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Content

Jet aircraft

Turboprop aircraft

Piston aircraft

Helicopters

Remotely Piloted Aircraft

Jet aircraft

Descent below lowest safe altitude involving Boeing 747, N416MC

What happened

On 12 February 2017, a Boeing 747-47UF (freighter) aircraft, registered N416MC, operating from Honolulu, Hawaii, conducted an approach to Sydney Airport, New South Wales. On board the aircraft were two flight crew. The captain was the pilot monitoring (PM) and the first officer was the pilot flying (PF).[1]

The aircraft was cleared by the approach controller for the runway 16R instrument landing system (ILS) approach.[2] The auto-pilot was engaged[3] and the modes for localiser and approach (glideslope) were armed[4] while the aircraft was flown at 2,200 ft on a heading of 200° to intercept the 16R ILS. The aircraft captured[5] the localiser and the PF turned it left onto the 16R final approach course, while maintaining 2,200 ft, in order to intercept the glideslope from below.

Shortly after the turn onto the final approach, the PF called 'glideslope captured' and the aircraft started to descend. However, the PM's primary flight display[6] was still showing the aircraft below the glideslope. The PM crosschecked the PF's display and noticed the glideslope was captured, then checked their own display and noticed there was a failure flag displayed for the glideslope. The PM again crosschecked the PF's display, noticed there was a failure flag for the PF's glideslope, and instructed the PF to disconnect the auto-pilot and stop the descent.

As the aircraft descended through 2,100 ft, the approach controller requested confirmation that they were established on the glideslope. The PM responded that they had an interruption on glideslope and would maintain altitude until they could re-intercept. During the response, a minimum safe altitude warning (MSAW) alert appeared on the approach controller's radar for N416MC at an altitude of 1,800 ft. The approach controller immediately issued the instruction 'go-around, you are well below the glide-path, go-around'. The PM immediately acknowledged the instruction and the flight crew initiated the missed approach procedure.

The lowest point on the approach was 1,559 ft from flight data (1,600 ft on radar) at about 8.0 NM (14.8 km) from runway 16R (Figure 1). This resulted in the aircraft descending about 1,000 ft below the nominal 3° glideslope at the time of the incident. The aircraft was flown on the second approach with auto-pilot engaged. The localiser and glideslope captured and tracked the ILS with no anomalies detected.

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

[2] The instrument landing system is a ground-based precision approach and landing aid. The main elements are (1) the localiser antenna, which provides centreline guidance; (2) the glideslope antenna, which provides a nominal 3° descent guidance; (3) the marker beacons (outer, middle and inner), which are used for altimetry checks and to indicate what stage of the approach has been reached; and (4) the approach lights (Distance Measuring Equipment (DME) and Global Navigation Satellite System (GNSS) may be used in lieu of marker beacons).

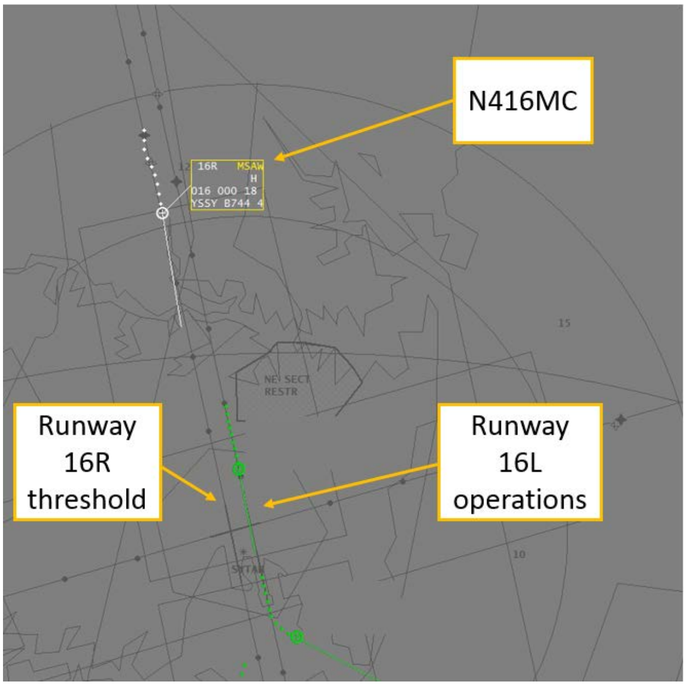
[3] Engaged: A system mode or function that is actively performing its function.

[4] Armed: A system mode or function that is set to become actively engaged at a later time, when certain conditions are met.

[5] Captured: A system mode has become engaged.

[6] An electronic flight display that presents the primary flight instruments, navigation instruments, and other information about the status of the flight in one integrated presentation.

Figure 1: Minimum safe altitude warning for N416MC

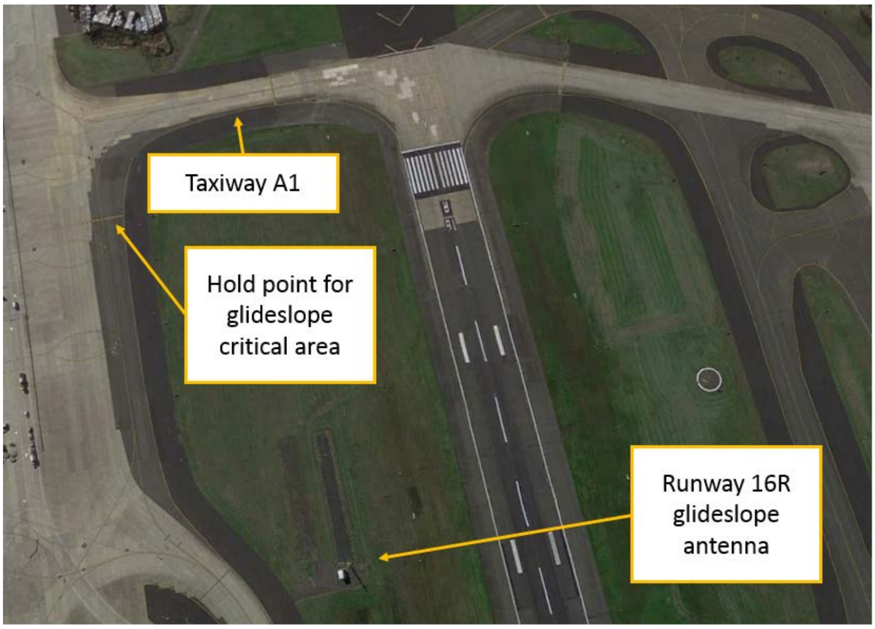


Source: Airservices, annotated by the ATSB

ILS signal interference

Disturbances to ILS localiser and glideslope courses are caused by fixed structures, such as buildings (static distortion), and moving vehicles or aircraft (dynamic distortion). The total ILS course distortion is determined by the root square summation of static and dynamic distortion and this is used to define critical areas[7] near each localiser and glideslope antenna (Figure 2).

