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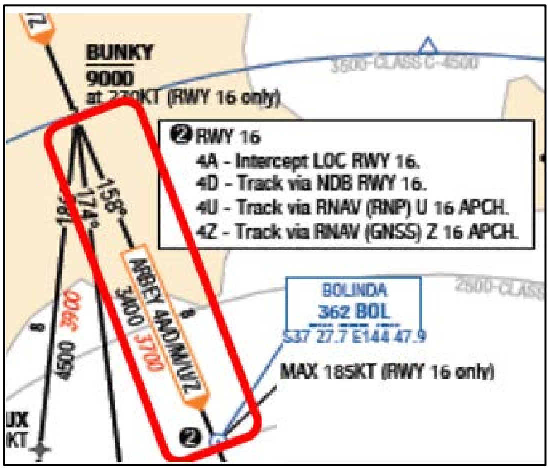
Descent below minimum altitude involving a Boeing 777, A6-ECO

What happened

On the morning of 18 July 2014, a Boeing 777 operated by Emirates Airlines, registered A6-ECO, was on descent into Melbourne, Victoria via an ARBEY 4U Standard Arrival Route (STAR)[1] for the Area Navigation U (RNAV-U) Required Navigation Performance (RNP) runway 16 approach. There was some cloud and showers in the area at the time, with the wind from the south-west.

The ARBEY 4U STAR required that the aircraft track from ARBEY to BUNKY, then to the Bolinda (BOL) non-directional (radio) beacon (NDB).[2] The arrival procedure included speed and altitude restrictions at BUNKY, and a speed restriction at BOL, but there was no altitude restriction at BOL depicted on the STAR chart. Even though there was no altitude restriction depicted at BOL, the STAR chart depicted a minimum en route altitude (MEA) of 3,400 ft and a minimum terrain clearance altitude (MTCA) of 3,700 ft, between BUNKY and BOL (Figure 1).[3]

Figure 1: Excerpt from the ARBEY 4 STAR chart used by the operator depicting MEA (3400) and MTCA (3700)



Source: Aircraft operator – image cropped by the ATSB

The ARBEY 4U STAR linked to the RNAV-U (RNP) runway 16 approach at BOL, which was identified as the initial approach fix for the RNAV-U (RNP) runway 16 approach. While no altitude was specified at BOL on the STAR chart, the RNAV-U (RNP) runway 16 approach chart depicted two altitudes at BOL (Figure 2). These were:

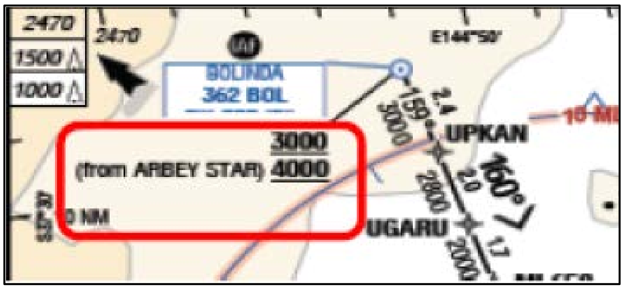
- an 'at or above' 4,000 ft altitude restriction at BOL when joining the approach from the ARBEY STAR
- an 'at or above' 3,000 ft altitude restriction at BOL applicable when the approach was linked with STAR procedures other than the ARBEY STAR.

1 A STAR is a published instrument flight rules arrival route that links the en route airways system to a fix at or near the destination airport.

2 An NDB is a radio transmitter at a known location, used as a navigational aid. The signal transmitted does not include inherent directional information.

3 The minimum en route altitude (MEA) and the minimum terrain clearance altitude (MTCA) are calculated differently, and both are depicted on the STAR chart used by the operator. Only the minimum en route altitude is depicted on the corresponding Airservices Australia STAR chart.

Figure 2: Excerpt from the RNAV-U (RNP) runway 16 approach chart used by the operator depicting two altitudes at BOL



Source: Aircraft operator – image cropped by the ATSB

As the aircraft approached BUNKY, air traffic control (ATC) cleared the crew to descend to 4,000 ft, and to conduct the RNAV-U (RNP) runway 16 approach. ATC radar data shows that the aircraft overflew BUNKY at 5,000 ft, then continued descent, passing through 4,000 ft about 5 NM prior to BOL. During the approach setup, the Flight Management Computer (FMC)[4] indicated an altitude constraint for BOL of 'at or above 3,000 ft'. The crew then selected this to an 'at 3,000 ft' constraint, which programmed the aircraft to overfly BOL at a 'hard altitude' of 3,000 ft.

Descent then continued, and ATC received a Minimum Safe Altitude Warning (MSAW)[5] alert, as the aircraft descended through 3,400 ft about 4 NM prior to BOL (Figure 3). ATC questioned the crew about their altitude, and advised them that the relevant radar lowest safe altitude was 3,200 ft. Moments later, the aircraft passed over BOL at about 3,000 ft and maintained that altitude until intercepting the vertical profile of the RNAV-U (RNP) runway 16 approach. ATC then transferred the crew to the next frequency, and the crew confirmed they had the correct QNH setting.[6] The approach continued for an uneventful landing.

A subsequent review of the ATC radar data showed that the aircraft left controlled airspace as it descended through 3,500 ft. The aircraft was briefly outside controlled airspace until it reached the 15 NM airspace boundary step, where the lower limit of controlled airspace became 2,500 ft. There was no report of conflict with other traffic outside of controlled airspace. Throughout the incident, the crew maintained visual contact with the terrain, and could see the airport environment from some distance out. No aircraft ground proximity warning system alerts were triggered during the incident.

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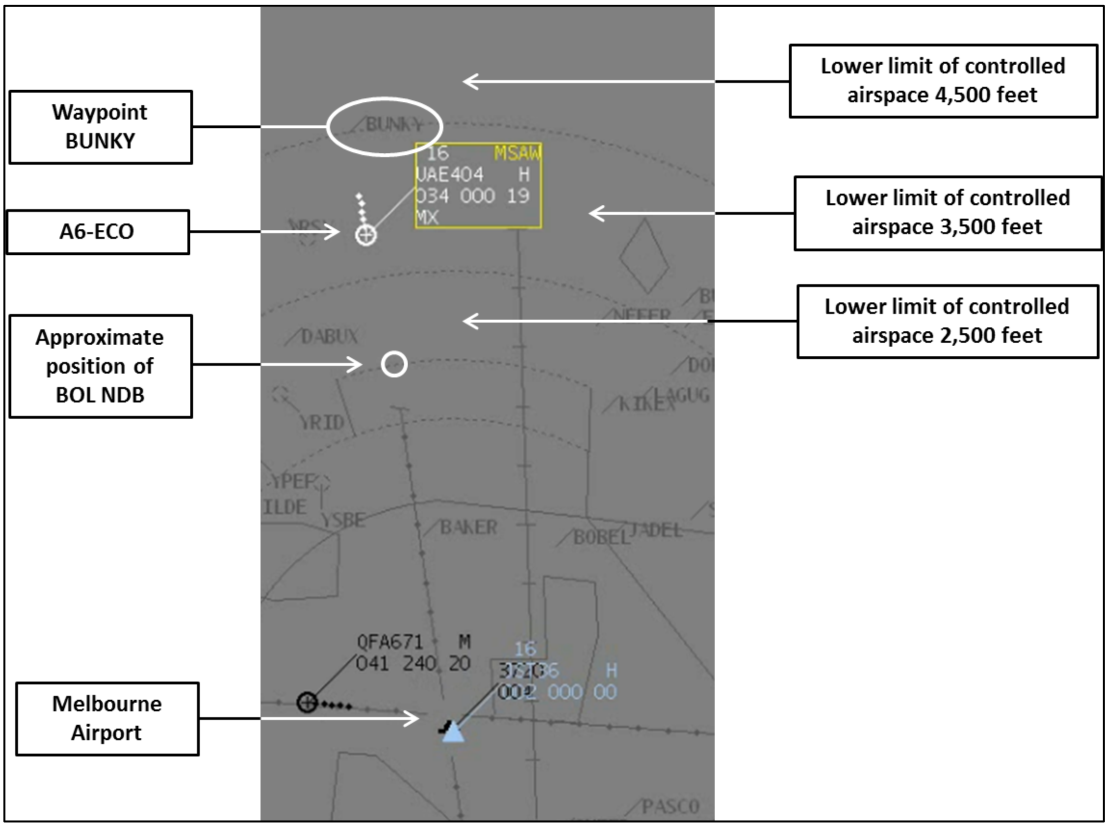
4 The FMC provides aircraft navigation, lateral and vertical guidance, and aircraft performance functions.

5 MSAW is a ground-based system intended to alert ATC to an increased risk of an aircraft collision with terrain.

6 QNH is an altimeter barometric pressure subscale setting. With QNH set, an altimeter provides an indication of the height of the aircraft above mean sea level.

Figure 3: ATC radar image at the time the MSAW alert activated



Source: Airservices Australia (modified by the ATSB)

Review of the factors identified in the investigation

The operator's investigation found that descent below the 4,000 ft altitude restriction at BOL occurred because the crew selected the 'hard altitude' of 3,000 ft for BOL. The potential for deviation below the 4,000 ft minimum altitude restriction at BOL was increased by factors related to aeronautical charts and the FMC navigation database. Some of these factors are discussed in the following paragraphs.

The ATSB obtained comments and responses from involved parties including:

- the United Arab Emirates General Civil Aviation Authority on behalf of Emirates Airlines
- Airservices Australia
- the Civil Aviation Safety Authority (CASA).

The RNP approach had been designed by GE Naverus (Naverus), based on information in the Airservices Australia Aeronautical Information Package (AIP). The charts and FMC data used by Emirates were supplied by LIDO. LIDO developed the charts and database based on information in the Airservices AIP.

Procedure design – level depiction on the ARBEY STAR

No minimum altitude was specified at BOL on the ARBEY FOUR STAR.

Operator comments

Within the STAR, BOL had a coded speed restriction of a maximum 185 kt for approaches to runway 16, but did not specify a minimum crossing altitude. This allowed arrivals from other directions to cross BOL at a minimum altitude of 3,000 ft, instead of 4,000 ft as required via ARBEY. This conditional altitude restriction was specified in the approach charts only and not on the STAR chart. This procedure design did not protect the MEA of 3,400 ft on the arrival segment from position BUNKY to position BOL by a 'hard procedural altitude'. BOL is located at a distance of 11.6 NM from runway 16 and a crossing altitude of 4,000 ft would permit a constant approach angle crossing BOL on a 3.0° vertical descent path. Based on this, a lower crossing altitude (3,000 ft) for other arrival directions does not seem necessary.

The operator suggested that Airservices Australia consider procedural amendments to specify a minimum crossing altitude over BOL (of 4,000 ft or above) for all approaches and within the STAR design. This would protect against descents below MEA (and outside controlled airspace) within the arrival segment from BUNKY to BOL. It would also satisfy the requirement of Airservices Australia to be able to specify higher crossing altitudes (above 4,000 ft) for traffic separation. If Airservices Australia, as the State AIP, changed the procedure design, the various chart providers would then amend their corresponding FMC/FMS databases as well as the STAR and instrument approach charts.

CASA comments

CASA suggested a possible solution would be to include the altitude restriction in the STAR chart. This would then make the altitude obvious on the text and plan view, and the altitude restriction would be coded in the FMS. They also found that the overall complexity of the STAR chart did not aid pilots' awareness.

Airservices response

In controlled airspace, the approach procedures are designed to keep aircraft 500 ft above the control area steps. The 4,000 ft minimum altitude was designed to keep aircraft in controlled airspace prior to BOL, rather than for terrain clearance.

Airservices further commented that a minimum altitude of 4,000 ft was not depicted on the STAR chart at BOL, as BOL was also applicable to the runway 27 arrival. This allows ATC to assign a higher altitude at that point for a runway 27 arrival due to potential runway 34 departures. No altitudes are depicted because two (or more) levels would be required to cater for the different runways. Only one level is permitted to be depicted against a waypoint (for a STAR) to avoid potential confusion as per Section 1-1-22 of Airservices 'Departure, Arrival and Air Route Management Design Rules' manual (ATS-MAN-0010).

Altitude requirements are not always specified on a STAR chart, and ATC is generally responsible for deciding whether altitudes are to be included or not. This occurs in the procedure design phase. When they are not included on the chart, ATC assigns individual altitudes to aircraft in order to facilitate vertical separation between them and assure terrain clearance.

RNAV-(U) RNP runway 16 approach chart design

Approaches with multiple altitudes at a common fix

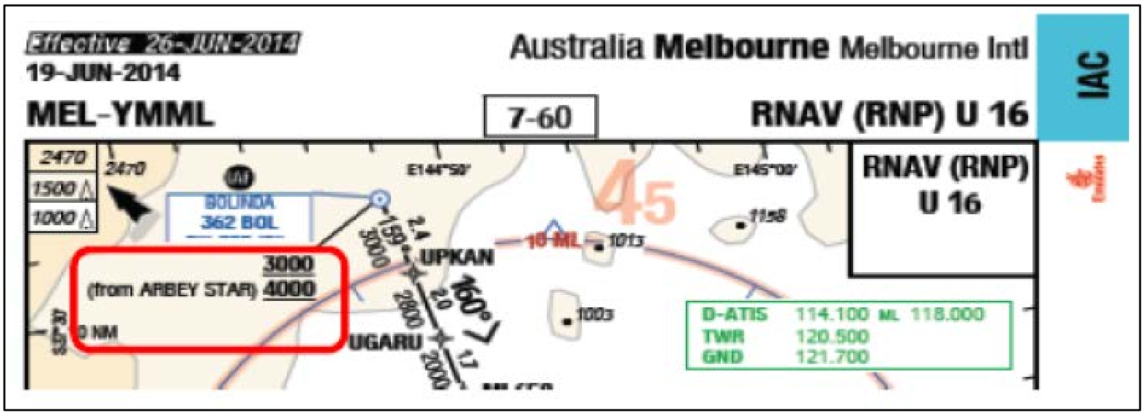
Airservices withdrew the RNAV-U (RNP) runway 16 approach early in 2015. Its withdrawal was not related to this incident. The ATSB reviewed all Australian approach charts published in the AIP Departure and Approach Procedures (DAP) current at the time of writing. The approach charts with a discrepancy between the STAR minimum segment altitude and the approach start altitude were Melbourne approach charts ILS – X, Y and Z runway 16, RNAV Z (GNSS) runways 16 and 27. No other Australian approach charts existed with that condition.

Chart depiction of the altitude restriction at BOL – operator comments

The operator reported that the absence of altitude restriction information on the STAR chart reduced the level of protection against deviation below the BOL minimum altitude restriction. The 4,000 ft altitude restriction at BOL when tracking from ARBEY STAR was physically depicted below the 3,000 ft altitude restriction applicable to other STAR procedures (see Figure 4a). This may also have influenced the crew's interpretation of the FMC altitude.

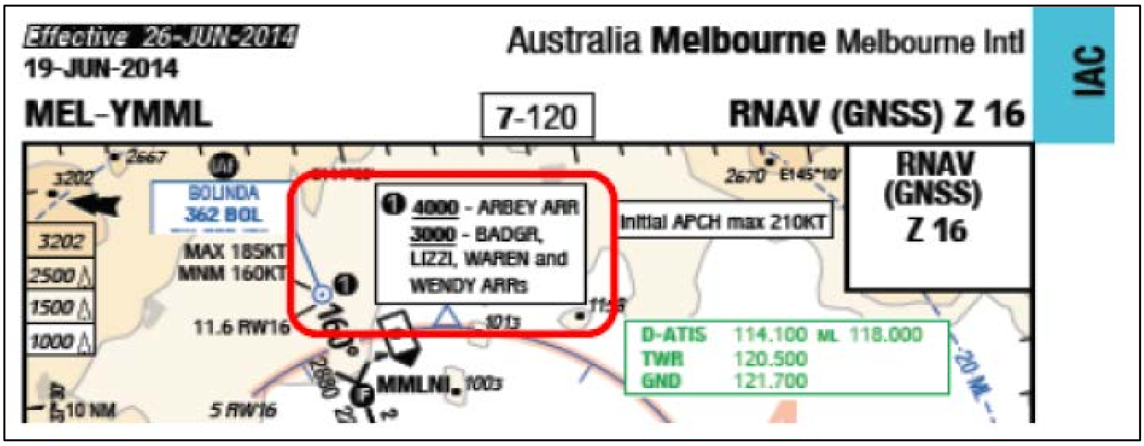
The following two figures show a comparison of two presentation options for multiple arrival altitudes. These altitudes are boxed in red.

Figure 4a: RNAV (RNP) approach chart used by the crew



Source: GCAA for chart provider (LIDO) modified by the ATSB

Figure 4b: RNAV (GNSS) Z approach chart



Source: GCAA for chart provider (LIDO) modified by the ATSB

Chart provider comments

The chart provider (LIDO) commented that presentation of information on a chart is normally at the discretion of the chart editor and based on:

- the amount of information which needs to be charted
- the amount of information already on the chart
- the space available for the information, based on standard font sizes.

If the information can be charted clearly using a leader line, this is used (see Figure 4a). As soon as the information exceeds two lines, the preference is usually for the information framed together in a box with a ball note[7] at the point in question (see Figure 4b).

The chart provider advised that on the RNAV (RNP) chart the higher value (4000) should have been depicted above the lower value (3000). They reiterated that the approach chart (Figure 4a) used in this incident is no longer valid.

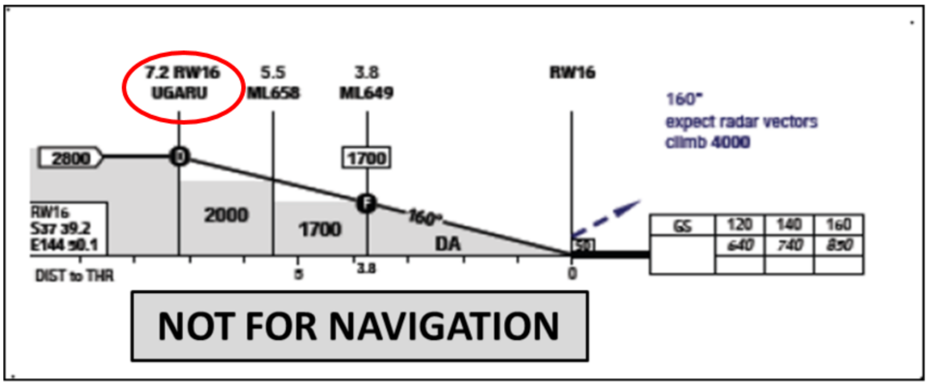
RNAV-U (RNP) runway 16 approach chart profile view

The approach chart provided a vertical profile view of the approach, but the view began immediately prior to intermediate fix (IF), waypoint UGARU, which is 4.4 NM beyond BOL (Figure 5a). As such, there was no profile view information on the approach chart for the approach

7 The ball note, as depicted in Figure 3b, includes the black circle with reference number 1 at BOL, with the explanation in the box using the same black dot (or 'ball') and matching reference number (or letter).

from the initial approach fix (IAF) BOL, to UGARU. Had this information been present in a vertical profile, it may have alerted the crew to the different altitude requirements at BOL, associated with the different STAR procedures.

