 March 2009

On 12 March 2009, amendment 58 of the AIP changed the pilot responsibility in relation to FIS from 'requesting' the operational information to 'obtaining' the information. The amendment also introduced the following change regarding the availability of aerodrome weather reports (METAR/SPECI):

> When providing FIS, ATC will not alert pilots to the availability of aerodrome weather reports that are available from an automatic broadcast service.

In addition, when there was a sudden change in pertinent operational information that was not described in a current meteorological product or NOTAM, and the change had an immediate and detrimental effect on the safety of an aircraft, ATC would communicate this change to pilots with the prefix 'Hazard Alert'. The AIP did not contain a list of information that would constitute a Hazard Alert, or what constituted non-routine meteorological products.

The information in amendment 58 was current at the time of the occurrence involving VH-YIR and VH-VYK.

Industry education on the changes to AIP in March 2009

The March 2009 changes to the AIP were communicated to the aviation industry by three methods. The first was the change to the AIP itself, which included standard amendment bar marking against each changed, introduced or deleted paragraph or text. The second was the issue of an Aeronautical Information Circular, effective 12 March 2009 that was intended 'to provide education on changes to the delivery of the SPECI and ARFOR elements of the ATC initiated Flight Information Service (FIS)'. The third method was an article in the *Flight Safety Australia* magazine, March-April 2009 edition. This magazine was produced by the Civil Aviation Safety Authority and distributed to pilots and other aviation personnel. The article stated:

> 'Aviation special weather' - SPECI, which can be obtained from an automatic broadcast service (ABS), no longer needs to be 'directed' or 'broadcast' to aircraft by ATS [air traffic services]. The availability of SPECI from an ABS meets the requirement for in-flight information service. If an ABS is not available, pilots may request weather information from ATS as part of the on-request flight information service.

A further article in the *Flight Safety Australia*, March–April 2012 edition, outlined the provision of ATC-initiated flight information services. That article highlighted the 60-minute flight time restriction on the provision of information. It also indicated that the FIS was for the provision of operational information, which included meteorological products and the existence of non-routine MET products. The article did not contain a definition of non-routine MET products but did contain the following practical example of what ATC-initiated FIS would not include:

> …you will **not** automatically receive **routine** TAF information showing deteriorating weather conditions if you are en route to a location [bolding in original].

The article directed readers to the applicable section of the AIP for more information. In May 2012, Airservices Australia (Airservices) published on its website an information paper for pilots about the provision of in-flight information services. That paper indicated that the ATC-initiated FIS service was 'mainly designed to inform you of unexpected or non-routine information'. Other sections of the information paper repeated the information that was contained in the AIP.

Manual of Air Traffic Services

The Manual of Air Traffic Services (MATS) is an Airservices and Department of Defence internal document that promulgates the procedures for the provision of air traffic services in Australia. It is not routinely made available outside these organisations and is not made available to pilots or operators. The content of MATS is intended to be consistent with the content of the AIP so that procedures and practices used by pilots and air traffic controllers are standardised.

Provision of flight information service

During the period prior to the occurrence involving VH-YIR and VH-VYK there were several amendments to the MATS regarding the provision of FIS, including three amendments as discussed below.

MATS of 15 March 2007

The MATS, current as at 15 March 2007, indicated that FIS was to be provided to all aircraft that were being provided with an ATC service, or were otherwise known to the relevant ATC unit. It stated that FIS was to include operational information about meteorological conditions and hazard alerts.

The MATS also contained a section dealing with the provision of a hazard alert service. It defined a hazard alert as information assessed by ATC to be of an unexpected and critical nature. It stated that controllers were to consult a number of sources of information to assess if a hazard alert was necessary. This included weather forecasts, amended forecasts and observations and reports indicating weather conditions at the destination have deteriorated below the Instrument or Visual Flight Rules alternate minima.

The MATS also indicated that responsibility for issuing a hazard alert rested with 'the responsible ATS unit'. Further information in the MATS stated:

> Unless the destination is within a control zone, it is the responsibility of the ATS unit within whose area the destination aerodrome is situated to distribute Hazard Alert information relating to the destination. It is the responsibility of the Tower to identify and coordinate Hazard Alert information relating to destination aerodrome(s) within activated civil or military control zones.

and that:

> Officers may, at times, experience situations not specifically covered whereby the safety of an aircraft may be considered to be in doubt. Nothing in these instructions shall preclude officers from exercising their best judgement and initiative to assist pilots.

Amendment 12 of 7 June 2007

In this amendment the section on the provision of FIS was changed in several areas. In particular, the sections on hazard alerts were amended, with other sections relating to the provision of significant information and a hazard alert service, and the associated responsibilities, being deleted from the manual.

The operational information required to be provided by ATC to pilots was amended to require the provision of information about meteorological conditions and the existence of non-routine meteorological products such as SPECI reports and amended TAFs.

A timing requirement on the provision of this operational information was also introduced so that pilots were alerted 'within one hour of the conditions' with controllers being able to use various means to communicate the information including:

> a. by directed transmissions to those aircraft maintaining continuous communications with ATS at the time the information is identified and that are within one hour's flight time of the conditions;[27]

Information on the provision of hazard alerts was amended to require controllers to:

> Communicate a sudden (not forecast or NOTAMed) change to a component of FIS having an immediate and detrimental effect on the safety of aircraft by using the prefix "Hazard Alert". Use the prefix only until an updated MET product or NOTAM is available for dissemination as per 5.1.1.9.