Figure 2: Runway 16R glideslope antenna and critical area hold point



Source: Google earth, annotated by the ATSB

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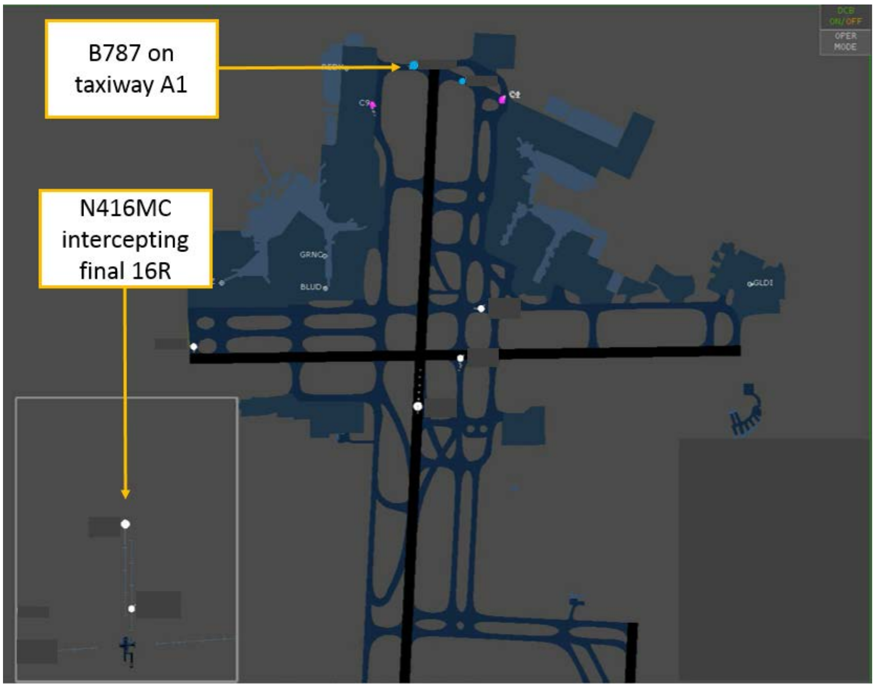
[7] The critical area is a volume of airspace encompassing lateral and vertical dimensions based around the localiser and glideslope antennas to protect the ILS signal transmissions to airborne aircraft in poor weather.

The critical areas are protected for low visibility approaches. This is when the cloud ceiling is at or below 600 ft, or the visibility is 2000 m or less. In which case, no aircraft or vehicle is permitted to enter the critical areas when an arriving aircraft is within the outer marker, or 4 NM from the threshold if there is no outer marker.

At the time N416MC intercepted the runway 16R localiser, a Boeing 787 was holding on taxiway A1, within the runway 16R glideslope critical area (Figure 3). However, the weather conditions did not require air traffic control to activate the ILS critical area, and N416MC was instructed to go-around before reaching the outer marker.[8]

Figure 3: Infringement of the 16R glideslope critical area



Source: Airservices, annotated by the ATSB

Receiver characteristics

A moving receiver passing through a distorted ILS signal will produce a guidance error. The error produced will vary depending on the receiver characteristics, its antenna characteristics and the speed of the vehicle carrying the receiver as it passes through the distorted signal.

Similar incidents

Glideslope signal disturbances

- On 17 March 2017, a Boeing 747-400 attempted to intercept the runway 16R ILS in instrument meteorological conditions using the autopilot for a coupled approach.[9] When the glideslope was captured, the indications began to oscillate and the autopilot chased the indications. A high rate of descent developed and a 'low on profile' call was made on the flight deck to stop the descent. The descent was stopped at about 1,500 ft, about 7 NM (13 km) from the threshold of runway 16R. An Airbus A380 was lined up for departure on runway 16R from taxiway A1 when the Boeing 747 was about 8 NM (14.8 km) from the threshold of runway 16R.
- On 23 March 2017, a Boeing 747-400 attempted to intercept the runway 16R ILS in instrument meteorological conditions using the autopilot for a coupled approach. Approaching 2,000 ft, the glideslope on the captain's primary flight display disappeared, followed by the glideslope on the

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[8] Runway 16R outer marker is about 3.9 NM from the runway threshold.

[9] Coupled approach: An approach flown by the auto-pilot.

first officer's primary flight display. The aircraft pitched nose down with an associated increased rate of descent. The captain disengaged the auto-pilot and stopped the descent at about 1,500 ft and 8 NM (14.8 km) on final for 16R. A minimum safety altitude alert activated and the approach controller instructed the flight crew to conduct a missed approach. An Airbus A380 was holding on taxiway A1 at the time of the incident. A second approach was flown using the auto-pilot without incident. There were no aircraft in the glideslope critical area during the second approach.

Localiser signal disturbance

On 27 August 2015, a Boeing 787-800 attempted to conduct an autoland[10] to runway 34L at Sydney Airport in visual meteorological conditions. The aircraft experienced a disturbance to the localiser signal at about 100 ft and the flight crew immediately disconnected the autopilot to complete the landing. The flight crew were aware the ILS critical area was not required to be protected at the time and had not notified air traffic control they were conducting an autoland. They were aware that disturbances to the ILS signals were possible and were prepared to intervene. An Airbus A330 departed directly in front of the 34L localiser antenna at the time of the incident.