Figure 5a: Excerpt from the RNAV-U (RNP) runway 16 approach chart used by the operator showing vertical profile information

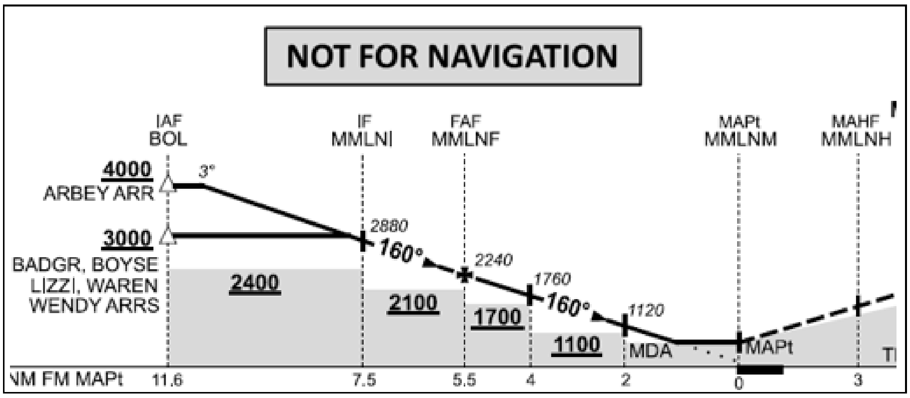


Source: Aircraft operator

Vertical profile view – operator comments

The operator noted that the profile view of Naverus charts was inconsistent with similar Airservices Australia charts. For example, the RNAV-Z (GNSS) runway 16 approach chart, which was designed by Airservices Australia, provided the important hazard information of the different minimum crossing altitudes over BOL in the profile view (Figure 5b). However the RNAV-U (RNP) runway 16 approach chart, which was designed by Naverus, depicted these altitudes in the plan view only. The operator considered that extension of the profile view, as published on similar Airservices Australia charts, would assist flight crews to select the correct altitude for the IAF.

Figure 5b: Excerpt from the Airservices RNAV-Z (GNSS) runway 16 approach chart for comparison



Source: Airservices Australia

The operator suggested that the profile view of the Naverus charts should be amended to conform to that of the Airservices Australia charts.

Airservices response

Airservices advised that the standard for the approach profile view was to commence at the final approach fix (FAF), and not to include the initial approach fix (IAF). Airservices opted to trial the inclusion of the IAF, in this case BOL, in the profile view of other similar charts. While its inclusion made the approach altitude clearer, Airservices stated that it was not likely to be adopted as the convention, either generally by Airservices or internationally. Naverus charts conform to the ICAO standard, and therefore the profile view did not commence at the IAF.

FMC navigation data

Consistent with the STAR chart, the ARBEY 4U STAR FMC navigation data did not include an altitude restriction at BOL (Figure 6). FMC navigation data for the RNAV-U (RNP) runway 16 approach included an altitude restriction at BOL, but that altitude restriction was '3000A' (meaning 'at or above' 3,000 ft) (Figure 7). The 3,000 ft restriction was applicable to a number of STARs that linked with the RNAV-U (RNP) runway 16 approach. But it was not applicable to the ARBEY STAR which had a 4,000 ft restriction.

Figure 6: ARBEY 4U STAR FMC navigation data

Apt	Ident	Via	Rwy	TrAlt	Fix	Type	Fix Latitude	Fix Longitude	T	PT	O	M	Cs/Hd	Alt1	CAS	RNP
YMML	ARBE4U	STARCR	16	11000	ARBEY	WPT	NOT FOR NAVIGATION									
YMML	ARBE4U	STARCR	16	11000	BUNKY	WPT								9000B	230	1
YMML	ARBE4U	STARCR	16	11000	BOL	NDB	S37-27-43.92	E144-47-53.58		TF					185	1

Source: Aircraft operator modified by the ATSB

Figure 7: RNAV-U (RNP) runway 16 approach FMC navigation data

Apt	Ident	Via	Rwy	TrAlt	Fix	Type	Fix Latitude	Fix Longitude	T	PT	O	M	Alt1	FPA	CAS	RNP
YMML	RNV16-U	APP	16	11000	BOL	NDB	S37-27-43.92	E144-47-53.58		IF			3000A			
YMML	RNV16-U	APP	16	11000	UPKAN	WPT	S37-30-03.42	E144-48-23.63		TF			3000A			0.3
YMML	RNV16-U	APP	16	11000	UGARU	WPT	NOT FOR NAVIGATION						2800A			0.3
YMML	RNV16-U	APP	16	11000	ML658	WPT							2000A			0.3
YMML	RNV16-U	APP	16	11000	ML649	WPT	S37-35-28.10	E144-49-24.04		TF			1700			0.3
YMML	RNV16-U	APP	16	11000	RW16	RWY	S37-39-11.50	E144-50-05.67		TF	Y		480	-2.99		0.3

Source: Aircraft operator modified by the ATSB

Compliance with the published procedure on this occasion required the crew to modify the FMC vertical profile at BOL by increasing the 'at or above' altitude restriction from 3,000 ft to 4,000 ft. Any requirement to modify the vertical profile brings about the potential to introduce errors, the consequences of which may be more significant when the FMC default altitude needs to be increased. If an error is introduced when the FMC vertical profile is modified, vertical path indications displayed to the crew during the approach may be misleading.

FCOM procedure

At the time of the incident, the FCOM stated that crews could change an FMC IAF 'at or above' altitude constraint, to an 'at' altitude constraint, using the **same** altitude. Technically therefore, the crew were unable to change the coded 3000A to the correct 4000A. This ambiguity within the FCOM procedure was raised with the aircraft manufacturer via the fleet technical pilots. At the time of publication, a response from the manufacturer was still pending.

FMC approach altitude

As depicted in Figure 6, there was no altitude on the STAR coded in the FMC, so when the crew selected approach mode, the 3000A appeared as the relevant altitude restriction for BOL. Only one altitude can be selected by the FMC. The ATSB was unable to clarify what coding logic was applied to determine which altitude is selected when two are provided.

The aircraft operator commented that they did not raise this issue with the FMC database provider, as the database coding reflects the AIP procedure design. The aircraft operator considered the conditional altitude over the waypoint BOL to be a procedure design weakness and raised that with Airservices Australia accordingly. The approach is no longer valid, but the operator intends to closely monitor for this issue in any new approaches.

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.

Aircraft operator

Crew awareness of restrictions on STAR

Soon after the occurrence, the aircraft operator published a company Notice to Airmen (NOTAM) for crew awareness. The NOTAM pointed out that approaches into Melbourne may include altitude restrictions that depend on the particular STAR being flown. The NOTAM also pointed out that some altitude restrictions may be depicted on the approach chart plan view only, and not necessarily on the relevant STAR chart, or the approach chart profile view. The NOTAM advised crews to exercise caution when reviewing STAR and approach procedures to ensure that all applicable altitude restrictions were observed.

Flight crew operations manual

The operator intends to reconsider Flight Crew Operations Manual guidance dealing with the benefits of changing initial approach fix ‘at or above’ altitude restrictions to hard altitudes, and discuss the depiction of altitude restrictions on the relevant charts with the chart provider.

Flight management computer coding

The operator has identified the FMC coding issue as a threat in their Hazard Identification and Risk Assessment statements. All new destinations and also, within the review cycle, existing destinations, will be checked against this threat and corrective action will be taken if applicable.

Airservices and CASA

CASA and Airservices intend to discuss the coding of the FMC at the next international instrument procedures panel, where an ‘integration’ subgroup includes FMC coding specialists. The aim of the discussion is to ensure the charts are used in the cockpit the way they are intended.

Safety message

For operators, this incident highlights the need for careful attention to FMC navigation data management, particularly any procedures that relate to crew modification of navigation data. Operators should remain mindful that any manipulation of FMC navigation data by flight crew has the potential to introduce errors. Additionally, operators are encouraged to work closely with aeronautical information service providers to ensure that aeronautical charts (and any other operational information) are presented in a manner that minimises ambiguity and reduces the potential for misinterpretation.

For flight crew, this incident highlights the need for careful attention to approach procedure documentation and FMC navigation data management.

For producers and providers of aeronautical information products, a guiding principle specified in *Procedures for Air Navigation Services, Aircraft Operations* is to keep all charts as simple as possible. This may assist in reducing flight crew workload and the risk of error, and coding issues when entering data into flight management systems.

General details

Occurrence details

Date and time:	18 July 2014 – 0710 EST	
Occurrence category:	Incident	
Primary occurrence type:	Flight below minimum altitude	
Location:	Near Melbourne, Victoria	
	Latitude: 37° 23.000’ S	Longitude: 144° 47.000’ E

Aircraft details

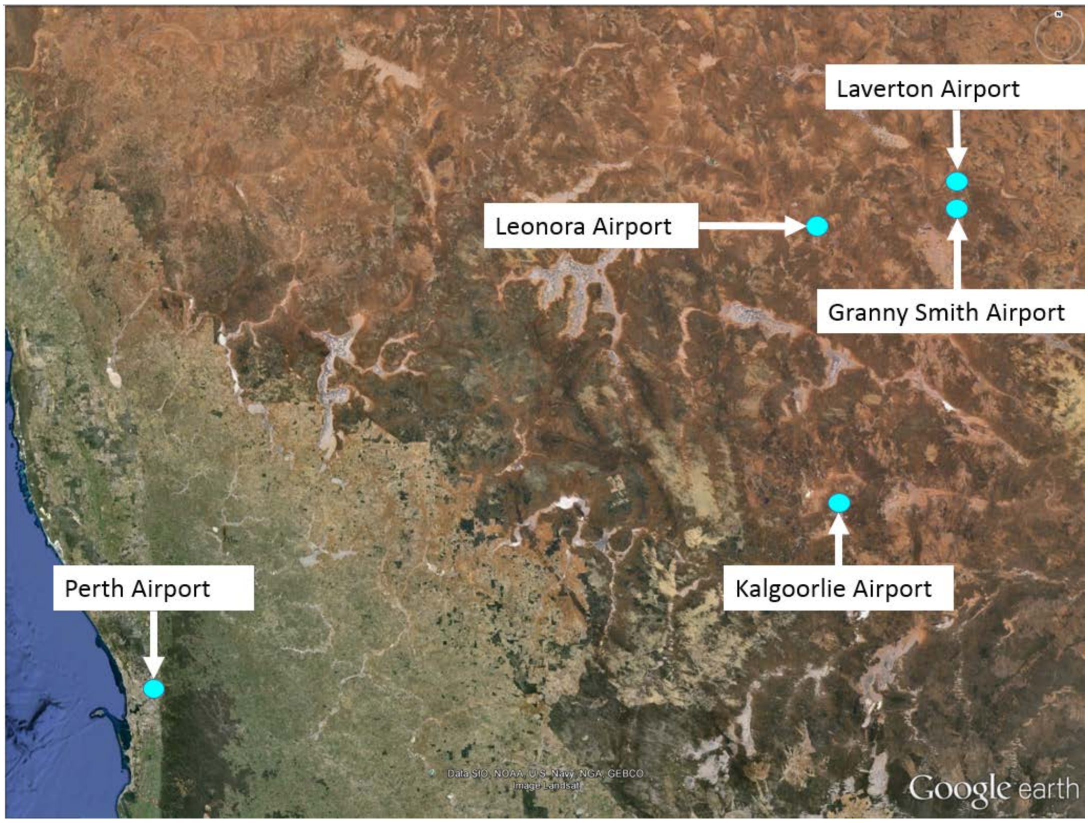
Manufacturer and model:	Boeing 777-36NER	
Registration:	A6-ECO	
Operator:	Emirates Airlines	
Serial number:	37706/765	
Type of operation:	Air Transport High Capacity	
Persons on board:	Crew – Unknown	Passengers – Unknown
Injuries:	Crew – Nil	Passengers – Nil
Damage:	None	

Flight below minimum altitude involving an Avro 146, VH-NJW

What happened

On 23 June 2015, at about 0420 Western Standard Time (WST), the captain and first officer of an Avro 146 aircraft, registered VH-NJW, and operated by National Jet Express, signed on to conduct a scheduled return flight from Perth to Granny Smith Airport, Western Australia (Figure1). The flight crew reviewed the weather forecast, including the aerodrome forecast (TAF)[1] for Leonora, which was the closest available TAF to Granny Smith. The TAF indicated broken[2] cloud 1,000 ft above ground level (AGL). The weather report (METAR) current at Leonora at that time indicated nil cloud detected (NCD). The forecast also included cloud at 1,500 ft AGL clearing at 0900 WST. Based on the weather forecast, the crew were required to plan for an alternate aerodrome,[3] and the captain planned sufficient fuel to return to Perth if they were unable to land at Granny Smith.

Figure 1: Selected aerodromes in Western Australia



Source: Google earth annotated by the ATSB

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1 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.

2 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.

3 Alternate minima are specified weather conditions or facilities for a particular aerodrome such that, if the weather conditions or facilities are less than the alternate minima, the pilot in command must provide for a suitable alternate aerodrome.

The first officer conducted the take-off and climb from Perth, and handed control of the aircraft to the captain after reaching the top of climb. In accordance with company procedures, the captain was required to conduct the landing at Granny Smith airport, due to the unsealed runway surface.

When established in the cruise, the flight crew received a weather report for Laverton indicating cloud at 800 ft AGL. The first officer spoke to the aerodrome reporting officer (ARO) at Granny Smith Airport, who reported that there were patches of blue sky above the aerodrome. The flight crew elected to continue to Granny Smith. They planned to overfly the aerodrome at the lowest safe altitude of 3,300 ft above mean sea level (AMSL), and if the weather was suitable, descend and join the circuit on downwind for runway 16. If they were unable to obtain the required visual reference for the aerodrome, the crew planned to divert to Laverton Airport, and conduct an area navigation (RNAV) approach and land there. The flight crew also discussed the option of conducting an RNAV approach at Laverton and, if suitable conditions for visual flight existed, they could then transit across to Granny Smith Airport, about 9 NM south of Laverton.

When the aircraft arrived overhead Granny Smith, the conditions were overcast. The flight crew elected to divert to Laverton, and advised the ARO that if they were able to establish visual reference at Laverton they would track from there to Granny Smith. The aircraft descended to the minimum sector altitude of 3,100 ft AMSL and the flight crew conducted the RNAV approach to runway 25. The crew configured the aircraft for the approach into Laverton, selecting gear down and flap 24, prior to arrival at the initial approach fix. When about 2.5 NM from the runway threshold and at about 2,150 ft AMSL, the aircraft became clear of cloud but the captain could not see the runway ahead at Laverton. The captain then disconnected the autopilot and turned the flight director off, in accordance with the standard company procedure for conducting a visual approach.

The weather to the south towards Granny Smith was clear, so the captain elected to divert to Granny Smith and turned the aircraft towards it, with the aircraft still configured for the approach with gear down and flap 24. The flight crew were able to maintain visual contact with the ground and reported about 8 km of visibility. The first officer had set the altimeter bug to 2,130 ft prior to commencing the descent, which was the minimum descent altitude (MDA) of 2,080 ft plus 50 ft as required by the company procedures. The wind was from 160° at 12 kt, and the captain planned to establish the aircraft on a straight in approach for runway 16.

The captain observed the radio altimeter (RADALT) indicating 500 ft and the electronic ground proximity warning system (EGPWS)[4] called '500', both indicating the aircraft was 500 ft AGL. Shortly afterwards, the crew received an EGPWS 'DON'T SINK' warning. The first officer observed the RADALT indicating 380 ft and the vertical speed indicator showing about 100 ft per minute descent. The captain immediately applied nose-up pitch and increased the thrust, in accordance with the standard response. The aircraft climbed towards cloud and the captain levelled the aircraft off to remain clear of cloud. The crew then received a second 'DON'T SINK' warning (see 'Don't Sink' section below). The first officer noted the RADALT indicating 410 ft and the captain immediately initiated a go-around, climbing to 4,000 ft AMSL.

Due to the time spent operating with the aircraft in the approach configuration, and the possibility of holding required in Perth, the captain then elected to divert to Kalgoorlie and refuel. After arrival in Kalgoorlie, the captain contacted the company flight operations manager. The manager queried whether the captain was fit to continue to operate the aircraft, to which the captain replied in the affirmative. After communicating with the company, at about 0900, the aircraft departed and tracked to Granny Smith. The conditions were still overcast at Granny Smith Airport, and the flight crew elected to track to Laverton, and conduct the RNAV approach. When at about 2,500 ft AMSL

4 The aircraft was fitted with an integrated terrain and traffic collision avoidance system that incorporated a number of functions, including a terrain awareness warning function (TAWS), a ground proximity warning function, and a traffic alert and collision avoidance function (TCAS).

the aircraft encountered visual meteorological conditions.[5] The flight crew then elected to track to Granny Smith Airport, where the aircraft landed. The crew subsequently conducted the return flight to Perth.

Don't Sink

According to the flight crew operating manual (FCOM), the EGPWS Mode 3 provides protection against loss of altitude after take-off or during a go-around. The amount of altitude loss is assessed against the height of the aircraft above the terrain. If the loss of altitude becomes significant for the height, a 'Don't Sink, Don't Sink' aural alert is given and the amber (terrain) 'TERR' caution lights illuminate. In response to a 'Don't Sink' caution, the FCOM specified one memory action: adjust the pitch attitude and thrust to restore a positive rate of climb.

Pilot comments

The captain had limited sleep in the preceding three weeks. In the 24 hours prior to signing on for duty, the captain had about three hours' sleep. The captain reported feeling irritable, with poor concentration, heavy eyes, and slow thinking processes. The captain believed that the captain's decision-making had been affected by lack of sleep. The captain advised the first officer prior to the flight of having had little sleep.

Both the captain and the first officer had been on leave for three weeks prior to the incident flight.

The first officer reported that they had made the decision to transit to Granny Smith, based on the understanding that a visual segment could be flown as the aircraft was within 30 NM of the aerodrome, clear of cloud and in sight of the ground with visibility greater than 5 km. However, that applied, according to Aeronautical Information Publication Australia (AIP) ENR 1.5-12 section 1.15 *Visual Approaches,* when the aircraft was 'at an altitude not below the lowest safe altitude [LSALT] /minimum sector altitude [MSA] for the route segment'. The minimum sector altitude was 3,300 ft.