Section 5.1.1.9 of the MATS indicated that components of the FIS would be notified to relevant aircraft as soon as practicable after receipt by ATC.

MATS version 1 of 7 September 2007

In September 2007, the MATS was entirely reformatted and the reference to amendments changed to 'versions', with version 1 being effective on 7 September 2007. The section of this version on the provision of FIS to pilots in flight indicated that the controller was to provide FIS to all aircraft that were being provided with an ATC service. The definition of FIS remained substantially the same as the 7 June 2007 release of MATS but the section on hazard alerts was reduced to:

> Use the prefix HAZARD ALERT when communicating a sudden change to a component of FIS which has an immediate and detrimental effect on the safety of aircraft.

The amendment further indicated that the use of the prefix 'hazard alert' was only to be used until such time as the updated meteorological product, such as a report or forecast, or NOTAM on which the alert was based, became available to pilots by other means.

In addition, the section relating to the responsibilities of officers 'exercising their best judgement and initiative to assist pilots' was removed from the section relating to the provision of flight information services.

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[27] The time period for the provision of SIGMETs (messages about en route weather phenomena that are potentially hazardous to aircraft) was increased to 2 hours in MATS version 6 effective on 19 November 2008.

The order of precedence in the provision of FIS by controllers was indicated as:

> Where air traffic service units provide both flight information and air traffic control services, give precedence to the provision of air traffic control over flight information, unless doing so would compromise safety.

The MATS also outlined the responsibility of air traffic service officers in relation to how information was to be communicated to relevant aircraft. It indicated that, if they became aware of information that was outside their area of responsibility, they may have to address the information to a pilot of an aircraft though another ATC unit. Furthermore, controllers were to notify the pilots of aircraft affected by non-routine meteorological products at the time that the products were identified in the form of a directed transmission to the pilots and within 60 minutes' flight time of the conditions notified.

MATS version 7 of 11 March 2009

MATS version 7, effective on 11 March 2009, amended the examples of non-routine meteorological products to 'selected' SPECI reports under the 'Scope of FIS' section. In respect of the provision of SPECI information to pilots, MATS was amended to include the requirement that:

> Do not alert pilots to the availability of a SPECI that can be obtained from an Automatic Broadcast Service.

In addition, an amendment was made so that pilots were responsible for 'obtaining' information necessary to make operational decisions, rather than being responsible for 'requesting' the information, as had been contained within MATS since 2001. That change was to reflect the availability of ABS and amendments to ATC-directed FIS.

MATS version 23 was current at the time of occurrence involving VH-YIR and VH-VYK. The section relating to the provision of FIS was substantially the same as version 7 of the MATS.

Reason for the change to the AIP and MATS in March 2009

Prior to the changes to the AIP and MATS in March 2009, ATC notified pilots receiving an ATC service about all SPECI reports and amendments to forecasts. However, an increase in the number of SPECI reports due to an increase in the number of AWS being commissioned, and the introduction of required change parameters being programmed into the software of the AWS led to a large increase in the number of SPECI reports being received by controllers. This reportedly increased controller workload and Airservices reviewed their position on the provision of in-flight information to flight crews. At the same time, Airservices were also conducting a review of the provision of hazard alerting services to aircraft. The result of these reviews was reflected in changes to the AIP and to MATS in March 2009.

The reviews, and subsequent procedural amendments, resulted in a number of changes in the way in which SPECI reports were handled by the air traffic control system and the way in which this information was relayed to pilots in flight. In particular, if a SPECI report was available from an automatic broadcast service (ABS) then it would not be made available to the pilot by ATC. The pilot would be responsible for seeking this information from the ABS or asking ATC.

The changes also resulted in any SPECI report that was available from an ABS not being sent automatically to a controller's workstation. The controller could request specific SPECI reports for an airport if required; however, only those SPECI reports that covered airports without an ABS would be automatically sent to the controller's workstation.

The changes were specifically introduced to reduce controller workload. In addition, changes regarding the 60-minute time period in which amended aerodrome forecast information would be broadcast to aircraft that are being provided with an ATC service, aligned the MATS to the International Civil Aviation Organization (ICAO) *Regional Supplementary Procedures*.

ICAO Regional Supplementary Procedures

ICAO Document 7030, *Regional Supplementary Procedures*, Fifth Edition 2008, outlined the procedural parts of the air navigation plans that have been developed to meet the needs of specific regions that are not covered in the worldwide provisions. The document described specific flight information regions in which the procedures were to apply, each having a section that was further divided into chapters dealing with specific topics.

The Brisbane and Melbourne flight information regions were listed in the section *Middle East/Asia (MID/ASIA) Regional Supplementary Procedures*. Chapter 6 – Air Traffic Services, stated:

> Amended aerodrome forecasts shall be passed to aircraft within 60 minutes from the aerodrome of destination, unless the information has been made available through other means.

Australian Transport Safety Bureau

The ATSB is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

Enquiries 1800 020 616
Notifications 1800 011 034
REPCON 1800 011 034
Web www.atsb.gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au
Facebook atsbgovau

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Landing below minima due to fog involving Boeing 737s, VH-YIR and VH-VYK, Mildura Airport, Victoria on 18 June 2013

AO-2013-100
Final – 31 May 2016