Manufacturer comments

Boeing, the aircraft manufacturer, reported that they have no reason to believe that the 747 would behave any differently to their other aircraft types. The same antenna system is installed on the 757, 767 and 777. However, there are some differences in the antenna locations. The 747 and 777 receiver antennas are located on the main landing gear doors, while the 757 and 767 antennas are located in the nose of the aircraft. The glideslope incidents might relate to a varying signal strength, rather than a distorted beam.

Aeronautical Information Publication

If a pilot advises air traffic control that an 'autoland' or 'coupled approach' is to be flown, then air traffic control will either report 'ILS critical area not protected' or 'LVP[11] in force' if the critical area is protected.[12]

Airservices Australia comments

Airservices Australia, the air traffic services provider, reported that disturbance of the glideslope signal is less for aircraft at the taxiway A holding point (holding point for glideslope critical area) than it is for the same aircraft at the holding point on taxiway A1. Airservices Australia conducted a computer simulation which indicated that an Airbus A380 aircraft stationary at holding point A1 is unlikely to have caused the large ILS signal disturbance observed in this incident.

The simulations and radar recordings indicated the observed disturbance in each case occurred after the holding aircraft was provided with its line up clearance and while taxiing between the holding point and the runway. In this respect, there will always be significant interference to approaching aircraft outside 4 NM regardless of whether the holding point on taxiway A or A1 is used at the same time as runway 16R is used for arrivals.

Safety analysis

N416MC intercepted the final approach and the auto-pilot captured the ILS localiser and glideslope at the same time as a Boeing 787 (B787) was holding on taxiway A1, which lies within the critical area for the runway 16R glideslope. The presence of the 787 in the critical area likely resulted in N416MC receiving either a distorted glideslope beam or a beam of varying signal strength. This required flight crew intervention following a glideslope failure indication, which was

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[10] Landing of the aircraft by the autopilot for the operational purpose of landing when there are no visual cues for the pilot.

[11] Low visibility procedures

[12] Refer: Aeronautical Information Publication (AIP) Australia AD 1.1 – 2.

detected by the captain crosschecking the two primary flight displays. At the time of the incident, the glideslope critical area was not required to be protected, in accordance with the manual of air traffic services.

ATSB comment

It has been previously noted by regulators and manufacturers, that it is common practice for operators to conduct coupled approaches and autoland to satisfy maintenance, training or reliability program requirements. These approaches may be conducted in weather conditions which do not require protection of the ILS signal. There have been incidents reported in which the autopilot has responded to disturbances in the ILS signal when the aircraft was close to landing. Airservices Australia advise that ILS signals may be disturbed with the consequential effect on autoland performance when weather conditions do not require protection of the ILS critical area.

For more information on ILS signal distortion and determination of protected areas following the introduction of the Airbus A380 see *Assessment of ILS protection areas impact on large aircraft operations*.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The descent below the nominal 3° approach glideslope was probably the result of the aircraft auto-pilot capturing a distorted glideslope beam.
- The glideslope beam was probably distorted due to the presence of a Boeing 787 in the glideslope critical area, which was not required to be protected in the weather conditions which prevailed at the time of the incident.

Safety message

This incident highlights the importance of crosschecks on the flight deck and between air traffic control and the flight crew. After detecting unexpected indications on the flight deck, the flight crew intervened to stop the descent, which was then followed by an instruction from air traffic control to initiate a go-around.

The aircraft manufacturer and regulators have recommended that flight crew remain vigilant for ILS disturbances with resulting unexpected flight control movements and be prepared to immediately disconnect the autopilot, particularly during autoland operations.

General details

Occurrence details

Date and time:	12 February 2017 – 2152 EDT	
Occurrence category:	Incident	
Primary occurrence type:	Flight below minimum altitude	
Location:	15 km NNW from Sydney Airport, New South Wales	
	Latitude: 33° 48.87’ S	Longitude: 151° 08.98’ E

Aircraft details

Manufacturer and model:	The Boeing Company 747-47UF	
Registration:	N416MC	
Serial number:	32838	
Type of operation:	Air transport high capacity - Freight	
Persons on board:	Crew – 2	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	

Descent below lowest safe altitude involving Boeing 777, 9V-SRP

What happened

On the morning of 22 February 2017, a Singapore Airlines Boeing 777-212, registered 9V-SRP, operated scheduled flight SQ291 from Singapore Changi Airport, Singapore, to Canberra Airport, Australian Capital Territory (ACT). There were 13 crew and 235 passengers on board. The instrument landing system (ILS) for runway 35 at Canberra was out of service at the expected arrival time.

Prior to descent to Canberra Airport, the flight crew reviewed the weather conditions for Canberra. Canberra weather observations indicated that the visibility was greater than 10 km and wind conditions favoured runway 35 to be used for landing. As the runway 35 ILS was not available, the flight crew prepared to conduct the Standard Arrival Route (STAR)[1] POLLI FOUR PAPA arrival (Figure 1 left) and associated RNAV-Z[2] approach[3] (Figure 2) for runway 35. As the aircraft was arriving from the west, the flight crew elected to commence the RNAV-Z approach from waypoint[4] SCBSG. The captain, acting as pilot monitoring,[5] entered the arrival and approach into the aircraft's flight management computer (FMC).

As the aircraft descended, air traffic control (ATC) instructed the flight crew to conduct the POLLI FOUR BRAVO arrival (Figure 1 right).

The flight crew had not briefed for this arrival and the first officer, who was pilot flying, identified that the POLLI FOUR BRAVO arrival led to the runway 35 VOR approach.[6] As the POLLI FOUR PAPA and POLLI FOUR BRAVO arrivals were very similar, the flight crew elected to reprogram the POLLI FOUR BRAVO arrival into the FMC while keeping the RNAV-Z approach. The flight crew intended to request the RNAV-Z approach from ATC upon first contact with the Approach controller. As the POLLI FOUR BRAVO arrival did not lead to the RNAV-Z approach, this created a discontinuity[7] in the programmed FMC flight path between the completion of the arrival at waypoint MENZI and the commencement of the approach. To correct this discontinuity, the first officer asked the captain to connect waypoint MENZI to the approach at waypoint SCBSI. In doing so, the waypoint SCBSG was erased from the programmed FMC approach.