Flight data

The aircraft operator analysed the flight data (Figure 2). The data showed that during the transit from Laverton to Granny Smith, EGPWS 'DON'T SINK' alerts were triggered when the aircraft's altitude reduced to 346 ft AGL, and again 1 minute later at 529 ft and then 520 ft AGL.

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5 Visual Meteorological Conditions is an aviation flight category in which visual flight rules (VFR) flight is permitted—that is, conditions in which pilots have sufficient visibility to fly the aircraft maintaining visual separation from terrain and other aircraft.

Figure 2: Plan view of the incident flight from the recorded flight data

Source: Aircraft Operator

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.

Aircraft operator

As a result of this occurrence, the aircraft operator has advised the ATSB that they are taking the following safety actions:

Fitness to fly

The head of flying operations (HOFO) for the aircraft operator sent a notice to all company flight crew. The notice stated that fitness to fly was critical for their daily functions. The HOFO reminded flight crew that their personal health and safe operations of company aircraft were of the highest priority. Company pilots were advised not to work if they did not feel 'up to the task'. The notice also provided contact information for the company's recommended employee assistance program.

Safety notice

The company immediately issued an operational notice to all flight crew, titled *Operations to airfields without instrument approach procedures*. The notice stated the following:

> *On arrival at the destination, descent below the LSALT is only permitted if, within 5 NM of the airfield, conditions exist to permit a visual approach as per the runway approach profiles specified in the applicable Operations Notice or the OM-C1.*
>
> *For reference,* ***OM-A2 1.5.3 Lowest Safe Altitude***
>
> *An aircraft may only be operated below the LSALT when:*

- *Departing the prescribed circling area and operation above the MSA*
- *Carrying out a published instrument approach*
- *Carrying out a minimum weather circuit within the circling area and not below the circling altitude*
- *In the process of taking off or landing in accordance with approved departure or arrival procedures*
- *Visual conditions exist, utilising criteria laid down in the Jeppesen Airway Manual – Air Traffic Control – General Flight Procedures*
- *Being radar vectored.*

It is not permitted to conduct an instrument approach at a nearby airfield to gain visual reference, and then transit to the destination airfield below LSALT.

Safety message

The captain noted that in hindsight their decision-making was impaired by lack of sleep. Research (Thomas and Ferguson, 2010) has shown that prior sleep is a critical fatigue-related variable. Less than 6 hours' sleep in the previous 24 hours was found to be associated with degraded operational performance and increased error rates.[6]

Civil Aviation Advisory Publication (CAAP) 48-1(1), states that 'determining fitness for duty has always been a complex and challenging task…and substantial fatigue research has demonstrated that humans are quite poor at determining how fatigued they actually are.' In addition, flight crewmembers 'who are fatigued will have impaired decision-making and they will have poorer judgment in terms of how fatigued they are and whether they are actually fit for duty'.

Prior to flight, it is important for pilots to assess their fitness to fly. The following checklist provides a quick reference. A description of aeromedical factors is available in the US Federal Aviation Authority Pilot's Handbook of Aeronautical Knowledge.

I'M SAFE Checklist
Illness - Symptoms **M**edication - Prescription or OTC **S**tress - Job, Financial, Health, Family **A**lcohol - 8 Hrs? 24 Hrs? **F**atigue - Adequately rested **E**ating - Adequately Nourished

6 Thomas, M.J., and Ferguson, S.A. (2010). *Prior sleep, prior wake and crew performance during normal flight operations*, in Aviation, space and environmental medicine, 81(7):665-70.

General details

Occurrence details

Date and time:	23 June 2015 – 0700 WST	
Occurrence category:	Incident	
Primary occurrence type:	Flight below minimum altitude	
Location:	near Granny Smith Airport, Western Australia	
	Latitude: 28° 45.80' S	Longitude: 122° 26.27" E

Aircraft details

Manufacturer and model:	British Aerospace Avro 146-RJ85	
Registration:	VH-NJW	
Operator:	National Jet Express	
Serial number:	E2329	
Type of operation:	Air transport high capacity – Passenger	
Persons on board:	Crew – 5	Passengers – 67
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Nil	

Turboprop aircraft

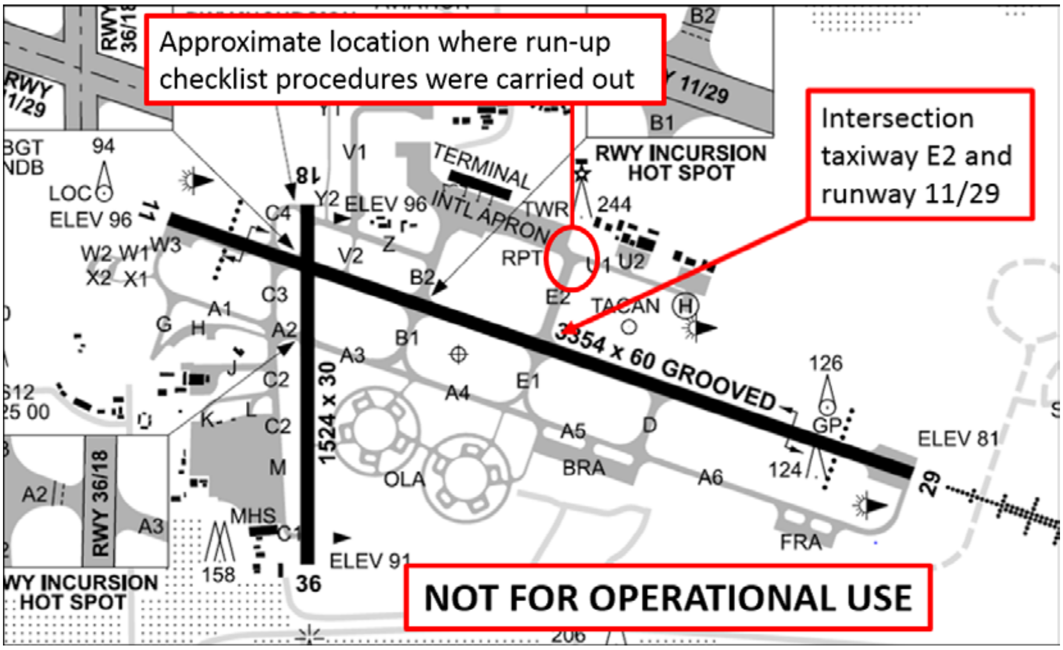
Stall warning event involving a Raytheon B200, VH-ZCO

What happened

At about 1300 Central Standard Time on 17 May 2015, the pilot of a Raytheon B200, registered VH-ZCO, taxied at Darwin Airport for a flight to Jabiru, in the Northern Territory. The flight was an aeromedical retrieval flight, with a doctor and flight nurse on board. The weight of the aircraft was just under the maximum permitted take-off weight. The weather conditions were fine and clear, with a light breeze from the north-east.

The pilot positioned the aircraft at the intersection of taxiways U1 and E2 to complete pre-flight run-up checklist procedures. During the first flight of the day, the operator's run-up checklist procedures included a check to confirm that the wing and horizontal stabiliser de-ice system was serviceable. The wing and horizontal stabiliser de-ice system includes pneumatically inflatable boots fitted to the leading edges of those surfaces (see later description for more detail). The pilot recalled that all run-up checks were normal, including the wing and horizontal stabiliser de-ice system check. Following completion of the run-up checklist procedures, the pilot taxied to the holding point on taxiway E2 before departing from that intersection on runway 11 (Figure 1).

Figure 1: Excerpt from Darwin Airport aerodrome chart showing the approximate location where run-up checklist procedures were carried out and the intersection from which the aircraft commenced take-off



Source: Airservices Australia, additions by the ATSB

The take-off was initiated with the flaps retracted, consistent with the operator's normal procedures for a take-off under the prevailing conditions. The take-off proceeded normally up to the point that the aircraft reached decision speed[1] and the pilot rotated the aircraft to the take-off pitch attitude. At that point, the pilot noticed that the aircraft did not 'unstick'[2] as readily as normally

1 Decision speed is the maximum speed at which a decision to reject the take-off can be made. Rejecting a take-off after having accelerated through the decision speed may result in over-running the runway.

2 Unstick is a term used to describe the point at which the aircraft lifts off the surface of the runway.

expected. At about the same time, the pilot recalled that the stall warning horn sounded.[3] The pilot continued with the take-off and the aircraft lifted off, but it was not climbing or accelerating as efficiently as normal. Despite the relatively poor performance, the pilot was able to build speed slowly by holding the aircraft in ground effect.[4]

After achieving a positive rate of climb, the pilot retracted the landing gear. As the aircraft continued a shallow climb, the pilot carefully balanced airspeed and rate of climb as the stall warning horn continued to sound intermittently. After passing about 200 ft above ground level, the pilot was able to reduce the pitch attitude to allow the aircraft to accelerate further. Beyond that point, the stall warning horn no longer sounded.

Satisfied that the aircraft had reached a safe altitude, the pilot inspected the wings in an attempt to ascertain the reason for the poor take-off performance and stall warning. At that point, the pilot noticed that the right wing de-ice boots appeared to be inflated. Due to the position of the sun, the pilot was unable to immediately ascertain if the boots on the left wing were also inflated. Nonetheless, the pilot was confident that the inflated condition of the wing de-ice boot (or boots) explained the poor performance and stall warning. The pilot immediately cycled the wing and horizontal stabiliser de-ice system control switch in an attempt to deflate the boots, but cycling the switch appeared to have no effect.

As the aircraft continued to accelerate, the pilot noticed that aileron control forces were abnormally light. The pilot surmised that light aileron control forces were the result of a disturbance in the airflow over the wing associated with the inflated leading edge de-ice boot (or boots). As the aircraft turned and its orientation changed with respect to the position of the sun, the pilot was able to clearly see that the boots on the left wing were also inflated.

The pilot advised air traffic control that a return to Darwin was necessary. Air traffic control initially asked the pilot if runway 36 was acceptable, but uncertain about aircraft performance and noting a crosswind on runway 36, the pilot indicated a preference for runway 11 (runway 11 is substantially longer than runway 36). The pilot was subsequently cleared by air traffic control to make a circuit for runway 11.

Given concerns regarding aircraft performance and control, the pilot elected to land with approach flap[5] selected, and added 20 kt to the approach reference speed. Making the approach at this speed allowed the pilot to comply with the operator's stabilised approach criteria, while providing increased confidence with respect to aircraft performance and controllability.

The pilot had no difficulty handling the aircraft during the circuit and landing, but noted that substantially more power than normal was required to hold the desired speed. The stall warning horn remained silent throughout the approach and landing. The pilot landed without further incident and taxied to the aircraft parking position. The wing de-ice boots remained inflated until the engines were shut down.

Subsequent inspection by engineering staff found that the wing de-ice boots inflated again during an engine ground run, without having been selected. The boots returned to normal operation when the wing and horizontal stabiliser de-ice system control switch was cycled.[6] Numerous subsequent system tests (in accordance with the relevant maintenance manual) found that the wing and horizontal stabiliser de-ice system functioned normally, and the aircraft was returned to service. The operator also advised CASA of the occurrence.

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3 The stall warning horn sounds to warn the pilot of an impending stall. The horn is triggered by a transducer vane fitted to the leading edge of the left wing. Angle of attack information from the transducer vane and flap position signals are processed by a computer that sounds the warning horn.

4 Ground effect is the term used to describe the improved performance of a wing experienced when an aircraft flies close to the ground, associated with the modification in airflow caused by the ground.

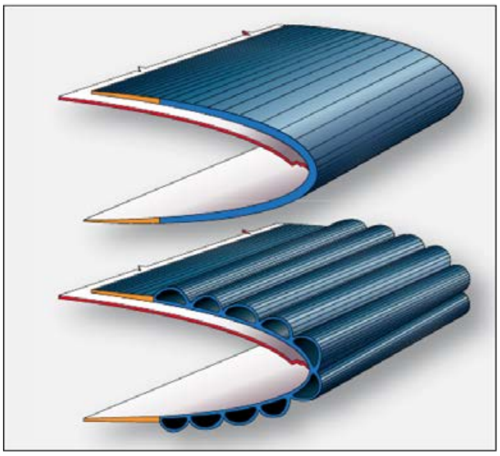
5 Approach flap is an intermediate flap setting often used for landing where runway length permits.

6 Engineering inspection also confirmed that only the wing de-ice boots had remained inflated, not the boots fitted to the leading edge of the horizontal stabiliser.

Raytheon B200 wing and horizontal stabiliser de-ice system

On the Raytheon B200, the leading edge of the wings and the horizontal stabiliser can be protected from an accumulation of ice by inflatable boots. The wing has an inner boot between the fuselage and engine nacelle, and an outer boot that extends from outboard of the engine nacelle. The boots are normally held down by a vacuum, and only inflated when an appropriate selection is made by the pilot. The boots are inflated by pneumatic pressure, and expand in a manner intended to shed any accumulated ice (Figures 2 and 3). Regulated high-pressure engine bleed air supplies pressure and a vacuum source for the wing and horizontal stabiliser de-ice system.

Figure 2: Pneumatic leading edge de-ice boot (representation) in the normal (deflated) condition and the inflated condition



Upper illustration shows leading edge boot held against the leading edge contour (normal in-flight condition). Lower illustration shows leading edge boot in an inflated condition, typically held in that position for a short time only, to remove an accumulation of ice.

Source: FAA, description added by the ATSB

Figure 3: Inflated Raytheon B200 wing leading edge de-ice boot

Source: Aircraft operator

The wing and horizontal stabiliser de-ice boots are operated by a three-position switch, spring-loaded to the centre OFF position (Figure 4). When the switch is selected to the DEICE CYCLE SINGLE (up) position, the wing boots are inflated for 6 seconds, followed by the horizontal stabiliser boots, which are inflated for 4 seconds to complete the cycle. The switch must be selected up again to commence another cycle. When the switch is selected to the MANUAL (down) position, the wing and horizontal stabiliser boots inflate simultaneously, and remain inflated while the switch is held in the MANUAL position. When the switch is released back to the centre OFF position, the boots deflate.

Figure 4: Raytheon B200 ice protection panel (typical) – wing and horizontal stabilizer de-ice control switch highlighted

Source: FAA

Apart from a visual inspection of the de-ice boots, there are no direct indications of the status of the boots available to the pilot. Aircraft pneumatic system gauges provide an indirect indication of boot function by indicating a momentary reduction in pneumatic pressure (and momentary needle movement on the gyro suction gauge) as pressure is redirected, but there is nothing that directly alerts the pilot to an inflated boot condition.

Where required by the operator's checklist procedures, the wing and horizontal stabiliser de-ice system is checked by selecting the switch to the up position, and monitoring pneumatic pressure (momentary decrease) and boot inflation for a single cycle. The switch is then held in the down position to check system operation in the manual mode, again expecting the boots to inflate with a corresponding momentary decrease in pneumatic pressure.

The aircraft flight manual includes a warning to pilots not to cycle the de-ice boots during take-off. The manual does not expand on the reasons for the warning, but it probably relates substantially to degradation in the aerodynamic qualities of the wing and horizontal stabiliser associated with inflated leading edge boots, and the associated impact on aircraft performance and control.

Pilot comments

The pilot believed that the wing de-ice boots probably remained inflated following the wing and horizontal stabiliser de-ice system check, and that the inflated condition of the boots went unnoticed following the check. The pilot could recall completing the checklist procedures as normal, by monitoring the pneumatic pressure gauges and the status of the wing boots during the check, but not specifically confirming that the wing boots had deflated following the check. The pilot also noted that even though the checklist procedure did not specifically call for confirmation that the wing de-ice boots had deflated following the check, it was normal practise to check them.

The pilot also commented that if the wing de-ice boots did remain inflated following the wing and horizontal stabiliser de-ice system check, a number of circumstantial factors may have increased the likelihood that their inflated condition went unnoticed. These factors included:

- The orientation of the aircraft with respect to the position of the sun (at the time the checks were completed) was such that the status of the wing de-ice boots may not have been readily apparent without a concentrated inspection.
- The taxi from the point where the pilot completed the run-up checklist procedures to the holding point of the runway was relatively short (see Figure 1). A short taxi following the run-up

checks reduced the likelihood that inflated wing de-ice boots would have been noticed during a normal lookout while taxiing.

- Flying conditions were such that it was unlikely that the wing and horizontal stabiliser de-ice system would be required during the flight. This may have reduced the intensity of the pilot's focus on the wing and horizontal stabiliser de-ice system check, and reduced the likelihood that the inflated condition of the wing de-ice boots would be noticed at the completion of the check.

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 that following this incident, the operator issued a safety bulletin to company B200 pilots, drawing their attention to the incident and highlighting the importance of checking that the wing de-ice boots deflate following a cycle of the de-ice system.

Safety message

Pilots operating Raytheon B200 or similar aircraft, fitted with pneumatic wing and horizontal stabiliser de-ice boots, are encouraged to take particular care when inspecting the boots during the system function check. Pilots are cautioned that the status of the boots may not be immediately obvious under some conditions, and that a concentrated inspection may be necessary. This may require the assistance of an external observer to assist with monitoring the status of the de-ice boots, particularly the boots fitted to the leading edge of the horizontal stabiliser which may not be visible from the cockpit.

Any aerofoil leading edge contamination, damage or distortion has the potential to significantly adversely affect aircraft performance and handling qualities, and aerodynamic stall characteristics. This incident highlights the significance of the manufacturer's warning not to cycle the de-ice boots during take-off.