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[1] Standard arrival route (STAR): A published procedure followed by an aircraft from the enroute phase of the flight to the commencement of the approach.

[2] Area navigation (RNAV) approach: An approach flown along a path of GPS waypoints.

[3] Approach: A published procedure followed by an aircraft between the conclusion of the STAR and the airport runway.

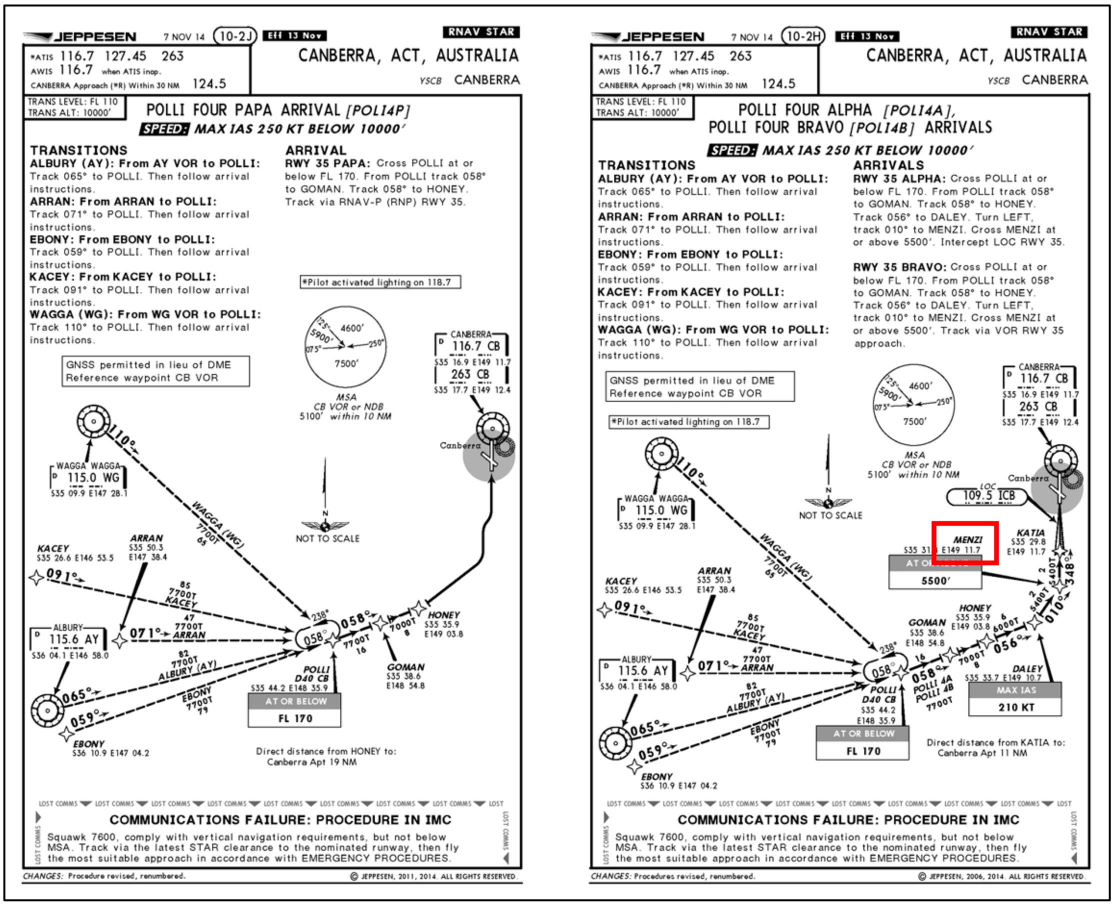
[4] Waypoint: A defined position of latitude and longitude coordinates, primarily used for navigation.

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

[6] VHF omnidirectional range (VOR) approach: An approach flown using tracking guidance from a ground based VHF transmitter.

[7] Discontinuity: Where there is a break in the FMC programmed flight path between waypoints or instrument flight procedures the FMC will indicate a discontinuity. The flight crew will need to input further information into the FMC to complete the programmed flight path.

Figure 1: POLLI FOUR PAPA (left) and POLLI FOUR BRAVO (right) arrivals



Source: Operator (annotated by ATSB)

At 0905 Eastern Daylight-saving Time (EDT), the aircraft was about 70 km (38 NM) southwest of Canberra at flight level (FL) 120,[8] with the autopilot engaged. ATC instructed the flight crew to contact the Approach controller. After establishing contact with the flight crew, the Approach controller instructed the flight to continue descending to 9,000 ft above mean sea level (AMSL). The controller advised the flight crew to expect the VOR approach to runway 35.

After the flight crew were advised to expect the VOR approach, they immediately requested the RNAV-Z approach. ATC instructed the flight crew to track to the commencement of the RNAV-Z approach at SCBSG and to expect the RNAV-Z approach. Due to high terrain to the south and southwest of Canberra, the RNAV-Z approach via SCBSG must be commenced from an altitude at or above the minimum sector altitude (MSA) of 7,500 ft. This altitude constraint is included in the FMC programmed flight path when selecting an approach using the arrivals/departures page in the FMC.[9]