General details

Occurrence details

Date and time:	17 May 2015 – 1315 CST	
Occurrence category:	Serious incident	
Primary occurrence type:	Stall warning event	
Location:	Darwin Airport, Northern Territory	
	Latitude: 12° 24.9' S	Longitude: 130° 52.6' E

Aircraft details

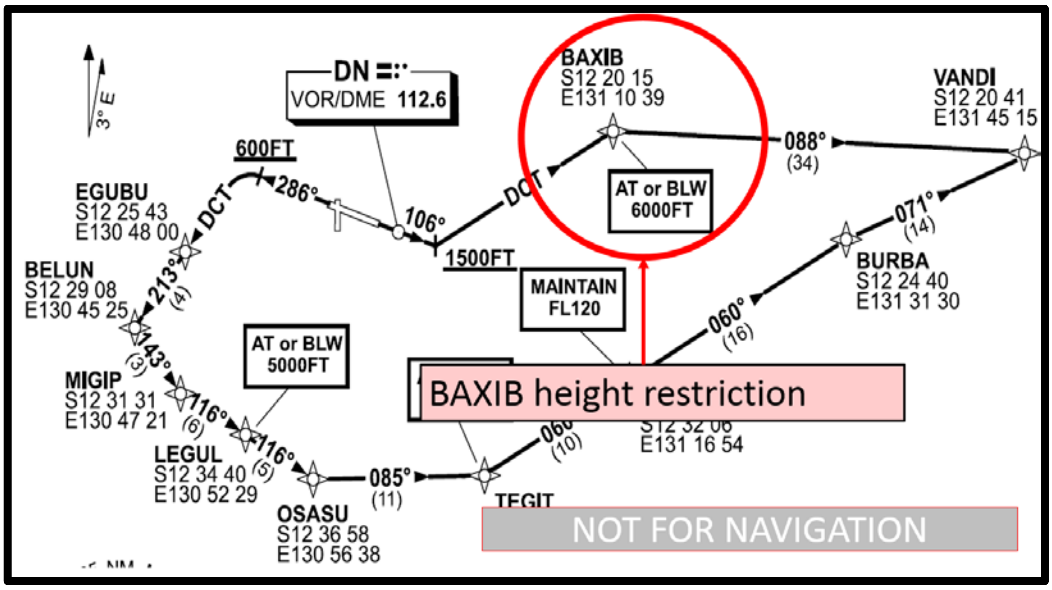
Manufacturer and model:	Raytheon Aircraft Company	
Registration:	VH-ZCO	
Serial number:	BB-1955	
Type of operation:	Aerial work	
Persons on board:	Crew – 3	Passengers – Nil
Injuries:	Crew – Nil	Passengers – Nil
Damage:	None	

Loss of separation involving a Cessna 441, VH-JLT, and a Raytheon B200, VH-ZCJ

What happened

On 10 June 2015, the pilot of a Cessna 441 aircraft, registered VH-JLT (JLT), conducted pre-flight preparations for a charter flight from Darwin to Oenpelli, Northern Territory with 6 passengers. The pilot planned to track direct to Oenpelli, but on requesting an airways clearance, was advised by the clearance delivery controller that there was a requirement to plan via the VANDI ONE standard instrument departure (SID) (Figure 1). The pilot then reviewed the SID chart and noted the left turn on departure and the height limit of 6,000 ft at waypoint BAXIB. The pilot wrote '6,000' on the navigation log. As part of the airways clearance issued to JLT, the pilot was initially issued a clearance to climb to 3,000 ft. The pilot entered '3000' into the aircraft's altitude alerter.

Figure 1: Extract of VANDI ONE SID



Source: Airservices Australia – annotated by the ATSB

At about 0856 Central Standard Time (CST), a Raytheon B200 aircraft, registered VH-ZCJ (ZCJ), operating an aeromedical flight with a pilot, a flight nurse and four passengers on board, was approaching Darwin from Elcho Island, Northern Territory, on the GATOR THREE A standard arrival route (STAR) (Figure 2). The pilot had been advised to expect track shortening and a visual approach to runway 11. At 0856:16, the Darwin approach controller cleared ZCJ to descend to 7,000 ft.[1]

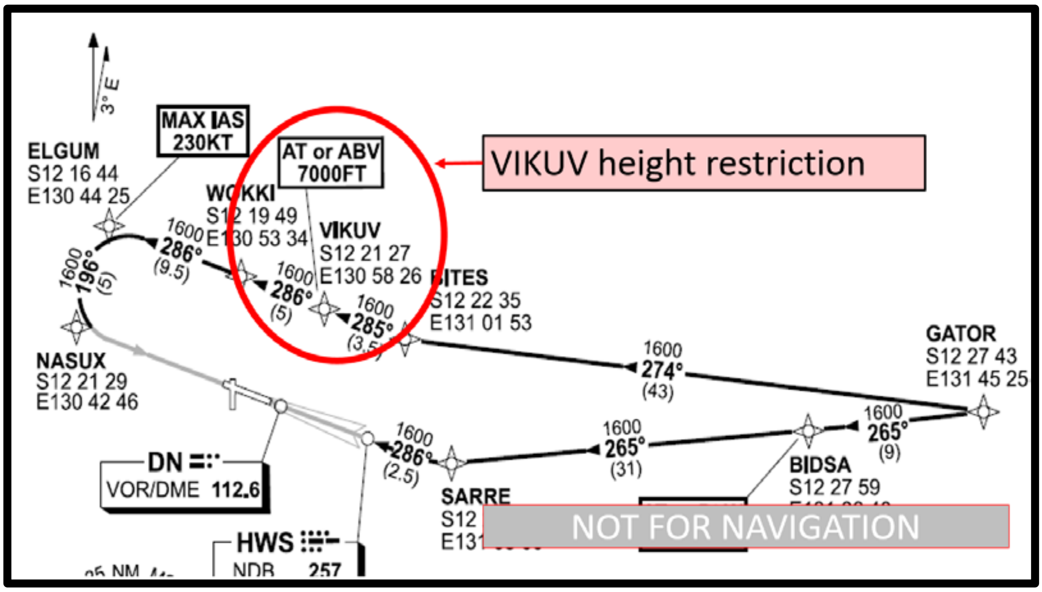
At about 0859, JLT took off. The pilot conducted a left turn as required by the SID, and the Tower controller directed the pilot to contact Approach. At 0859:52, the pilot of JLT contacted the approach controller and advised that they were conducting a VANDI SID, and passing 1,000 ft on climb to 3,000 ft. About 20 seconds later, the pilot of ZCJ reported that they were visual and were then passing about 8,400 ft on descent.

[1] The Australian Defence Force provides the air traffic control services in Darwin.

At 0900:44, the approach controller cleared JLT to climb to flight level (FL) 130.[2] The pilot then selected 13,000 in the altitude alerter. The controller did not cancel any requirements, hence JLT was still required to be at or below 6,000 ft at waypoint BAXIB in accordance with the SID. Shortly after that communication, the pilot of JLT inadvertently selected Brisbane Centre frequency (on COM1), and was no longer able to hear Darwin Approach frequency.

At 0901:00, the approach controller cleared ZCJ, which was then passing about 7,700 ft, to descend to 3,000 ft. In accordance with the STAR, that could only be complied with after passing waypoint VIKUV at or above the 7,000 ft height restriction published for that point on the STAR.

Figure 2: Extract of GATOR THREE A STAR



Source: Airservices Australia – annotated by the ATSB

About 13 seconds later, the approach controller observed ZCJ approaching 7,000 ft. The controller asked the pilot of ZCJ to confirm they were aware that the level restriction at VIKUV still applied, and to expect track shortening after VIKUV. The pilot responded ‘roger’. The radar display indicated the aircraft then descended below 7,000 ft to 6,800 ft, which was still within the specified tolerances (+/- 200 ft) of the level restriction. At 0901:41, the radar display showed the ZCJ at 6,700 ft, and the controller asked the pilot to confirm they were maintaining 7,000 ft, and the pilot responded ‘affirm’.[3] JLT was then about 11 NM away, and there was still about 3,100 ft vertical separation between the aircraft at that time.

At about 0902, ZCJ was approaching waypoint BITES at 7,000 ft, JLT was at 5,000 ft and the aircraft were about 6 NM apart (Figure 3). The controller then issued JLT as traffic to the pilot of ZCJ, and advised that JLT had been assigned FL130 and had a 6,000 ft requirement at BAXIB. The pilot of ZCJ acknowledged the traffic and could see it on the aircraft’s traffic collision avoidance system (TCAS). The pilot of JLT did not hear that communication as they were not listening on the approach frequency at that time.

2 In Australia, altitudes below 10,000 ft are reference the local or area QNH and are referred to as feet (ft). When operating at altitudes above 10,000 ft an aircraft’s height above mean sea level is referred to as a flight level (FL) and is reference a standard pressure setting of 1013.2 HPa.

3 The radar has a predictive capability due to a 5 second refresh rate so if an aircraft is approaching an assigned altitude with a high rate of descent the radar read out will effectively ‘predict’ the attitude in five seconds time. The pilot reported the aircraft indicated about 6,900 ft, but the radar indicated 6,700 ft.

At 0902:41, as the two aircraft converged, an Australian Defence Air Traffic System (ADATS) predicted conflict alert (PCA) activated on the controller's situational display (Figure 4). The controller advised the supervisor, as required following a PCA activation, that vertical navigation 'strategic' separation was in place (see right). JLT was then at 6,100 ft, above the level restriction of 6,000 ft, and ZCJ at 7,000 ft with less than 2 NM between the aircraft. At 0903:07, 1.6 NM and 800 ft existed between the aircraft, and the pilot of ZCJ reported that they had JLT in sight. The approach controller confirmed that the pilot of ZCJ was able to maintain separation with JLT. The pilot of ZCJ then received a TCAS 'TRAFFIC TRAFFIC' alert and disconnected the autopilot in anticipation of taking avoiding action. The approach controller quickly attempted to contact JLT, advising that ZCJ was maintaining separation with them and to confirm they were complying with the level restriction, but did not receive a reply; JLT continued to climb. The controller then advised the pilot of ZCJ that the aircraft had climbed through the 6,000 ft level restriction and issued a requirement to the pilot of ZCJ to maintain separation with that aircraft. By the time the controller had completed that transmission, the two aircraft had passed. The approach controller then cancelled ZCJ's level restrictions, and cleared the aircraft to descend to 4,000 ft. ZCJ continued to descend in accordance with the STAR route and the pilot did not take any avoiding action.

At 0903:36, the approach controller again called JLT and received no response. At 0903:55, the approach controller received an ADATS conflict alert (CA), with the closest proximity according to the radar reducing to 400 ft vertically and 0.3 NM between the two aircraft. The pilot of ZCJ estimated the proximity between the aircraft to be about 200 ft vertically and 100-200 m horizontally. The controller stated that 'surveillance passing' separation standard was in place (see right). .

The pilot of JLT sighted ZCJ slightly above, to their left, and closer than normal. The pilot realised the radio was selected to Brisbane Centre frequency and switched it to the Darwin Approach frequency. After two more unsuccessful attempts to contact JLT on the Darwin frequency, Brisbane Centre advised the controller that JLT was with them. The pilot of JLT, then back on Darwin Approach frequency, asked the approach controller whether they had been trying to contact them. The approach controller advised the pilot that the aircraft had climbed through a level restriction, and the pilot asked the controller to confirm they had been cleared to FL130. The controller said yes, but in accordance with the SID. The controller then handed JLT off to Brisbane Centre. ZCJ landed on runway 11 without further incident.

Separation Standards

According to the Manual of Air Traffic Services (MATS), separation is the concept of ensuring aircraft maintain a prescribed minimum from another aircraft (or object), whilst meeting the associated conditions, and requirements of the standard. A separation standard is a prescribed means to ensure separation between aircraft using longitudinal, lateral, vertical and visual standards.

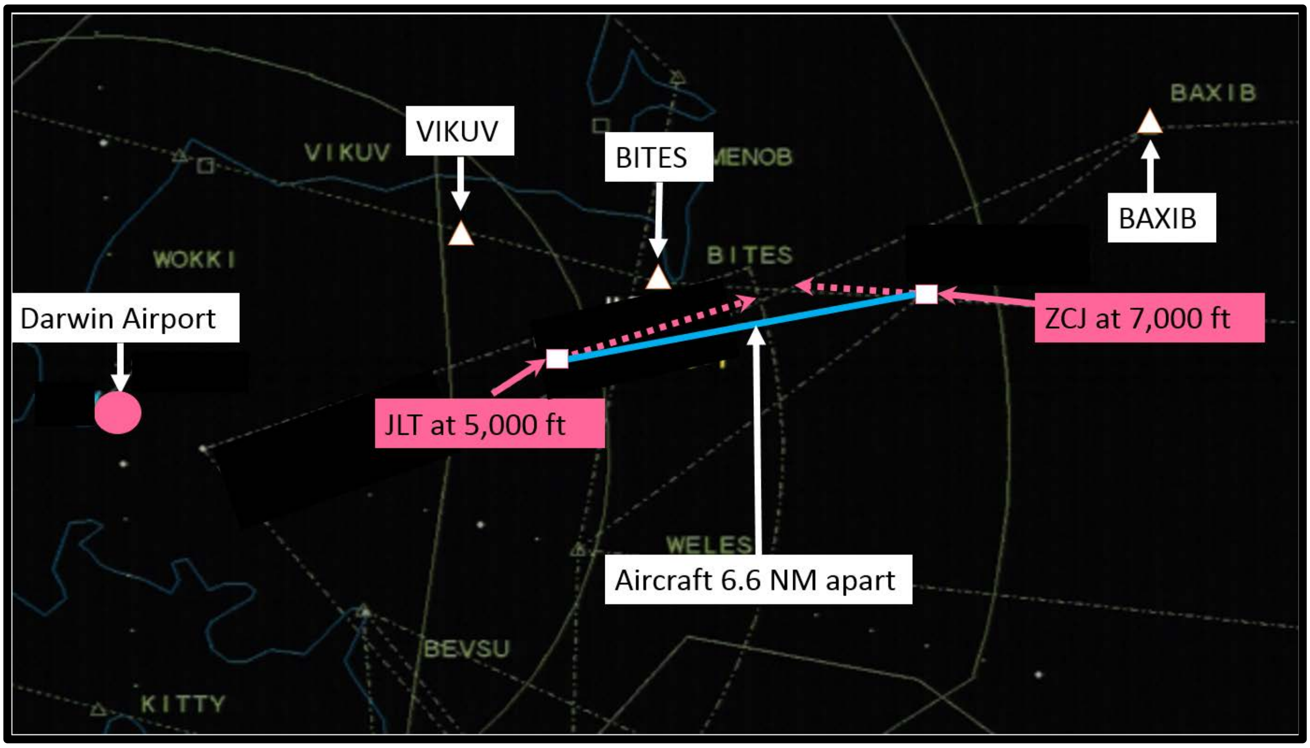
Strategic Separation

Strategic separation is achieved by designing flight paths that minimise conflictions between arriving and departing aircraft. Tactical separation is achieved by changing an aircraft's speed, altitude or direction, including requiring aircraft to proceed at specific times to preserve separation.

Surveillance Passing

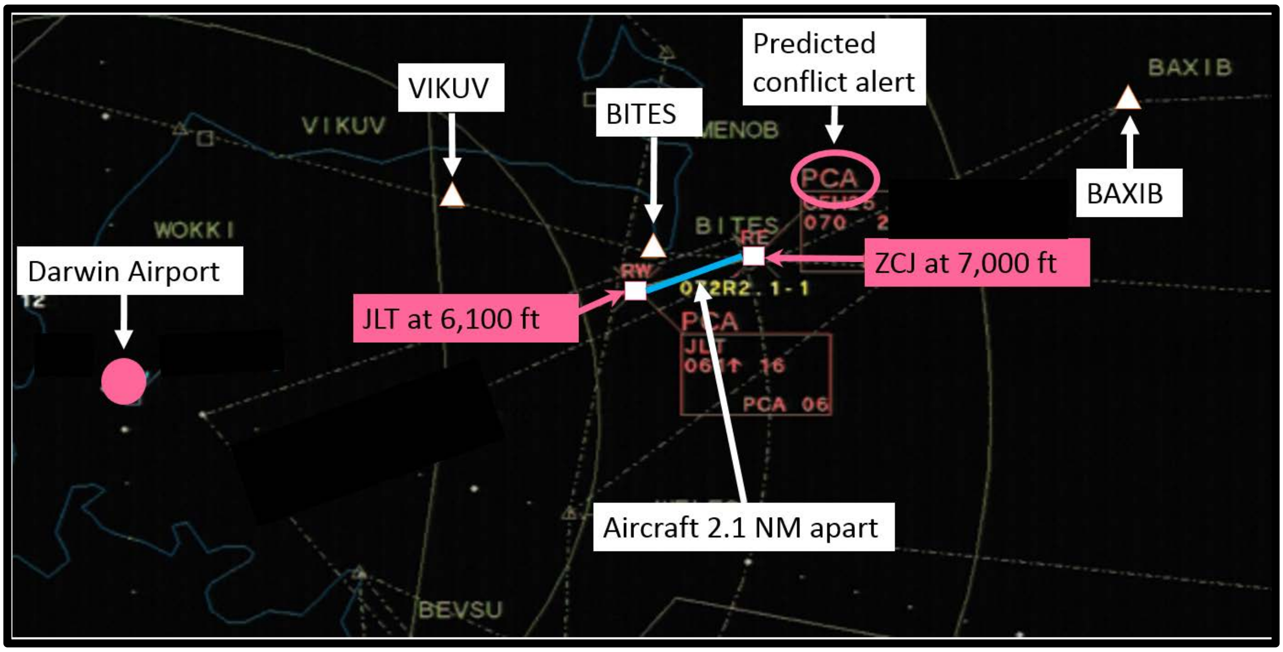
The 'surveillance passing' standard applies to aircraft on reciprocal tracks (within 45° of each other's track), when aircraft are observed by an air traffic surveillance system to have definitely passed and their position symbols are not touching.

Figure 3: Situation display showing JLT at 5,000 ft and ZCJ at 7,000 ft



Source: Defence air traffic control – annotated by the ATSB

Figure 4: Situation display showing the predicted conflict alert, with JLT at 6,100 ft and ZCJ at 7,000 ft



Source: Defence air traffic control – annotated by the ATSB

New traffic management plan (TMP) for Darwin Airport

A new traffic management plan (TMP) for Darwin Airport came into effect on 28 May 2015. This was the result of about two years of design and development, and included consultation with industry. Traffic management planning regulates the flight profiles of arriving and departing aircraft to improve the traffic flow. The new procedures consisted of a number of vertical navigation requirements, with intermediate level restrictions. Several notices to airmen (NOTAMs) were promulgated by Airservices Australia advising of the new TMP, commencing in December 2014. Local operators were asked to provide feedback on the plan.

An Airservices Air Traffic Management (ATM) specialist reported that the new TMP was based on fulfilling a requirement from the Civil Aviation Safety Authority (CASA) to reduce controller workload. Removing the need to assign levels to each aircraft, also reduces the number of radio transmissions. The new procedures meant that the controllers would not be required to issue as much tactical separation, as the new procedures provided strategic separation. The TMP was designed to be of most benefit during busy periods, when Darwin can have up to 45 aircraft on frequency at the same time, including military jet aircraft. Controllers would then have more time to process and communicate with aircraft that are not captured in the TMP.

Since the implementation of the new plan, there had been a significant number of non-compliance events with the vertical navigation requirements. Darwin was one of the few airports in Australia with vertical navigation requirements on SIDs and STARs, and has more of them than any other airport in Australia.

Controller comments

The approach controller provided the following comments:

- The duty runway was runway 11.
- In accordance with the TMP, ZCJ was inbound on the GATOR THREE STAR, and JLT outbound on the VANDI ONE SID. With the vertical requirement for that STAR and SID, there was a 1,000 ft buffer between the planned routes of the two aircraft.
- All communications and clearances were issued in accordance with the current Airservices Australia Aeronautical Information Package (AIP). Phraseology published in the AIP refers to cancellation of STAR level restrictions but not SID level restrictions. Consequently, the controllers had been advised to cancel the waypoint level restriction on a SID using the phrase, for example, ‘cancel BAXIB level restriction’.
- The new TMP included changes to the departure and approach procedures design and charts, radiotelephony, and was a significant change to the airspace and their mode of operations. The controllers had been directed to issue full climb and descent clearances, which was consistent with Airservices operations in other locations where intermediate level restrictions existed.
- The controller did not, and was not required to issue a safety alert to ZCJ, and believed that to do so would increase risk. The controller did not issue a safety alert to JLT and assigned separation responsibility to the pilot of ZCJ. The pilot of ZCJ had JLT in sight and if the controller had issued a heading or climb instruction to the pilot of ZCJ, the pilot may have looked inside at the instruments to follow the instruction, instead of keeping JLT in sight.
- The controller’s initial response was to attempt to communicate with the pilot of JLT and confirm they were maintaining 6,000 ft, but the pilot did not respond. The controller wanted to issue a safety alert to the pilot of JLT as they had not been issued ZCJ as traffic. However, on receiving no response from the pilot of JLT, the controller immediately assigned safety recovery to ZCJ, and then confirmed the aircraft had passed each other.
- The controller was also the senior training officer in Darwin, and because of the significant number of VNAV restrictions in the new TMP, the controller created maps and diagrams, and clearly depicted the restrictions on SIDs and STARs, and placed them on the console as a situational awareness tool for the controllers.
- Prior to a controller operating under the new TMP, they had completed two simulator sessions. The scenarios included common and predicted conflictions and multiple aircraft not tracking via SIDs and STARs, and aircraft not in compliance with the TMP requirements.

Immediate actions

Following the incident, the pilots of both aircraft participated in a briefing with the controllers. They viewed the radar tapes and discussed the TMP. The aim was to educate the pilots, as local operators, and discuss the TMP with the aim to prevent further incidents from occurring.

The operator of JLT attended this briefing. They were surprised that the controllers had assumed the Cessna 441 was equipped with a traffic collision avoidance system (TCAS) and a flight management system (FMS). It was not fitted with either. The operator also stated that the same applies to most of the general aviation aircraft operating in and out of Darwin Airport.

Pilot comments

Pilot of VH-JLT

The pilot of JLT provided the following comments:

- The pilot should have reviewed the en route section of the Jeppesen for the planning. The new Jeppesen charts only arrived the day before the new TMP came into effect.
- The Planner advised that four other pilots had also flight planned direct to Oenpelli that morning (instead of via the VANDI ONE SID).
- They had never had altitude restrictions before on the SIDs. It was the first time the pilot had ever been cleared to an altitude above a level restriction. The STARs have intermediate level restrictions, but prior to the new TMP, the pilot had only ever been cleared to an altitude lower than the restriction when also cancelling the height restriction (for example ‘descend to 4,000 cancel STAR level restriction’).

Pilot of VH-ZCJ

The pilot of ZCJ stated that the flight management system (FMS) calculated the top of descent point based on the track of the STAR. As the pilot had been advised to expect track shortening and a visual approach, they had to commence the descent earlier. The aircraft was slightly above the normal approach path and at a slightly higher rate of descent than normal, when approaching 7,000 ft. The pilot had vertical navigation (VNAV) mode selected, with VPATH in the flight mode annunciator, and ALTV armed, therefore the FMS follows the STAR profile programmed and captured the approach level restriction (of 7,000 ft).

In addition, the pilot commented that the company had sent emails and a flight operations notice to company flight crew highlighting the changes and new procedures for Darwin, prior to the commencement of the new TMP. There were NOTAMs issued months beforehand about the new SIDs and STARs to ensure the pilots were aware of the new procedures.

Operator comments – operator of VH-JLT

The operator of JLT advised that the auto-flight system of JLT was unserviceable on the incident flight. That unserviceability led to increased pilot workload, therefore reducing the pilot’s spare capacity to maintain situational awareness.

The operator believed that the change management process prior to the airspace changes was insufficient. The number of incidents that occurred immediately following the implementation of the new TMP supported that belief. The operator suggested that face-to-face briefings with the local pilots would have been more effective than just issuing NOTAMs.

The Jeppesen Charts with the new procedures were only released the day before the changes were implemented. Additionally, the associated GPS software was not available until 10 hours after the new procedures commenced at midnight.

Safety actions

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 actions in response to this occurrence.

Aircraft operator – VH-ZCJ

As a result of this occurrence, the operator of ZCJ has advised the ATSB that they have taken the following safety actions:

Education email from Defence air traffic control (ATC)

An email from Defence ATC was sent by CASA to the operator of ZCJ, who then distributed the email to company pilots operating out of Darwin. The email advised that since the new TMP came into effect on 28 May, there had been nine occurrences of pilots failing to comply with the VNAV requirements of the SIDs and STARs. The email directed pilots to the relevant sections of the AIP. These stated that when ATC issues climb clearances to an aircraft on a SID, or descent clearances to an aircraft on a STAR, the aircraft must comply with all level restrictions or requirements published on the SID or STAR charts unless ATC explicitly cancels the restrictions or requirements.

Safety bulletin

A safety bulletin was issued to all flight crew operating out of Darwin. The bulletin advised flight crew of the recent violations of SID and STAR altitude restrictions under the new TMP. Pilots were reminded to maintain extra vigilance and situational awareness while briefing and approaching the new level restrictions. The bulletin noted that as evidenced by this incident, other aircraft may not comply with the restrictions. Flight crew were directed to engage VNAV with active vertical mode where available. In aircraft without VNAV capability, the Altitude Selector was to be set to the limiting altitude and the cleared level written down until the SID or STAR restriction had been passed.

Critical to Safety Operations notice

A ‘Critical to Safety Operations’ notice was issued to all flight crew operating out of Darwin. The notice reiterated the need to comply with level restrictions unless explicitly cancelled. The notice also provided directives regarding the use of VNAV and the FMS to conduct SIDs and STARs in Darwin.

Flight operations manual update

The Flight operations manual is being updated with further guidance on the new Darwin procedures.

Local airspace briefing

The local airspace briefing presentation for new pilots has been updated to incorporate the new Darwin TMP procedures.

Aircraft operator – VH-JLT

As a result of this occurrence, the operator of JLT has advised the ATSB that they are taking the following safety actions:

Training information for flight crew

Company flight crew have been reminded of the importance of adhering to standard operating procedures and regulatory requirements.

Traffic control facility training

The operator will participate in training sessions in the Air Traffic Control Facility with Defence ATC Darwin, to develop understanding of the issues that flight crew and air traffic control personnel identify with the airspace.

Safety newsletter

A safety newsletter will be sent to all company flight crew to remind them of the importance of understanding the SID and STAR chart requirements.

Air traffic control

New procedure implemented

With immediate effect, Darwin ATC implemented a new procedure following this incident. If a VNAV restriction is in place and one aircraft has not complied, the controller is to immediately resort to tactical separation until that confliction is cleared.

Training and awareness

Materials designed to enhance awareness of the requirements and implications of the new traffic management plan will be promulgated to local aviation operators.

Incident briefings

Defence ATC provided briefings with other local operators at the ATC Facility showing this incident, discussing the TMP and the need for compliance of VNAV on the SID's and STARs.

Safety message

For controllers, this incident highlights the need to monitor aircraft after issuing a full climb or descent, where an intermediate level restriction applies. If an aircraft appears not to be complying with a level restriction, apply tactical separation.

For pilots, this incident provides a reminder to become familiar with published standard departure and arrival procedures and charts, particularly those with intermediate level restrictions, and the associated phraseology used by air traffic controllers and pilots.

General details

Occurrence details

Date and time:	10 June 2015 – 0910 CST	
Occurrence category:	Incident	
Primary occurrence type:	Loss of separation	
Location:	near Darwin Airport, Northern Territory	
	Latitude: 12° 24.88' S	Longitude: 130° 52.60' E

Aircraft details: VH-JLT

Manufacturer and model:	Cessna Aircraft Company, 441	
Registration:	VH-JLT	
Serial number:	441-0138	
Type of operation:	Charter – Passenger	
Persons on board:	Crew – 1	Passengers – 6
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Nil	

Aircraft details: VH-ZCJ

Manufacturer and model:	Raytheon Aircraft Company, B200	
Registration:	VH-ZCJ	
Serial number:	BB-1853	
Type of operation:	Aerial Work – EMS	
Persons on board:	Crew – 2 (1 Pilot, 1 Flight nurse)	Passengers – 4
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Nil	

Piston aircraft

Fuel starvation event involving a Cessna 210, VH-BKD

What happened

On 3 May 2015, at about 0230 Central Standard Time (CST), a Cessna 210 aircraft, registered VH-BKD (BKD), departed from Alice Springs Airport, Northern Territory for a ferry flight to Broome, Western Australia. The pilot was the sole person on board.

At about 70 NM from Broome, the pilot obtained a weather report from the automated aerodrome weather information service (AWIS) located at Broome Airport. The AWIS indicated a dewpoint[1] of 22 °C and an ambient temperature of 22° C, which indicated conditions suitable for the development of fog.

The pilot reported that the AWIS information prompted them to start considering alternatives should fog prevent a landing. The pilot had planned and flown BKD at the optimum endurance profile of 45% power[2] and changed tanks[3] on a regular time-based pattern. The pilot reviewed the fuel log and determined they had sufficient fuel for a 30-minute search for a suitable break in the fog. If unsuccessful, the pilot planned to turn back inland on a reciprocal to the inbound track and land on the highway.

At about 15 NM from Broome, the pilot observed the start of a thick layer of fog below the aircraft. Arriving overhead Broome Airport at about 0622 Western Standard Time (WST), with the right fuel tank selected, the pilot initially surveyed the area from about 1,000 ft above ground level. However, as there were no breaks in the fog, the pilot descended the aircraft to about 650 ft. The pilot kept the aircraft in visual conditions while circling the airport and Cable Beach areas (Figure 1) occasionally flying at a lower level to take a closer look for possible breaks. With the right fuel tank still selected, the pilot's search continued for about forty-five minutes.

Figure 1: Broome Airport and accident site

Source: Google earth annotated by the ATSB

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1 Dewpoint is the temperature at which water vapour in the air starts to condense as the air cools. It is used among other things to monitor the risk of aircraft carburettor icing or likelihood of fog at an aerodrome.

2 Endurance power setting allows for the longest time in the air.

Deciding that landing was not possible until the fog lifted, the pilot sought assistance from the person waiting on the ground for the aircraft. As this person was local and understood the likely extent of the fog, they were able to offer the pilot two alternate airports, as options. The first option, Beagle Bay was about 62 NM to the north, and the second option Eco Beach, about 23 NM to the south. The pilot considered these options, but reasoned that with such widespread fog, these options may also be fog bound. With limited choices and now limited fuel, the pilot turned BKD for one last low-level check along runway 10. The pilot then initiated a climb with the intent of heading back to the highway to land.

Shortly after applying full power to initiate the climb, the aircraft's engine surged and spluttered. The pilot instantly realised that the right tank had been selected for over an hour, and quickly changed the fuel selector to the left tank. However, the engine did not respond. The pilot then attempted to restart the engine with the ignition key, but reported hearing a crunching noise as the starter motor engaged. The propeller was still windmilling.

With the aircraft only at about 500 ft and descending into the thick layer of fog, the pilot levelled the aircraft's wings and prepared for a forced landing. Electing to leave the undercarriage retracted, the pilot descended through the fog and noted the outline of a dirt track. The pilot attempted to land on the track, but the aircraft collided with the sandy terrain just prior to reaching it. The aircraft momentum allowed it to skid across the track, coming to rest in the mangroves a few metres on the other side (Figure 2 and 3). The accident site was located within the mangrove area of the Dampier Creek.

The pilot was not injured; however, the aircraft propeller and engine sustained substantial damage.

Figure 2: Initial contact point

Figure 3: VH-BKD in the mangroves

Source: WA Police (both figures)

Pilot experience and comments

The pilot had around 3,850 flying hours, with around 830 of those on Cessna 210 aircraft.

Pre-flight planning

The pilot elected to conduct the flight at night to increase their night command hours. The evening before the flight, the pilot checked the weather forecast and completed the flight plan. They noted a 30% probability of fog on the terminal area forecast (TAF) for Broome during the planned arrival time. However, the pilot reported that, in their experience, 30% probability of fog would mean non-existent or minimal impact on operations, so they did not consider or plan for any alternates

The pilot pre-flighted the aircraft in the morning prior to the 0230 departure.

The pilot had personal commitments in Broome that morning and back in Alice Springs the next day. Hence, they needed to deliver the aircraft in time to catch the lunchtime jet flight back from Broome to Darwin and eventually be back in Alice Springs the next morning.

The flight

The pilot made the following comments about the flight:

- the cruise level was 8,500 ft
- there was smooth conditions enroute but with a stronger headwind than forecast
- the flight time between Alice Springs and Broome was about 5 hours.

Fuel management

The pilot maintained a fuel log during the flight. They initially used fuel from the left tank for 30 minutes, then 60 minutes on the right, back to the left. The pilot continued using this pattern until they arrived overhead Broome.

Although the pilot had calculated there was sufficient fuel to search for a break in the fog for 30 minutes, once pressured and distracted looking for an expected opening to be able to land, the pilot reported flying in excess of 60 minutes with the right fuel tank selected.

The aircraft fuel tanks were dipped post- accident. The right tank had no fuel remaining while there was 45 L remaining in the left tank.

Aviation weather forecasts and alternate aerodrome requirements

The Aeronautical Information Publication Australia (AIP) ENR 1.1 87 details the following requirements concerning planning for alternate aerodromes:

> *A pilot in command must make provision for flight to an alternate aerodrome, when required, in accordance with the following paragraphs:*
>
> *…Except when operating an aircraft under the VFR by Day within 50NM of the point of departure, the pilot in command must provide for a suitable alternate aerodrome, when arrival at the destination will be during the currency of, or up to 30 minutes prior to the forecast commencement of, the following weather conditions:*
>
> *Cloud – more than SCT below the alternate minimum*
>
> *Visibility – less than the alternate minimum*
>
> *Visibility – greater than the alternate minimum, but the forecast is endorsed with a percentage probability of fog, mist, dust or any other phenomenon restricting visibility below the alternate minimum….*
>
> *Note: When weather conditions at the destination are forecast to be as above, but are expected to improve at a specific time, provision for an alternate aerodrome need not be made if sufficient fuel is carried to allow the aircraft to hold until that specified time plus 30 minutes.*

AIP GEN 3.5-7 explains that:

> *PROB% is used in terminal area forecasts (TAF) to indicate an expected 30 or 40% probability of occurrence. If greater than or equal to 50% probability is forecast, reference is made to the phenomenon in the forecast itself not by the addition of a PROB statement*

Safety message

The pilot had planned the flight using maximum endurance performance figures and kept a fuel log. The pilot's fuel management used a time-based system up until arriving overhead the destination. Due to the unexpected distraction and increased workload of arriving at the destination airport covered in thick fog, with no planned alternates, the pilot lost situational awareness of the aircraft's fuel state.

Issue number 5 in the ATSB's Avoidable Accident Series – *Starved and exhausted: Fuel management aviation accidents* looks in more detail at such scenarios. The report notes that fuel exhaustion is more likely to occur on flights when there is little flight fuel margin.

The *Avoidable Accidents* series is available on the ATSB website under the *Safety Awareness* tab at www.atsb.gov.au

The ATSB published a research report titled *Dangerous Distraction, an examination of aviation accidents and incidents involving pilot distraction in Australia between 1997 and 2004*, covers in detail the role of pilot distraction in a number of aircraft accidents.

The research looked closely at 325 occurrences involving some measure of pilot distraction. The researchers were able to develop a taxonomy of three major causes of distraction. They were 'flight management tasks', 'external objects', and 'people on board the aircraft'. The report concludes with a number of tentative suggestions for minimising the risk of pilot distraction. Further reading is available on the ATSB website.

Information regarding alternate aerodrome requirements is available in the Air Information Publication (AIP), ENR 1.1-87. This is available on the Airservices Australia website at www.airservicesaustralia.gov.au.

The Civil Aviation Safety Authority flight planning kit covers issues such as planning for alternates, obtaining local knowledge when flying to an unfamiliar destination and the importance of considering all aspects of the weather forecast.

This *Flight Planning Kit* is available from the online shop on the CASA website at www.casa.gov.au.

General details

Occurrence details

Date and time:	3 May 2015 – 0725 WST	
Occurrence category:	Accident	
Primary occurrence type:	Fuel starvation	
Location:	3 km east of Broome Airport, Western Australia	
	Latitude: 17° 56.80' S	Longitude: 122° 15.55' E

Aircraft details

Manufacturer and model:	Cessna Aircraft Company	
Registration:	VH-BKD	
Serial number:	21063127	
Type of operation:	Private	
Persons on board:	Crew – 1	Passengers – Nil
Injuries:	Crew – Nil	Passengers – N/A
Damage:	Substantial	

Smoke event involving a Cirrus SR22T, VH-EPG

What happened

VH-EPG

Source: Fly Cirrus

On 19 May 2015, the pilot of a Cirrus SR22T aircraft, registered VH-EPG (EPG), planned to conduct a flight from Moorabbin to Mildura, Victoria, under the instrument flight rules (IFR) with one passenger. At about 0812 Eastern Standard Time (EST), the aircraft departed Moorabbin Airport, and the pilot conducted a climb to flight level (FL) 180.[1] During the climb, the pilot selected the de-ice system on, which then remained on for about 20 minutes. After levelling off at FL180, the pilot switched off the de-ice system.

About 5 minutes later, the pilot received an 'ALT AIR OPEN' alert on the primary flight display (PFD). The alternate air caution indicated a blockage, probably due to ice, of the induction air intake to the engine. The alternate air then routed unfiltered air to the engine. Soon after the alert illuminated, light brown smoke entered the cabin through the cabin air vents. The pilot attempted to determine the source of the smoke. All engine parameters, exhaust gas, turbo and engine temperatures were normal, the electrical system was functioning normally and no circuit breakers had popped. The source of the smoke appeared to be forward of the engine panel, with no flames or external smoke visible.