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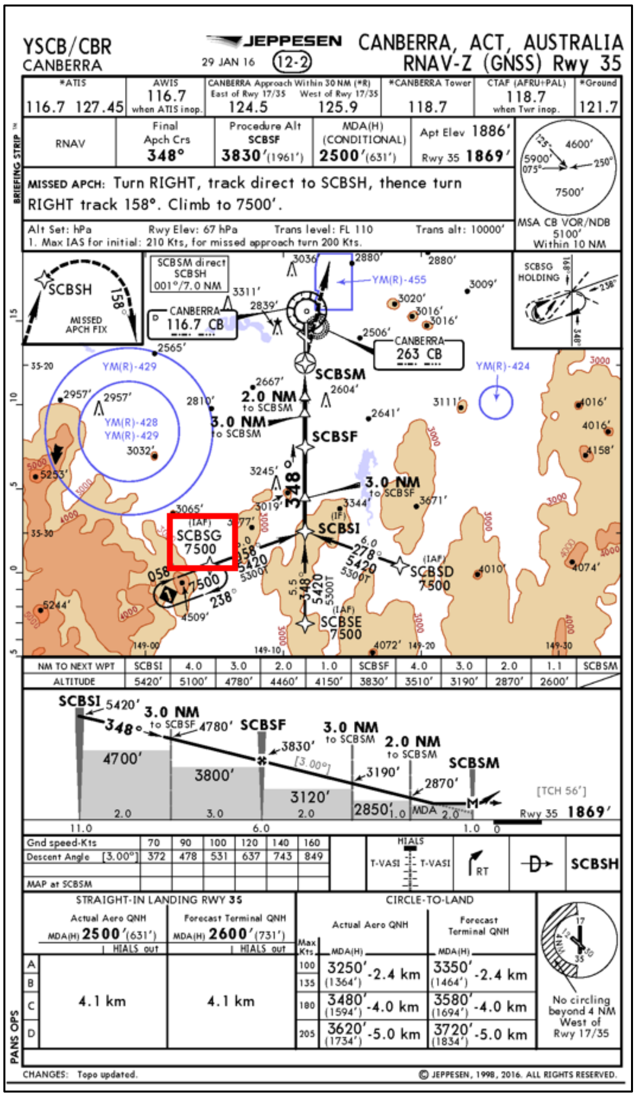
[8] Flight level: at altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 120 equates to 12,000 ft.

[9] When an RNAV-Z approach is selected in the aircraft FMC, all waypoints associated with that approach are programmed into the FMC, including altitude constraints for each leg of the approach. When an individual waypoint is manually entered into the FMC, no altitude constraint is automatically associated with that waypoint.

Figure 2: RNAV-Z Approach



Source: Operator (annotated by ATSB)

After the controller advised the flight crew to expect the RNAV-Z approach, the captain manually re-entered SCBSG into the FMC without detecting that the 7,500 ft MSA constraint was now missing. The captain then manually connected SCBSG to SCBSI for the continuation of the approach.

At 0908, ATC cleared the flight for the RNAV-Z approach. After receiving clearance to conduct the RNAV-Z approach, the first officer entered the final approach fix crossing altitude of 3,900 ft[10] into the autopilot altitude selector. This directed the autopilot to continue descent to 3,900 ft.[11]

At 0909.16 in visual conditions, the aircraft tracked towards SCBSG. About 7.5 NM (13.9 km) prior to SCBSG, the aircraft descended below 7,500 ft (Figure 3). At 0909.37, as the aircraft descended to about 7,000 ft, the controller contacted the flight crew and advised that they were required to maintain 7,500 ft until SCBSG. The flight crew immediately disconnected the autopilot and

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[10] The final approach fix crossing altitude was 3,830 ft. As the autopilot altitude selection is made in 100 ft graduations, the first officer elected to use 3,900 ft.

[11] Had the 7,500 ft minimum safe altitude constraint at SCBSG remained in the autopilot, the FMC would have automatically restricted descent to 7,500 ft until passing SCBSG. After passing SCBSG, the descent would then have recommenced and continued to 3,900 ft.

climbed the aircraft to 7,500 ft. After climbing to 7,500 ft, the first officer reconnected the autopilot with 7,500 ft as the selected altitude.

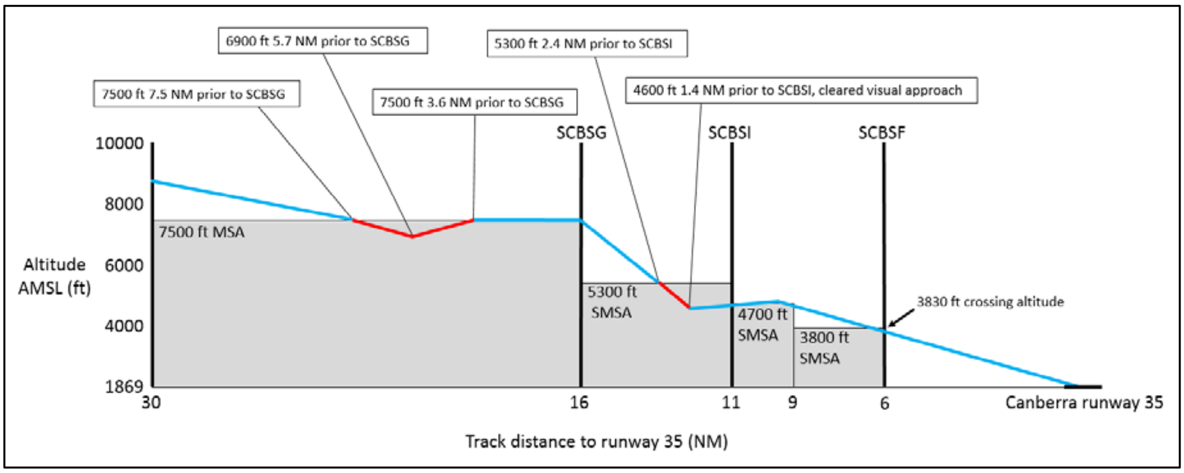
At 0911:24, after the aircraft passed SCBSG, the first officer selected the final approach fix crossing altitude of 3,900 ft in the autopilot altitude selector and the aircraft commenced descending. The segment minimum safe altitude (SMSA)[12] for the leg of the approach from SCBSG to SCBSI was 5,300 ft.

As the aircraft descended through about 6,000 ft, and before they had passed SCBSI, the first officer sighted the runway. The first officer advised the captain that they wished to manually fly the aircraft and conduct a visual approach to runway 35. The captain agreed and the first officer disconnected the autopilot and commenced a manual visual approach. The flight crew did not advise ATC that they were visual and had sighted the runway, or that they had elected to conduct a visual approach.

At 0912.37, about 2.1 NM (3.9 km) prior to passing SCBSI on the segment between SCBSG and SCBSI, the aircraft descended below 5,300 ft. As the aircraft descended to about 4,600 ft the captain commented that the aircraft approach profile was becoming low. At the same time, the controller contacted the flight crew and advised them that the aircraft was below the SMSA and that they were required to maintain 5,300 ft until passing SCBSI. The first officer immediately levelled the aircraft at about 4,600 ft. The flight crew advised the controller that they had the runway and terrain in sight. The controller then cleared the flight to conduct a visual approach. After being cleared for a visual approach, the first officer commenced a climb to about 5,000 ft and re-established the aircraft on the desired approach profile.

At 0917, the aircraft landed on runway 35. The aircraft was not damaged and no persons were injured.

Figure 3: Arrival and approach profile



Source: ATSB, derived from Airservices Australia radar data

Captain comments

The captain of 9V-SRP provided the following comments:

- The runway 35 ILS was not available, therefore the RNAV-Z approach was selected as this approach provided the lowest available minimum descent altitude (MDA).[13] The captain did not

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[12] The segments of an RNAV approach between the waypoints include a SMSA. The SMSA are included to provide aircraft with terrain clearance during the approach. When conducting an approach, aircraft should not descend below the SMSA to ensure terrain clearance.

[13] Minimum descent altitude is the lowest altitude to which an aircraft conducting an instrument approach which does not include glideslope guidance may descend. The flight crew must be visual to continue the approach below this altitude or conduct a missed approach.

expect to receive, and had not prepared, for the POLLI FOUR BRAVO arrival and associated VOR approach.

- After receiving the POLLI FOUR BRAVO arrival, the captain elected to delay requesting the RNAV-Z approach until in contact with the Approach controller. The captain was not sure how the clearances were coordinated between different ATC units in Australia and believed it would be simpler to request the approach directly from the Approach controller.
- As the POLLI FOUR BRAVO arrival tracked via MENZI, this presented a smooth transition to the RNAV-Z approach at SCBSI. The captain did not expect ATC to instruct the flight crew to track via SCBSG as this required a left turn from their position to SCBSG, then a right turn to SCBSI, then another left turn onto final approach.
- The waypoint SCBSG should have been added to the FMC programmed flight path by selecting the SCBSG transition using the arrivals/departures page of the FMC. This would have ensured the SCBSG 7,500 ft altitude constraint remained programmed into the FMC.
- ATC should have been advised when they became visual and elected to conduct a visual approach.
- At the time the first officer commenced the visual approach, the runway 35 T-VASIS[14] was not visible.
- During the visual approach, the flight crew used runway visual perspective and attitude along with a check of expected altitudes at specified distances from the runway to assess the approach profile.

Operator report

The operator conducted an investigation into the incident which identified the following points:

- The flight crew fixated on flying the RNAV-Z approach as the crew had briefed and planned for this approach. The approach briefing did not include reversion to conventional navigation.
- Standard operating procedures direct the flight crew to advise ATC when the flight crew have established visual conditions and are flying a visual approach.
- The company operations manual states that flight crew must check FMC waypoints against the arrival chart, the navigation display map and the control display unit. This check shall include the verification of any altitude and speed constraints.
- The flight crew training manual directs flight crew to avoid making manual entries when an approach or transition is available in the FMC, to prevent input errors or omissions.
- Any transition to a visual approach should only be made when the appropriate cues to ascertain vertical profile such as T-VASIS are clearly visible.

Related occurrences

A number of ATSB investigations have examined occurrences relating to deviations in flight path involving foreign crew operating within Australia. Of these, three are summarised below, full reports are available at the *ATSB website*.

ATSB investigation AO-2011-086

At 2019 at night on 24 July 2011, a Boeing Company 777-3D7 aircraft, operated by Thai Airways, was conducting a runway 34 VOR approach to Melbourne Airport, Victoria. During the approach, the tower controller observed that the aircraft was lower than required and asked the flight crew to check their altitude. The tower controller subsequently instructed the crew to conduct a go-around. However, while the crew did arrest the aircraft's descent, there was a delay of about 50 seconds before they initiated the go-around and commenced a climb to the required altitude.

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[14] T-VASIS: a 'T' shaped visual approach slope indicating system that uses high intensity lighting to assist pilots identify the correct approach path to the runway.

The ATSB established that the pilot in command may not have fully understood some aspects of the aircraft’s automated flight control systems and probably experienced ‘automation surprise’ when the aircraft pitched up to capture the VOR approach path. As a result, the remainder of the approach was conducted using the autopilot’s flight level change mode. In that mode the aircraft’s rate of descent is unrestricted and therefore may be significantly higher than that required for an instrument approach. In addition, the flight crew inadvertently selected a lower than stipulated descent altitude, resulting in descent below the specified segment minimum safe altitude for that stage of the approach and the approach not being managed in accordance with the prescribed procedure.

ATSB investigation AO-2010-027

On 4 and 29 May 2010, an Airbus A330-343E aircraft, was being operated by AirAsia X to the Gold Coast, Queensland. On both occasions, there was low cloud and reduced visibility on arrival at the Gold Coast.

During VOR approaches conducted at Gold Coast Airport on both days, the flight crews descended the aircraft below the segment minimum safe altitudes. As a result, the aircraft descended to an altitude where there was no longer separation assurance from terrain and aircraft operating outside controlled airspace.

ATSB investigation AO-2008-080

On 17 December 2008, a Boeing Company 737-4MO aircraft, operated by Garuda Indonesia, made a significant diversion around weather at night while en route to Darwin, Northern Territory. The aircraft was cleared to conduct the runway 11 VOR approach via the initial approach fix NASUX. After the weather diversion, it was more convenient for the flight crew to make a pilot intercept of the 285 radial from the VOR but there was a period of misunderstanding as a result of a breakdown in the application of standard radiotelephony readbacks.

The flight crew left the previously-cleared altitude of 3,000 ft on descent although they had not been cleared to do so. When this became apparent, no updated clearance for a pilot intercept of the 285 radial was issued by the controller. The aircraft continued to descend on the basis of the runway 11 VOR descent profile, even though it was not conducting the runway 11 VOR approach.