The pilot assessed the probable cause of the smoke to be a turbocharger issue and elected to conduct a descent. The pilot also commenced preparations for a possible diversion to the nearest airport. At about 0848, the pilot requested a descent to FL140 and air traffic control (ATC) cleared the aircraft to descend to FL150, due to traffic. When the pilot reduced power for the descent, the smoke cleared. However, after reaching FL150, the pilot resumed cruise power and the smoke reappeared. This added to the pilot's assessment that there was a turbocharger leak. The Cirrus recommendation for a suspected turbocharger leak was to descend and land as soon as possible, which the pilot followed.

At about 0852, the pilot declared a PAN[2] and requested further descent and a diversion to Bendigo, Victoria. Passing FL140 on descent, the separation between EPG and a SAAB 340 aircraft was 4.2 NM. That distance was less than the required separation standard for that airspace, of 5 NM. The controller issued a turn to the SAAB to re-establish the required separation. The pilots of both aircraft were aware of each other.

During the descent, the smoke evaporated, but a moist brown residue was depositing on the windscreen reducing the visibility. To try to clear the windscreen, the pilot turned on the cabin heated air, and fan up to full ('3'). Turning on the cabin air had the effect of drawing in more contaminant, which was condensing and increasing the deposit on the windscreen.

The pilot selected the radio navigation (RNAV) global navigation satellite system (GNSS) approach to runway 17 at Bendigo Airport (Figure 1). They then conducted the descent and approach using the autopilot and the flight director. At about 0904, the aircraft turned left to track towards the initial approach fix for the RNAV approach procedure (Figure 2). The aerodrome

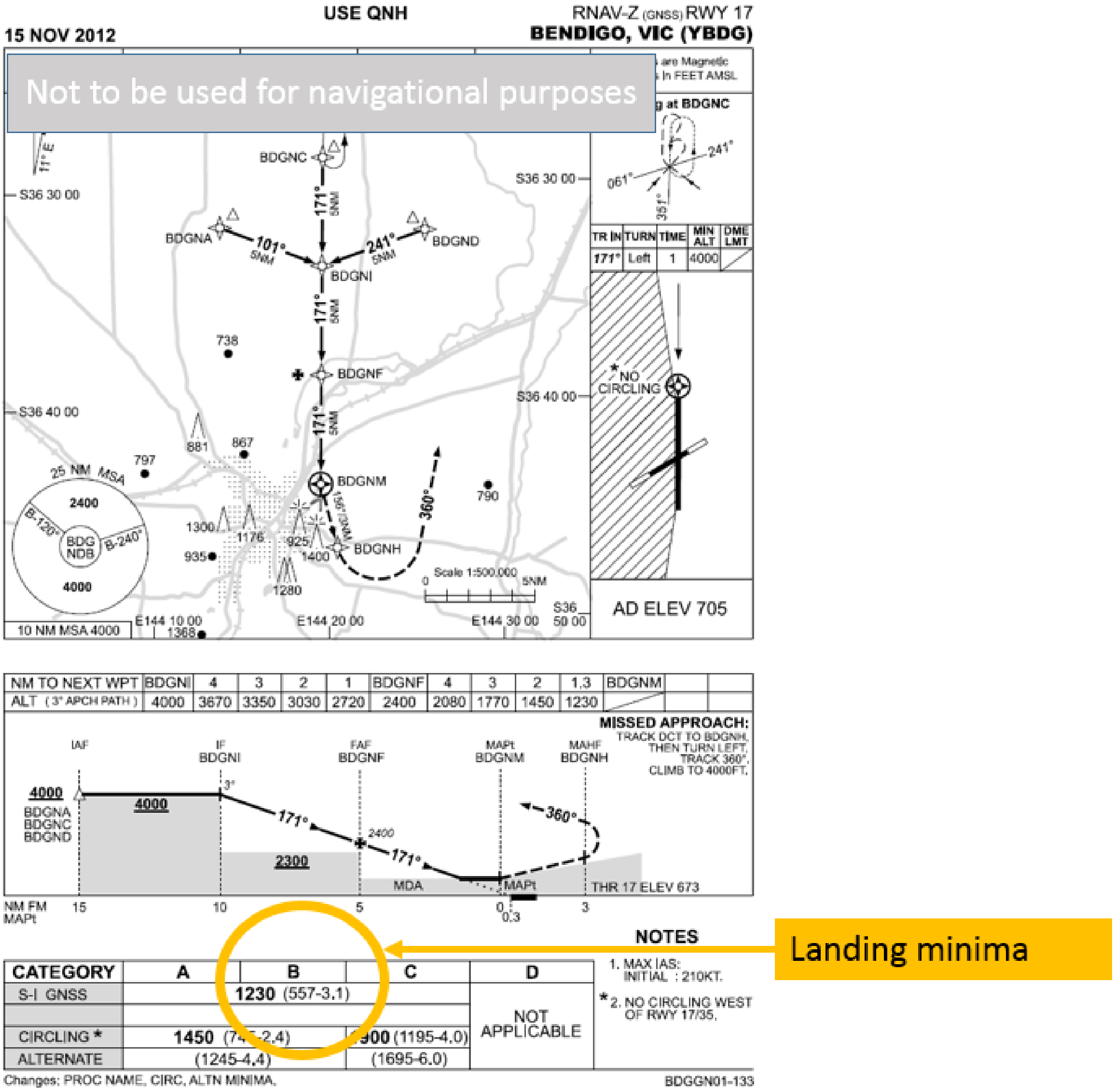
[1] At altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 180 equates to 18,000 ft.

[2] An internationally recognised radio call announcing an urgency condition which concerns the safety of an aircraft or its occupants but where the flight crew does not require immediate assistance.

weather information service (AWIS) at Bendigo was reporting cloud below the minima.[3] Despite the weather conditions, the pilot elected to continue the approach. The pilot based the decision to continue on their assessment of a turbocharger leak. The pilot also considered the smoke that increased with power increase and the potential for catastrophic engine failure or fire.

The pilot switched on the runway lights. Bendigo Airport did not have approach lighting available.

Figure 1: RNAV-Z (GNSS) approach for runway 17 Bendigo



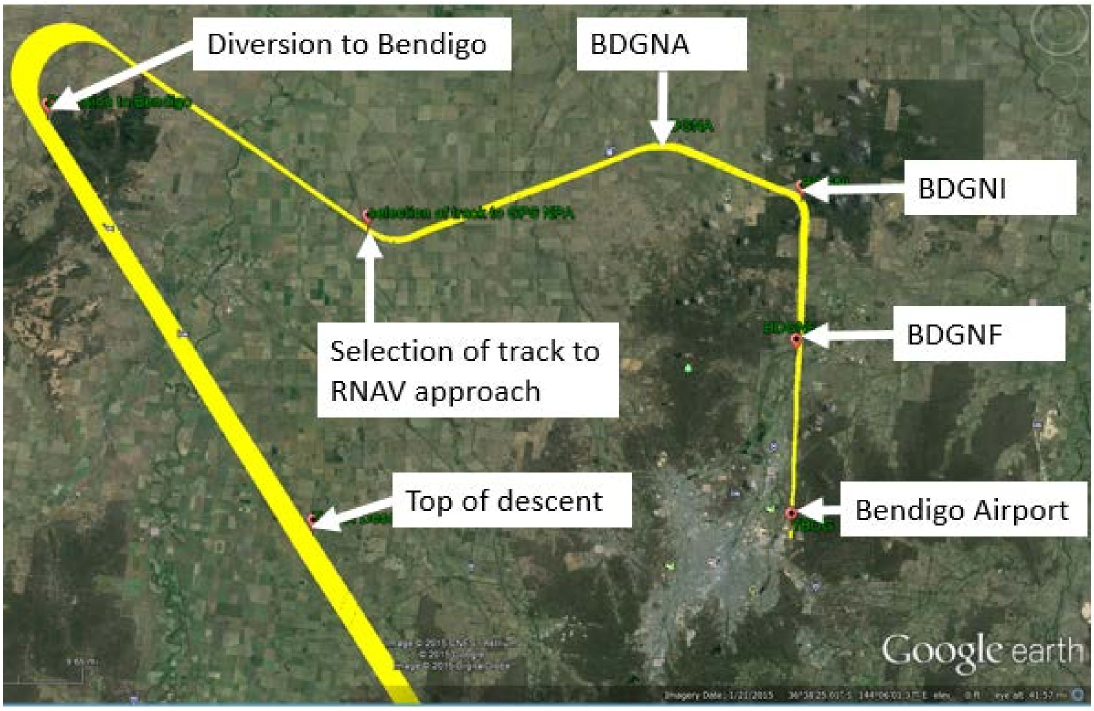
Source: Airservices Australia

After arriving at the final approach fix 'BDGNF', the autopilot disengaged and the pilot took over manual control of the aircraft. No vertical profile guidance was available to the pilot from the navigation system. They reported being in heavy rain, and that visibility through the windscreen was obscured by the contamination. The pilot could see the runway lights through the contaminated windscreen and rain, but reported difficulty in identifying the exact location of the ground. The aircraft was clear of cloud, but in rain, and the pilot estimated the visibility to be about 2 km. The flight data indicated that the aircraft's rate of descent in this section of the approach reached about 1,200 ft per minute.

3 Specified meteorological conditions of cloud ceiling and visibility. In order for an aircraft to land at an aerodrome, the actual weather conditions need to be at or above the landing minima.

When on final approach to runway 17, about 0.6 NM from the runway threshold, the pilot suddenly sighted a row of trees. The pilot immediately conducted a climb to avoid them, and estimated that the aircraft cleared the trees by a few feet. The pilot then landed the aircraft on the runway threshold. The pilot and passenger were uninjured and the aircraft was not damaged.

Figure 2: Aircraft track showing diversion to Bendigo and RNAV approach



Source: Google earth and flight data, annotated by the ATSB

Pilot comments

The pilot stated that the emergency and abnormal checklists were electronic and built into the aircraft system. If engine compartment fire is suspected, the actions are to set throttles to idle, select mixture to cut-off, and select the fuel to off. The recommendation is then to conduct an emergency descent and land immediately, and to not deploy the aircraft parachute (Cirrus airframe parachute system – CAPS). However, if there is no power available and the aircraft is in instrument meteorological conditions (IMC), the recommended action is to deploy the CAPS. The pilot stated that the ambiguity on whether or not to deploy the CAPS when you have a suspected engine compartment fire in IMC may need to be addressed.

In addition, the pilot commented that:

- Because they had the windscreen heat on in the freezing conditions, the residue condensed and deposited on the windscreen.
- Their workload was not too high because of familiarity with the aircraft (over 1,200 hours on type) and the avionics available.
- They did not have vertical profile information after the final approach fix (FAF) but have subsequently upgraded the *Integrated Modular Avionics – Perspective* software. This version of the software now provides a Baro-VNAV approach. That mode option provides vertical navigation guidance.
- The pilot considered the option to continue to Mildura, where the weather was better, but that would have required another 1.5 hours of flying. With the smoke increasing as they increased power, the pilot elect to divert to Bendigo.
- They were using oxygen due to the requirements of operating at flight levels. The aircraft was fitted with a carbon monoxide warning which did not activate.

- The aircraft was fitted with an infra-red camera to aid visibility outside the aircraft in poor weather conditions. The pilot had not switched the camera on during the incident flight, but subsequently used the camera in reduced visibility conditions. The pilot believed that the improved vision provided by the camera would have assisted from the final approach fix to the landing at Bendigo.

Weather

The weather at Bendigo at the time included heavy rain, visibility less than 2 km, cumulus cloud with base about 500 ft above ground level, and temperature 14 °C.

Engineering report

After the incident, an engineering inspection found the following sequence had occurred to create smoke in the cockpit and residue on the windscreen:

1. De-icing fluid from the Anti-Ice System had pooled in the aircraft cowling. For propeller de-icing, the fluid is distributed from a slinger ring mounted to the spinner backing plate, to rubber boots at the root end of the propeller blades. The engineer found a partial blockage of the slinger ring nozzle, which disrupted the flow spray pattern. This had caused one of the propeller deice fluid lines to spray fluid into the cowling and engine compartment, and reduced flow to the propeller.
2. When the alternate air source opened, the engine intake allowed the air/de-ice fluid vapour mixture through the induction system to the turbo/intercooler system. The engine compartment air had therefore drawn in the de-ice fluid and compressed it in the intercooler.
3. The heated cabin air was drawn from fresh air on the right cowl, and heated air from the intercoolers. The cabin air drew in the de-ice fluid and was distributed into the cabin. Due to the cold outside air temperature and the selection of warm air onto the windscreen, the moisture condensed onto the windscreen. Contamination on the inside of the window was found to be moisture contamination with deice fluid residue.

The engineer was unable to capture the foreign material that had blocked the slinger ring nozzle, but after the line was blown clear and the system flushed, operation was returned to normal. The system has a strainer and filters which have a two-year life and without trapping the blockage material they were unable to report whether the item was internal or external of the nozzle as it dislodged easily from the discharge nozzle.

There were no faults found with the turbocharger – no leaks, no cracks, and no obvious concern of fire risk.

Cirrus Aircraft in the United States advised that they were not aware of any previous examples of de-icing fluid entering the cabin via the alternate air box. The engineer and pilot queried whether there was a risk of spontaneous combustion, as the de-ice fluid was flammable, compressed in the engine and then vaporised. Cirrus Aircraft responded that the fluid could not spontaneously combust as:

- the auto-ignition temperature (ignition by heat) of the de-ice fluid is 770 degrees Fahrenheit (410 ^{o}C)
- the flash point (ignition by spark or flame) for the de-ice fluid is 220 degrees Fahrenheit (104 ^{o}C)
- the air temperature entering the intercooler is around 550 degrees Fahrenheit (288 ^{o}C)
- the de-ice fluid in the warm air entering the intercooler is well below the auto-ignition temperature of the de-ice fluid and no spark or flame is found in the induction system.

Cirrus instructor comment

A certified Cirrus instructor advised the ATSB that the Bendigo RNAV could be flown in VS mode using the appropriate power settings without pilot intervention. This should be done rather than manually overriding the vertical speed mode to reduce pilot workload and maintain the optimal vertical profile.

Flight data analysis

The ATSB analysed the aircraft flight data and noted the following.

The aircraft was fitted with a Garmin GFC-700 autopilot system. The recorded data indicated the aircraft was flown with the autopilot engaged and controlling both pitch and roll modes until the aircraft descended to about 1,100 ft barometric altitude and was about 1.1 NM from touchdown.

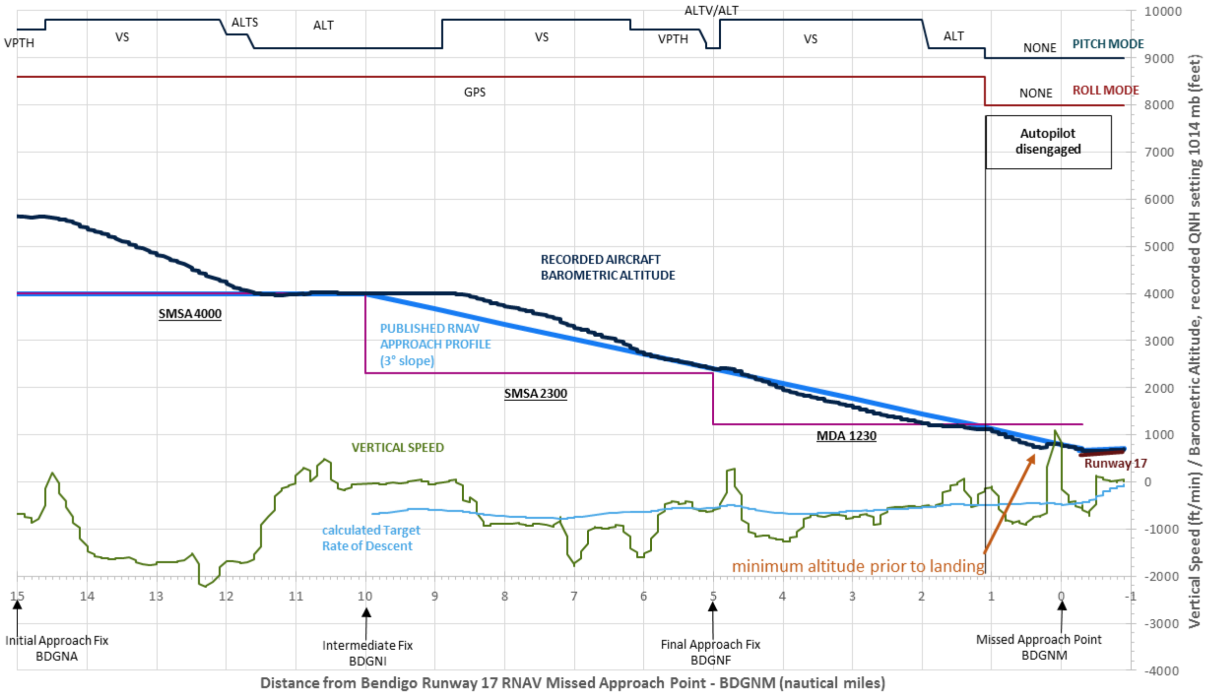
The aircraft followed the published RNAV approach lateral path, passing over the published waypoints. The recorded data showed that the roll control mode was made by using GPS information, which resulted in very precise lateral tracking.

The vertical profile recorded by the aircraft systems showed significant variation both above (about 350 ft high) and below (about 120 ft low) the 3° approach path angle shown in the published RNAV procedure (black line in Figure 3). The aircraft pitch modes during the approach were predominantly vertical speed with altitude capture hold and vertical path also becoming active. The aircraft recorded vertical speed was plotted in comparison with a target rate of descent calculated using the recorded groundspeed (light blue line in Figure 3).

Descent from sector minimum safe altitude of 4,000 ft was initiated using vertical speed as the pitch mode. The aircraft was above the published approach profile when the descent began (black line in Figure 3). The aircraft recorded a vertical speed of about 900 ft per minute. At about 6.2 NM from the missed approach point, as the aircraft was descending through 2,900 ft, the pitch mode changed to vertical path. The rate of descent reduced and the aircraft followed the published descent profile to about 5.1 NM, where the pitch mode changed to VNAV target altitude capture and then altitude hold (recorded barometric altitude of 2,393 ft, FAF published altitude 2,400 ft) modes at the final approach fix. About 8 seconds after altitude hold mode became active the pitch mode changed to vertical speed. The rate of descent increased to about 1,200 ft per minute and the aircraft descended below the published approach profile. The rate of descent reduced to a value similar to the calculated target rate of descent at 9:13:28, as the aircraft was passing through about 2,000 ft. This rate of descent was maintained until 9:14:26 when the pitch mode changed to altitude hold (recorded barometric altitude 1,235 ft, MDA 1,230 ft) at about 1.9 NM from the missed approach point.

The autopilot was disengaged at 9:14:59, about 1.1 NM from the missed approach waypoint, ‘BDGNM’. Following the autopilot disengaging, the rate of descent increased and the aircraft reached a barometric altitude of about 715 ft at 9:15:33, about 0.3 NM from ‘BDGNM’. The aircraft then proceeded to pitch up, to about 15°, and climbed to about 810 ft. The aircraft regained the published approach path angle and continued the approach to land at Bendigo Airport. The estimated touchdown was about 9:15:57, on the runway threshold – about 0.3 NM beyond the missed approach point), and the barometric altitude recorded was about 670 ft.

Figure 3: Comparison of recorded aircraft altitude and published approach procedure vertical profile



Source: Aircraft flight data analysed by the ATSB

ATSB Comment

The checklist in the aircraft's pilot operating handbook for Smoke and Fume Elimination included selecting Air Conditioner to OFF and if the source of smoke and fumes was forward of the firewall forward selecting Airflow to OFF. Following these selections may have prevented the contaminant condensing on the windscreen during the approach.

Safety message

SafetyWatch

The ATSB SafetyWatch highlights the broad safety concerns that come out of our investigation findings and from the occurrence data reported to us by industry. One of the safety concerns is *safety around flying with reduced visual cues*. This incident provides a timely reminder to flight crews of the importance of monitoring the flight instruments when encountering areas of reduced visual cues.

This incident provides an excellent example of challenges that may be involved in pilot decision making processes. The pilot was faced with an emergency situation and poor weather conditions. The decision to continue an approach in marginal conditions led to very quick action needed to avoid trees on the final approach. Pilots are encouraged to think through such scenarios in advance, which may assist with their decision making if confronted with similarly challenging circumstances. Following published checklists, particularly in emergency situations is important to enable pilots to identify the issue and to resolve it.

The Federal Aviation Authority handbook includes a chapter on Aeronautical Decision-Making. The American AOPA Air Safety Foundation Safety Advisor, *Decision making for pilots*, stated that effective decision making begins with anticipation – thinking about what could go wrong before it actually does.

General details

Occurrence details

Date and time:	19 May 2015 – 0856 EST	
Occurrence category:	Incident	
Primary occurrence type:	Smoke event	
Location:	44 km W of Bendigo Aerodrome, Victoria	
	Latitude: 36° 37.75' S	Longitude: 143° 51.42' E

Aircraft details

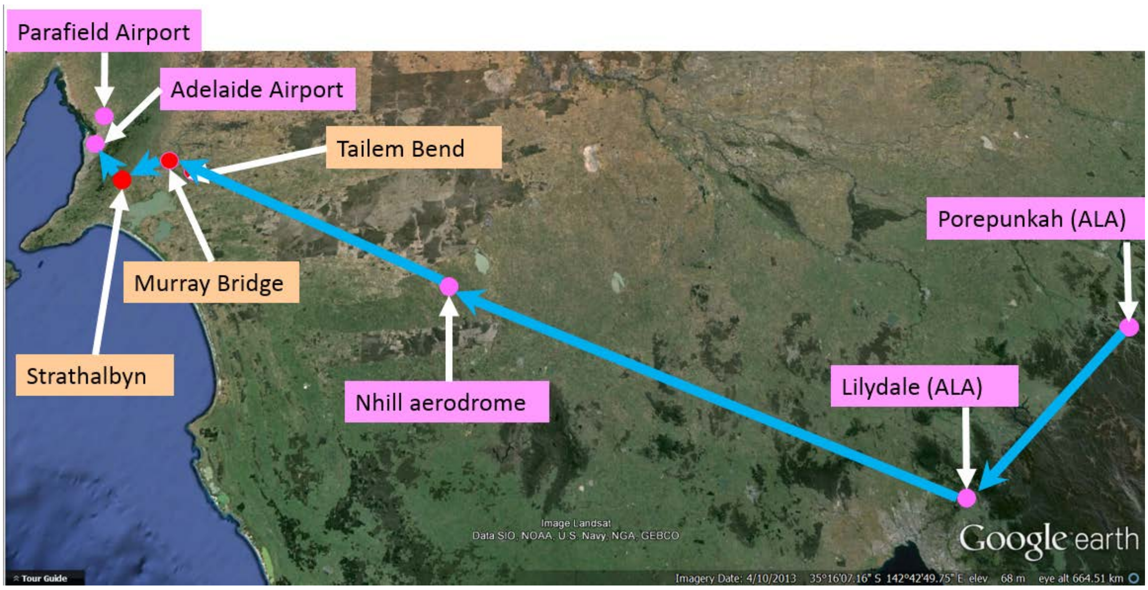
Manufacturer and model:	Cirrus Design Corporation SR22T	
Registration:	VH-EPG	
Serial number:	0269	
Type of operation:	Private	
Persons on board:	Crew – 1	Passengers – 1
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Nil	

Low fuel event involving a Piper PA-28, VH-MHI

What happened

On 10 July 2015, the pilot of a Piper PA-28 aircraft, registered VH-MHI (MHI), conducted a flight from Porepunkah to Lilydale, Victoria (Figure 1). In Lilydale, the pilot refuelled the aircraft, filling the tanks to full (189 L). Then the aircraft departed for Parafield, South Australia at about 1400 Eastern Standard Time (EST), with the pilot and two passengers on board.

Figure 1: Approximate aircraft track from Porepunkah to Lilydale and Adelaide



Source: Google earth annotated by the ATSB

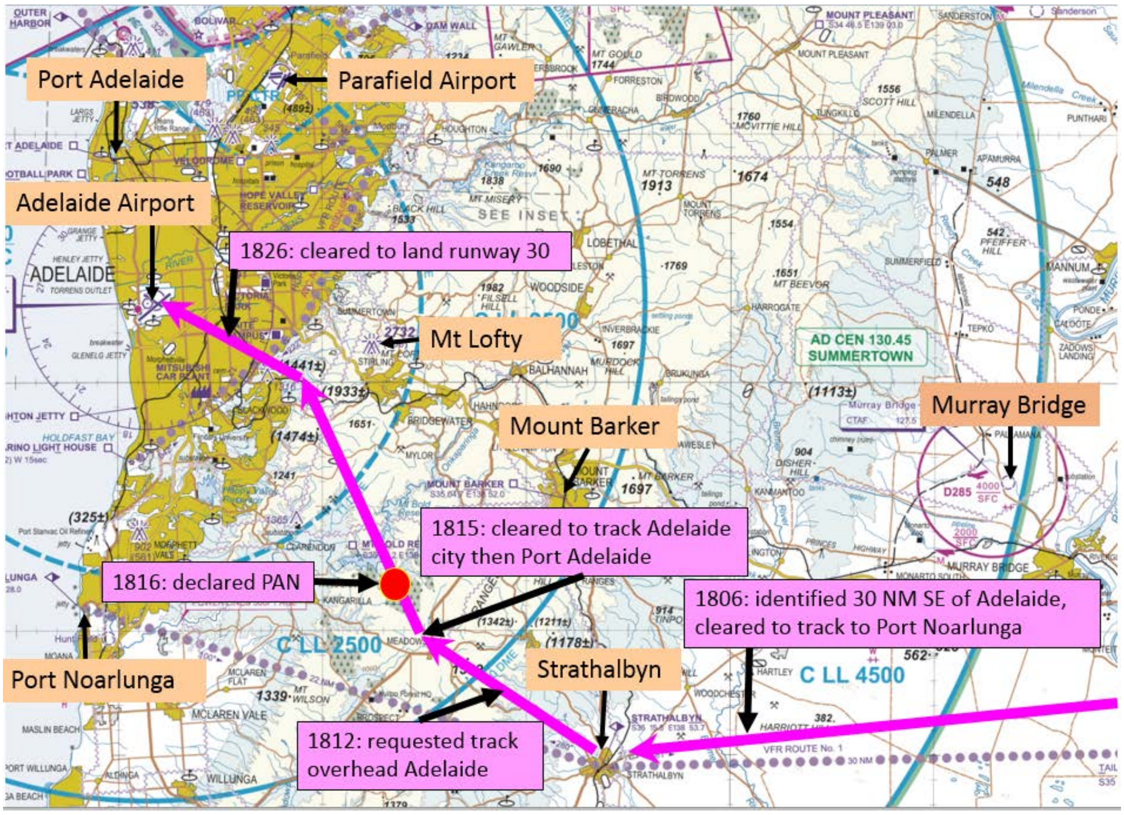
As the aircraft passed overhead Nhill, Victoria, the pilot assessed the fuel status. The fuel gauges indicated about 100 L of fuel remaining, which the pilot reported was in agreement with the expected fuel consumption rate. The pilot calculated that based on 90 minutes flight time remaining, 60 L of fuel was required, plus 30 L fixed reserve. Therefore, the pilot assessed that sufficient fuel remained to complete the planned flight, and elected to continue towards Parafield.

The pilot reported that the forecast cloud base was 4,500 ft in the area around Tailem Bend, South Australia. However, when approaching Tailem Bend at 4,500 ft above mean sea level (AMSL), the pilot was required to deviate and descend around cloud to remain in visual meteorological conditions (VMC). This deviation increased the track miles flown.

At about 1750 Central Standard Time (CST), the pilot contacted Adelaide Centre air traffic control (ATC), and advised that they were overhead Tailem Bend, and requested a clearance into the Adelaide control zone. The controller assigned the pilot a unique transponder code, and the aircraft tracked towards Murray Bridge, South Australia. At about 1755, when abeam Murray Bridge, the pilot advised ATC of the aircraft's current position. The controller confirmed the pilot had the correct transponder code and advised that the aircraft was not visible on the ATC radar display and they were therefore to remain outside Class C airspace. About 2 minutes later, the pilot recycled the transponder, then advised ATC of the code they had selected on the transponder. The controller responded that the aircraft was still not visible on the radar display. In addition, they advised the pilot that if they were unable to identify the aircraft on radar, the pilot would not be given a clearance to enter Class C airspace. The pilot repeated the transmission about 3 minutes later, when about 30 NM south-east of Adelaide at 4,500 ft. Again, the controller advised that the aircraft was still not visible on the radar display, and would therefore not be able to obtain a clearance into controlled airspace.

The pilot then switched the transponder off for about one minute, before switching it back on. At about 1803, the Adelaide Centre controller told the pilot that the Tower controller at Parafield Airport had advised that they were unable to see Mt Lofty from Parafield due to cloud. The pilot advised the controller that the aircraft was then approaching Strathalbyn and the weather appeared to be clear towards Adelaide (Figure 2). The controller then stated that the aircraft was now visible on the radar display.

Figure 2: Approximate aircraft track from Strathalbyn to Adelaide



Source: Airservices Australia annotated by the ATSB

At about 1805, the pilot again reported to ATC that they were approaching Strathalbyn at 4,500 ft and the controller advised the pilot to standby for a clearance. About 1 minute later, the controller identified the aircraft on the radar display, about 30 NM south-east of Adelaide and cleared the pilot to track to Port Noarlunga, then expect to track up the coast to Port Adelaide and on to Parafield.

At about 1812, the pilot was becoming increasingly concerned about the aircraft's fuel status, with both fuel gauges indicating close to empty. Therefore, the pilot requested a clearance to track overhead Adelaide to shorten the distance remaining to Parafield. About 2 minutes later, the controller cleared the aircraft to track direct overhead Adelaide city then to Port Adelaide.

When about 15 NM southeast of Adelaide, the engine ran roughly. The pilot changed the selected fuel tank from the left to the right, and assessed that the left tank was empty. The left fuel gauge was indicating empty and the right gauge was indicating just above empty.

At about 1816, the pilot declared a PAN[1] due to low fuel and requested a clearance to track direct to Adelaide Airport for a landing there. The controller advised the pilot to expect a clearance to

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1 An internationally recognised radio call announcing an urgency condition which concerns the safety of an aircraft or its occupants but where the flight crew does not require immediate assistance.

land on runway 30 at Adelaide. About 5 minutes later, the pilot was cleared to conduct a visual approach to runway 30 and the controller suggested to the pilot to 'remain as high as you can for as long as you can'.

At about 1824, the pilot contacted the Adelaide Tower controller and switched on the aircraft landing lights. Two minutes later, the tower controller cleared MHI to land, and the aircraft subsequently landed at Adelaide on runway 30.

After the flight, the pilot dipped the fuel tanks. The dipstick indicated no fuel in either tank. The calibration for the dipstick in that aircraft stated that zero fuel would indicate on the stick when 20 L or less remained in either tank. As the left tank had run dry, the pilot assessed there had been less than 20 L of fuel remaining after shutting down the aircraft.

Weather

The weather forecast for Parafield aerodrome (TAF) valid from 1730 CST included wind from 320° at 15 kt, showers of light rain, and broken[2] cloud at 4,500 ft above ground level (AGL). The weather forecast for Adelaide aerodrome (TAF) included wind from 320° at 15 kt, showers of light rain, and broken cloud at 4,500 ft AGL.

The area forecast for Area 50 valid for the flight included wind at 5,000 ft AMSL from 280° at 30 kt, and broken cloud with base from 3,000-8,000 ft AMSL and scattered showers of rain.

Pilot comments

The aircraft was filled with fuel and close to maximum weight when departing Lilydale. The aircraft departed about 90 minutes later than planned from Porepunkah for Lilydale and was then further delayed waiting for fuel in Lilydale. Prior to those delays, the pilot had anticipated arriving in Parafield before last light. The pilot had planned to refuel (during daylight hours) at Murray Bridge if it was assessed as necessary during the flight. However, there was no aerodrome lighting available at Murray Bridge. There were also numerous airfields between Nhill and Parafield suitable for landing during daylight hours, if additional fuel was required. After dark, Nhill was the last airport with pilot activated lighting (PAL) before Adelaide, but fuel was only available at Nhill by prior arrangement.

The pilot had planned to conduct the cruise at 4,500 ft, but had to descend close to the lowest safe altitude of 3,800 ft to stay clear of cloud. The delay with radar identification meant they had to divert from the direct track to remain outside controlled airspace. These factors contributed to the low fuel state.

Airservices Australia comments

Airservices Australia provided the following comments:

- If the aircraft's transponder had been operating normally, the controller should have been able to identify the aircraft at the altitude and location where the pilot first contacted Adelaide Centre.
- At the pilot's planned altitude of 4,500 ft, the aircraft was not required to divert to remain outside controlled airspace until within 20 NM of Adelaide Airport.
- The controller would have facilitated a clearance without radar identification, if the pilot had declared a PAN when initially requesting a clearance.

Fuel endurance

The following table provides a summary of the pilot's fuel planning figures.

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2 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.

Table 1: Fuel calculation

Fuel	Pilot plan
Taxi and climb allowance	10 L
Planned fuel required	4 hours x 40 L = 160 L
Reserve fuel	30 L
Total fuel required	200 L

The pilot operating handbook (POH) for the Piper PA-28-181, Cherokee Archer II, stated that the fuel capacity was 189 L, with 182 L usable fuel. The handbook provided graphs to estimate fuel range, dependent on pressure altitude, power setting from 55% to 75%, and with mixture leaned to 100 °F rich of peak exhaust gas temperature (EGT) for 'best power mixture range', and with mixture leaned to peak EGT for 'best economy range'. The pilot reported an airspeed of about 120 kt, indicating power setting between 75% power and full throttle at 4,500 ft AMSL, based on the 'Speed power – performance cruise' graph in the POH. At 75% power at 4,500 ft the graph indicated a range of about 500 NM with 45 minutes reserve fuel, in zero wind conditions.

The pilot planned on fuel consumption of 40 L/hr and reported that the aircraft usually consumed about 37 L/hr when cruising above 5,000 ft. The pilot had set the fuel mixture control slightly rich of peak EGT. The planned total distance was about 400 NM and total time about 4 hours. The pilot reported that the airspeed was indicating 120-150 kt.

Lilydale to Parafield is about 370 NM in a straight line, and it is about 173 NM from Nhill to Parafield. The direct track from Lilydale to Parafield is 296°. Based on the forecast wind for the area at 5,000 ft, the aircraft would have encountered a headwind of about 25-30 kt. The pilot estimated that the aircraft had a headwind of about 10 kt.

After passing Nhill, the pilot selected the cabin heat on and thought this may have increased the fuel consumption. According to the aircraft's POH, the cabin heat is routed from air from around the manifold exhaust and does not increase fuel consumption. They did not have carburettor heat on at any stage of the flight.

Safety message

The pilot commented that at night, it is important to be more prudent with fuel planning. At night, greater consideration should be given to planning to track via aerodromes with fuel and aerodrome lighting available.

The ATSB SafetyWatch highlights the broad safety concerns that come out of our investigation findings and from the occurrence data reported to us by industry. One of the safety concerns relates to aircraft fuel management.