The flight crew used the position calculated by the aircraft's inertial reference system (IRS) to intercept the 285 radial, instead of using the signal from the VOR. The IRS position was not accurate enough for this, and the aircraft tracked to outside of the stipulated 5 degrees tolerance either side of the 285 radial. From then on, the aircraft was no longer 'established' on the 285 radial even though it was below the minimum sector altitude in cloud. When it broke through the cloud, the aircraft was clearly not aligned with the runway and a missed approach was carried out.

ATSB Comment

Over recent years, the number of active VORs has reduced as part of the Airservices Australia *Navigation Rationalisation Project*. Global navigation satellite system (GPS) is now the primary means of navigation for instrument flight rules aircraft, including RNAV approaches where an ILS is not available.

Internationally, the prevalence of VOR approaches is even further reduced. This reduces the exposure of international flight crew to VOR approaches and therefore reduces the familiarity of international flight crew with the conduct of a VOR approach.

This incident, along with the previous occurrences identified above, highlight the importance of familiarity with this approach type. However, this familiarity may be reduced for foreign flight crews operating into Australia.

The air traffic services provider in Australia, Airservices Australia, advised that all of the runway connected STARs have been removed from the VOR approaches at Melbourne, Adelaide and all but one at Perth to discourage their use. While the VOR approaches are still available on request, flight crews are assigned only instrument approach procedures that are connected to STARs.

Safety analysis

The flight crew planned to conduct the POLLI FOUR PAPA arrival and RNAV-Z approach. When ATC issued instructions for the POLLI FOUR BRAVO arrival and VOR approach, the flight crew accepted the POLLI FOUR BRAVO arrival while preparing to conduct the RNAV-Z approach, instead of the associated VOR approach. This lead to a discontinuity in the programmed flight path between the arrival and approach. The flight crew did not select the entry to the approach in the FMC and manually entering the waypoint SCBSG. As the waypoint was manually entered, the 7,500 ft altitude constraint was not included into the FMC programmed flight path. This missing altitude constraint was not detected by the flight crew.

The flight crew entered the altitude of 3,900 ft into the autopilot altitude selector prior to commencing the approach. With the autopilot engaged, the aircraft descended through 7,500 ft prior to commencing the approach at SCBSG. The flight crew did not detect that the aircraft had descended through the 7,500 ft MSA. The approach controller identified the error and alerted the flight crew.

Once established visual with the runway, the flight crew elected to conduct a manually flown visual approach without advising ATC, and did not receive a clearance to discontinue the RNAV-Z and conduct a visual approach. The aircraft then descended below the standard profile which led to the aircraft descending below the 5,300 ft SMSA prior to passing SCBSI.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The captain manually entered the waypoint SCBSG into the FMC instead of selecting the RNAV-Z approach via waypoint SCBSG. This removed the 7,500 ft altitude constraint.
- The crew did not identify the aircraft had descended below the 7,500 ft minimum sector altitude prior to passing SCBSG.
- Prior to passing SCBSI, the flight crew elected to conduct a visual approach without advising air traffic control, the flight crew then descended the aircraft below the 5,300 ft segment minimum safe altitude.
- The aircraft was in visual conditions at all times.

Safety message

This incident highlights the importance of preparation and communication prior to commencing a phase of flight. Requesting a preferred clearance early allows ATC to ensure that a clearance can be provided, or if not available, allows the flight crew time to prepare for a different clearance.

The Australian air traffic control provider, Airservices Australia, document: *Standard Instrument Arrival Routes (STARS)* provides further information to assist flight crew in adhering to clearances when conducting arrivals and approaches.

This incident also underlines the importance of adhering to standard operating procedures (SOPs). By deviating from SOPs and manually entering the waypoint, the crew removed a protection which was in place to prevent data input errors.

The ATSB has identified numerous accidents worldwide that were the result of simple human errors in data calculation or entry.

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.

Data input errors-such as the wrong figure being used as well as data being entered incorrectly, not being updated, or being excluded-happen for many different reasons.

The consequences of these errors can range from rejected take-offs through to collisions with the ground. Errors can occur irrespective of pilot experience, operator, aircraft type, location and take-off performance calculation method.

General details

Occurrence details

Date and time:	22 February 2017 – 0909 AEDT	
Occurrence category:	Incident	
Primary occurrence type:	Flight below minimum altitude	
Location:	40 km SSW of Canberra Airport, Australian Capital Territory	
	Latitude: 35° 18.42’ S	Longitude: 149° 11.70’ E

Aircraft details

Manufacturer and model:	The Boeing Company 777-212	
Registration:	9V-SRP	
Operator:	Singapore Airlines	
Serial number:	33369	
Type of operation:	Air Transport High Capacity	
Persons on board:	Crew – 13	Passengers – 235
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	

Loading related event involving Boeing 737, VH-VUF

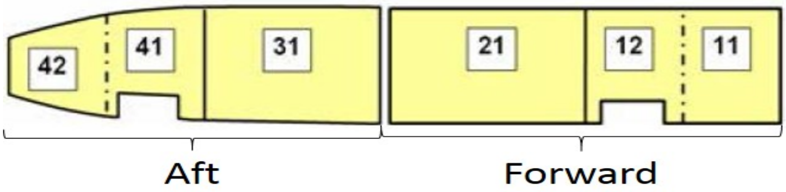
What happened

On 13 December 2016, a Virgin Australia Boeing 737-800 aircraft, registered VH-VUF, was being prepared to operate flight VA 1393 from Adelaide, South Australia to Brisbane, Queensland.

At 0927 Central Standard Time (CST), the graphical load instruction report (GLIR) was sent to the ramp staff allocated to load the aircraft. Virgin Australia used an electronic load control system (LCS), which was accessed by the leading hand on a mobile tablet device to organise the loading of the aircraft.

The GLIR indicated the Brisbane bound bags and all cargo (seafood and four dogs) were to be loaded in the forward compartment (section 21), and the bags which would be transferred to connecting flights and the priority Brisbane bags were to be loaded in the aft compartment (section 31) (Figure 2).