Pilots are reminded of the importance of careful attention to aircraft fuel state. ATSB Research report AR-2011-112 Avoidable accidents No. 5 *Starved and exhausted: Fuel management aviation accidents*, discusses issues surrounding fuel management and provides some insight into fuel related aviation accidents. The report includes the following comment:

> *Incidences of fuel exhaustion often happen close to a flight's destination and, if it occurs when the aircraft is close to landing, it may offer the pilot less time and opportunity to successfully manage the situation.*

General details

Occurrence details

Date and time:	10 July 2015 – 1822 CST	
Occurrence category:	Serious incident	
Primary occurrence type:	Low fuel	
Location:	15 NM SE of Adelaide Airport, South Australia	
	Latitude: 35° 04.20' S	Longitude: 138° 47.65' E

Aircraft details

Manufacturer and model:	Piper Aircraft Corporation PA-28-181	
Registration:	VH-MHI	
Serial number:	28-7790350	
Type of operation:	Private	
Persons on board:	Crew – 1	Passengers – 2
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Nil	

Wirestrike involving an Eagle DW1, VH-FHP

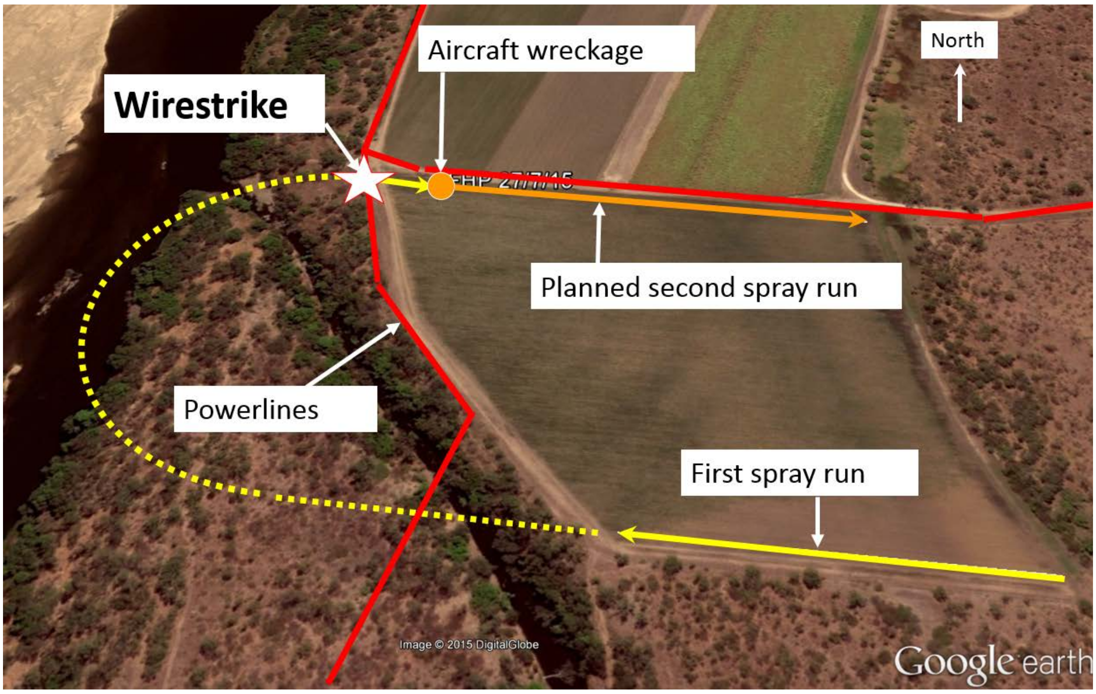
What happened

On 27 July 2015, the pilot of an Eagle DW1 aircraft, registered VH-FHP, was conducting aerial spraying operations on a property about 77 km southeast of Townsville, Queensland. The pilot completed aerial spraying of two paddocks, and then loaded the aircraft with about 450 L of chemical (about half capacity), and half a tank of fuel.

At about 0930 Eastern Standard Time (EST), the pilot took off to spray the third paddock for that day. The pilot overflew the paddock and identified two sets of powerlines. The pilot formed a plan to spray the paddock using a racetrack pattern and flying it in a clockwise direction. One set of powerlines ran parallel to the spray direction, and the other ran across it at the western end. There was a line of trees along the western powerline, which obscured vision of the power poles.

The pilot completed the first spray run towards the western powerline, overflew it, and then turned to line up for the second spray run (Figure 1). A small area of about 30 m of trees had been cleared for a pump installation and the clearing was in line with the start of the second spray run. The pilot noted the powerline ahead, but then diverted their attention to the other powerline, running parallel to the direction of flight, and about 5 m off the left wingtip. The pilot also looked inside at the GPS to check the aircraft's line for the spray run.

Figure 1: Paddock to be sprayed showing powerlines and wirestrike location



Source: Google earth and the pilot of VH-FHP – annotated by the ATSB

The pilot commenced the descent into the paddock through the clearing in the trees and did not see the powerline at that time. As the aircraft descended, the pilot looked up and suddenly sighted the powerline. The pilot elected to push forwards on the controls to make the aircraft descend. The aircraft then struck the powerline above the propeller on the wing struts.

After the aircraft struck the wires, it yawed violently to the left. The pilot used the right rudder to turn the aircraft away from the other powerlines, and the force of the aircraft pulled the transformer off the power pole on the left. The aircraft then yawed to the right. The force broke the power pole on the right and severed the powerline.

The aircraft decelerated rapidly and the wires pulled the aircraft towards the ground. The pilot landed the aircraft with the wings level. The landing gear sheared off, the propeller struck the ground and the aircraft ground-looped, coming to rest facing the opposite direction. The pilot sustained minor injuries and the aircraft was destroyed (Figure 2).

Figure 2: Photo of VH-FHP at the accident site showing damage to the aircraft and wires

Source: Aircraft operator

Pilot comments

The pilot provided the following comments:

- The pilot had sprayed that paddock once previously, and had used an anti-clockwise racetrack pattern. On that occasion, as the power poles were on the eastern side of the trees, they were more visible from that direction.
- The pilot elected to descend after sighting the powerline, to prevent the landing gear from potentially catching on the wires and flipping the aircraft over.
- The aircraft had a wire cutter on the undercarriage and a wire deflector between the top of the wing and the tail, but not on the struts where the wire struck.
- The powerlines were three phase.

Safety message

The pilot was aware of the powerline the aircraft collided with, but did not have it front-of-mind at the start of the spray run. The pilot's attention was diverted to other powerlines, parallel to the direction of flight, and also inside the aircraft to the GPS. The pilot reported that stating aloud 'powerlines ahead', would have helped to maintain awareness of the wires.

The Aerial Agricultural Association of Australia suggests a way to keep focus is to ask yourself:

- Where is the wire now?
- What do I do about it?
- Where am I in the paddock?

For further risk management strategies for agricultural operations, refer to the Aerial Application Pilots Manual.

The ATSB research report *Aerial application safety: 2014-2015 year in review*, stated that aerial application operations have a high accident rate relative to other aviation sectors. These operations involve inherent risks. Those risks include low-level flying, high workloads and obstacles such as powerlines. More than half of the total accidents and serious incidents over the past 10 years were wirestrikes.

The report also stated that it is important to constantly monitor the environment, so the hazards that were identified in pre-planning can be recognised and avoided. If a pilot is not specifically looking for a hazard, it is unlikely they will notice it.

The ATSB investigated a similar accident, involving a Robinson R66 helicopter. A copy of that report is available here: AO-2014-142.

General details

Occurrence details

Date and time:	27 July 2015 – 0930 EST	
Occurrence category:	Accident	
Primary occurrence type:	Wirestrike	
Location:	150 km SE of Townsville, Queensland	
	Latitude: 20° 02.72' S	Longitude: 147° 55.52' E

Aircraft details

Manufacturer and model:	Eagle Aircraft Australia DW-1	
Registration:	VH-FHP	
Serial number:	DW-1-0027-81	
Type of operation:	Aerial work	
Persons on board:	Crew – 1	Passengers – Nil
Injuries:	Crew – 1 Minor	Passengers – Nil
Damage:	Destroyed	

Helicopters

Collision with terrain involving a Robinson R22, VH-RBO

What happened

On 28 June 2015, at about 1500 Central Standard Time (CST), a Robinson R22 helicopter, registered VH-RBO, took off from a property near Daly Waters, Northern Territory, for a local flight, including inspection of bores on the property. The temperature was about 30°C with a south-easterly wind at 10-15 kt. After flying for about 20 minutes, the pilot, who was the sole occupant of the helicopter, landed to open a gate and put out a bucket of chain. The pilot selected the governor off, then exited the helicopter, leaving the engine running. The pilot then re-boarded the helicopter and took off.

After a further 5 to 10 minutes of flight, when at about 100 ft above ground level, and an airspeed of 40 kt, the pilot conducted a turn to the south. The low rotor revolutions per minute (RPM) warning horn sounded. The pilot immediately wound the throttle fully open, and lowered the collective[1] to try to regain rotor RPM. The helicopter continued to descend. The pilot attempted to flare[2] the helicopter when low to the ground. The main rotor blades collided with tree branches. The helicopter landed heavily, the skids dug in to the soil and the helicopter rolled onto its side.

The pilot sustained minor injuries and the helicopter was substantially damaged (Figure 1).

Figure 1: Accident site

Source: Aircraft engineer

Pilot comments

The pilot was unsure whether the engine was running normally when the helicopter touched down, and could only recall hearing the rotor RPM warning horn. The pilot was focused on looking outside the helicopter at an earth tank and a mob of cattle and not inside at the instruments. The pilot reported that it was their normal procedure to switch off the governor when exiting, and then select it back on when returning to the helicopter. However, on this occasion, the pilot could not recall specifically switching it back on.

1 A primary helicopter flight control that simultaneously affects the pitch of all blades of a lifting rotor. Collective input is the main control for vertical velocity.

2 Final nose-up pitch of landing aircraft to reduce rate of descent to approximately zero at touchdown.

Engineering report

A 100-hourly maintenance inspection and the replacement of two cylinders was completed on the morning of the accident flight. The pilot and an engineer then conducted a flight of about 20 minutes duration, during which the helicopter performance and all indications were normal.

An initial inspection of the helicopter following the accident found the following:

- No oil on the exterior of the engine or helicopter to indicate any oil line failure.
- Fresh oil droplets on the right skid and a smear on the right strut. Immediately adjacent to the helicopter there was a small oil spill on the ground, probably from impact damage.
- The fuel tanks still contained a substantial amount of fuel, which was leaking out down the mast.
- Fuel from the drum was checked with no contamination found. The helicopter was fuelled with premium unleaded petrol.
- Icing was found to have been unlikely.
- Drive belts were still on and intact.
- Clutch engagement position appeared normal.
- Main rotor blades were buckled and damaged, partly from falling onto a fence, but were still attached to the hub.
- Main rotor blades were evidently not turning fast when they hit the ground.
- The engine was running on impact.
- The governor switch was in the OFF position. The engineer turned on the master switch, and the governor light (GOV OFF) illuminated.

The engineer removed the main rotor blades and rolled the helicopter upright. The bottom spark plugs were removed and cleaned of oil, and then replaced. The engineer then started the engine and a positive oil pressure indicated. The engine was ground run for about 30 seconds and the magnetos, temperatures and pressure indicated normally.

Safety message

The Robinson Helicopter Company Safety Notice SN-24 states that rotor stall due to low RPM causes a very high percentage of helicopter accidents. These mostly occur close to the ground during take-off and landing. Safety Notice SN-10 reminds pilots to have their 'reflexes conditioned so they will instantly add throttle and lower collective to maintain RPM in an emergency'.

General details

Occurrence details

Date and time:	28 June 2015 – 1600 CST	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	near Daly Waters (ALA), Northern Territory	
	Latitude: 16° 16.00' S	Longitude: 133° 22.00' E

Helicopter details

Manufacturer and model:	Robinson Helicopter Company R22 Beta	
Registration:	VH-RBO	
Serial number:	0810	
Type of operation:	Aerial work	
Persons on board:	Crew – 1	Passengers – Nil
Injuries:	Crew – 1 Minor	Passengers – Nil
Damage:	Substantial	

Collision with terrain involving a Robinson R44, VH-VOH

What happened

On 14 July 2015, the pilot of a Robinson R44 helicopter, registered VH-VOH, was conducting aerial mustering operations on a property, about 70 NM east of Alice Springs, Northern Territory.

At about 1300 Central Standard Time (CST), the pilot was mustering cattle along a creek system. The helicopter was above tree height, at about 50 ft above ground level (AGL), when the pilot slowed the helicopter to an airspeed of about 40 kt. The pilot felt a small vibration, and initially thought it was due to loose tape on the main rotor blade. The pilot looked for a suitable landing site, but the vibration increased significantly.

As the helicopter descended, the pilot manoeuvred the helicopter through a gap between trees, and pushed the cyclic[1] forward to maintain airspeed. The pilot lowered the collective[2] and noticed the engine seemed to go very quiet and the low rotor revolutions per minute (RPM) warning horn sounded. The pilot made a radio call to advise another pilot operating nearby that the helicopter was going down. The pilot then flared[3] the helicopter to try to cushion the landing impact. The right skid touched down first, and the helicopter rolled onto its right side.

The pilot sustained minor injuries and the helicopter was substantially damaged (Figure 1).

Pilot comments

The pilot provided the following comments:

- There was no noise to indicate that the helicopter had hit anything.
- The helicopter did not yaw when it vibrated.
- The wind was from the southeast at less than five knots, and the pilot turned the helicopter towards the east between the trees.
- The weather was fine; there were no visible signs of moisture, and only a few high level clouds.
- The pilot did not select the carburettor heat on at any stage during the flight.
- Both tail rotor blades broke off the helicopter’s tail. This may have occurred prior to striking the ground, but the pilot did not detect the helicopter tail rotor colliding with anything.

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1 A primary helicopter flight control that is similar to an aircraft control column. Cyclic input tilts the main rotor disc varying the attitude of the helicopter and hence the lateral direction.

2 The collective pitch control, or collective, is a primary flight control used to make changes to the pitch angle of the main rotor blades. Collective input is the main control for vertical velocity.

3 Flare reduces rate of descent before ground impact by increasing collective pitch; this increases lift, trading stored rotor kinetic energy for increased aerodynamic reaction by blades, and should result in a gentle touchdown.

Figure 1: Accident site showing damage to VH-VOH

Source: Aircraft owner

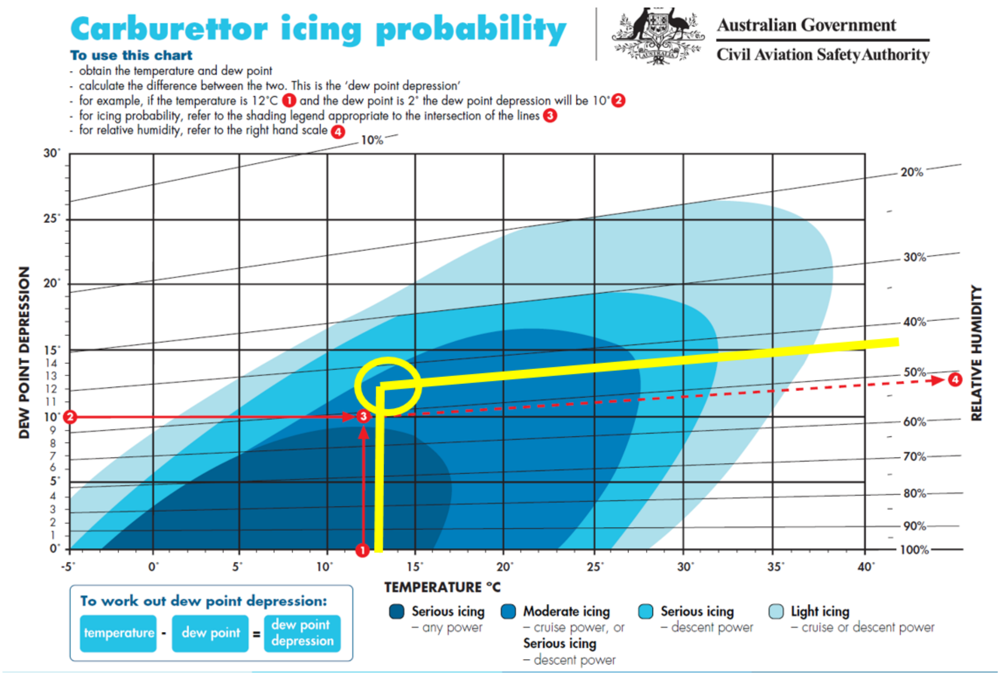
Meteorological conditions

Weather observations from the Bureau of Meteorology's automatic weather station at Alice Springs indicated that at 1300, the temperature was 12.9°C, relative humidity 45%, and the dew point[4] was 1.2°C. The dew point depression, calculated by subtracting the dew point from the temperature, at that time was 11.7.

According to the Carburettor Icing Probability chart (Figure 2), the conditions indicated a high probability of serious carburettor icing at descent power.

[4] Dewpoint is the temperature at which water vapour in the air starts to condense as the air cools. It is used among other things to monitor the risk of aircraft carburettor icing or likelihood of fog at an aerodrome.

Figure 2: Carburettor icing chart showing prevailing conditions in yellow



Source: Civil Aviation Safety Authority – modified by the ATSB

Safety message

The ATSB advises all pilots of aircraft fitted with a carburettor to check the forecast conditions and know the risk of carburettor icing prior to each flight. The carburettor icing probability chart is available on the CASA website.

The following publications provide additional information on carburettor icing:

- Melting Moments: Understanding Carburettor Icing
- Flight Safety Australia – A chill in the air
- Mornington Sanford Aviation – No ice, thank you
- Helicopter Safety – Carb Icing

General details

Occurrence details

Date and time:	14 July 2015 – 1300 CST	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	70 NM E Alice Springs, Northern Territory	
	Latitude: 23° 48.50' S	Longitude: 133° 54.05' E

Helicopter details

Manufacturer and model:	Robinson Helicopter Company R44	
Registration:	VH-VOH	
Serial number:	2149	
Type of operation:	Aerial work – Aerial mustering	
Persons on board:	Crew – 1	Passengers – Nil
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Substantial	

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau 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 safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

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.

About this Bulletin

The ATSB receives around 15,000 notifications of Aviation occurrences each year, 8,000 of which are accidents, serious incidents and incidents. It also receives a lesser number of similar occurrences in the Rail and Marine transport sectors. It is from the information provided in these notifications that the ATSB makes a decision on whether or not to investigate. While some further information is sought in some cases to assist in making those decisions, resource constraints dictate that a significant amount of professional judgement is needed to be exercised.

There are times when more detailed information about the circumstances of the occurrence allows the ATSB to make a more informed decision both about whether to investigate at all and, if so, what necessary resources are required (investigation level). In addition, further publically available information on accidents and serious incidents increases safety awareness in the industry and enables improved research activities and analysis of safety trends, leading to more targeted safety education.

The Short Investigation Team gathers additional factual information on aviation accidents and serious incidents (with the exception of 'high risk operations), and similar Rail and Marine occurrences, where the initial decision has been not to commence a 'full' (level 1 to 4) investigation.

The primary objective of the team is to undertake limited-scope, fact gathering investigations, which result in a short summary report. The summary report is a compilation of the information the ATSB has gathered, sourced from individuals or organisations involved in the occurrences, on the circumstances surrounding the occurrence and what safety action may have been taken or identified as a result of the occurrence.

These reports are released publically. In the aviation transport context, the reports are released periodically in a Bulletin format.

Conducting these Short investigations has a number of benefits:

- Publication of the circumstances surrounding a larger number of occurrences enables greater industry awareness of potential safety issues and possible safety action.
- The additional information gathered results in a richer source of information for research and statistical analysis purposes that can be used both by ATSB research staff as well as other stakeholders, including the portfolio agencies and research institutions.
- Reviewing the additional information serves as a screening process to allow decisions to be made about whether a full investigation is warranted. This addresses the issue of 'not knowing what we don't know' and ensures that the ATSB does not miss opportunities to identify safety issues and facilitate safety action.
- In cases where the initial decision was to conduct a full investigation, but which, after the preliminary evidence collection and review phase, later suggested that further resources are not warranted, the investigation may be finalised with a short factual report.
- It assists Australia to more fully comply with its obligations under ICAO Annex 13 to investigate all aviation accidents and serious incidents.
- Publicises ***Safety Messages*** aimed at improving awareness of issues and good safety practices to both the transport industries and the travelling public.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Short Investigations

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