Figure 2: Compartments of a Boeing 737-800



Source: Operator (modified by the ATSB)

While loading the aircraft, a member of the loading staff advised the leading hand that the Brisbane bags would not fit into the compartment with the cargo unless they were placed on top of the dog crates. If the bags were placed on the crates, the loading staff thought the dogs may not have enough oxygen to breathe. To resolve this issue, the leading hand used the LCS to move 55 bags into section 31, and saved the changes in the system. When the changes were made, the 'Move Mode' and the 'Ramp Clear Mode' buttons on the tablet's screen greyed out and the load control status changed to 'LL'.[1] The loading staff proceeded to load these bags in section 31. When the leading hand refreshed the device after the bags had been moved, the status returned to normal and the leading hand presumed the changes had been accepted.

At about 0938, the load controller in Brisbane noticed an approval request in the LCS (for the load to be redistributed). This request was for 55 bags (equal to 870 kg) to be moved from section 21 to section 31. The LCS will allow the leading hand/load supervisor to move up to 500 kg of freight provided the centre of gravity moment does not change by more than 5 index units[2] without the approval of the load controller only if the resultant centre of gravity remains within operational limits. However, as this amount exceeded the limits, the change needed to be approved by the load controller. Two indications were generated by the LCS for the leading hand indicating the system was locked and the take-off index was exceeded (greying out of the 'Ramp Clear Mode' and 'Move Mode', and the load control status change to LL).

A high priority message was also shown on the load controller's screen stating the take-off index had exceeded the aft limit by 4.8 index units. This meant the aircraft was no longer within the

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[1] LL means 'Load Control Closed-Approve Distribution required'.

[2] A unit of measure used to represent the moment of an aircraft or the moment effect of adding or removing weight from an aircraft. A moment is the weight of an object multiplied by the distance of the object from a datum.

required centre of gravity limits. In response, the LCS was locked for 7 minutes while the load controller calculated the required changes to the load and approved the changes in the LCS.

The load controller calculated that moving 40 bags from section 31 of the aircraft back to section 21, or moving a number of passengers forward, would be enough to return the aircraft to balance.

Because the leading hand was using the mobile application, the load controller thought they had a direct line of communication with the leading hand so they used the in-built messaging system to send a message. The message the load controller wrote was the request to move the bags was denied and the solution was to move passengers or to put 40 bags in section 21. The load controller received no response from the leading hand and amended the LCS. The flight information was then unlocked so the ground crew could continue to update the LCS. The leading hand did not receive these messages and they subsequently finalised the flight, without making any changes or checking the LCS, and the final documents were released by the LCS automatically. This indicated the changes had been accepted and the aircraft had been loaded correctly.

After the aircraft had departed, the leading hand was re-checking the paperwork and saw the bags had been moved in the LCS back to section 21 by load control. The leading hand then spoke to the airport movement co-ordinator (AMCO). The AMCO attempted to contact the aircraft by radio, but received no response.

The AMCO then contacted the load controller to explain what had happened. The load controller determined the aircraft was out of balance by 4.8 index units past the aft limit for take-off and the flight crew should be advised 40 bags (equal to 626 kg) were in section 31, not section 21.

To return the aircraft to balance, the load controller advised the AMCO that three passengers would have to move forward from zone D to zone B. When the flight crew rang for the departure call, the AMCO passed on this information, however, when asked to confirm they had received this information, there was no response. Flight dispatch then contacted the flight crew via satellite phone and confirmed the flight crew had received this information. The flight crew contacted the cabin supervisor with the request to move three passengers forward. There were no control issues during flight.

Loading procedures

Virgin’s airport airside operations manual included the following steps in regards to loading aircraft:

Loading aircraft

- The load supervisor/leading hand/delegate confirms the final load is loaded in accordance with the final loadsheet and this is reflected in the loading report (LDR).

Live animals loading/unloading

- All ramp staff are responsible for monitoring and protecting the welfare of live animals.
- Baggage and/or cargo must not be loaded on top of cages and ventilation holes on the cages must not be covered.

Load control system

Subscribe to flight

- Before a flight is selected to work on, the user must first subscribe and add themselves to it. This is needed to ensure any messages regarding the flight are received and it also adds the users contact details.

Identifying compartment overloads

- Compartments will only display in red on the LCS, if the leading hand/AMCO/delegate makes a change to the deadload[3] that exceeds the compartment weight or volume.

Deadload change ramp tolerance

- Changes can be made to a flight's deadload on the LCS without having to verbally communicate with load control. The change to the deadload weight for a Boeing 737, in the operator's system, is limited to 500kg when the change to the centre of gravity moment is no more than 5 index units and the resultant centre of gravity remains within operational limits.
- Changes that are made outside these tolerances will need to be approved by load control. The notification is sent automatically to load control for their approval.
- If load control denies the change request, e.g. out of balance, then a phone call will be made to the port to advise. If the change is approved, the leading hand/AMCO/delegate will see this approval by viewing the load control flight status.
- As a result, if changes are required above the pre-determined tolerances, the leading hand/AMCO/delegate should contact the load controller for the flight by either phone or by using the message screen.

Out of balance

Virgin's load control standard operating procedures included the following steps in regards to solving out of balance situations:

- Contact the leading hand/delegate with the requirements advising what deadload and in which compartment it needs to be moved to.
- The leading hand/delegate is responsible for ensuring the deadload is redistributed as advised and updated in the mobile application to reflect the changes.

Operator report

The operator conducted an internal investigation with the following findings:

- If the aircraft is out of trim, overweight or the move exceeds the pre-set tolerance (500kg and/or five index units) allowable for a ramp agent the change, as long as it is acceptable, may be approved by the load controller. Any change requiring load control acceptance, is indicated by the 'Move Mode' and 'Ramp Clear Mode' buttons becoming 'greyed out' and not being accessible. In addition to this, the load control status at the top of the screen changes to 'LL' (Load Control Closed-Approve Distribution required). The leading hand recalled being unsure of what the load control status meant.
- The load controller used the flight management loading system to move the 40 bags to compartment 21. The screen on the mobile application was refreshed a short time later with the 'Move Mode' and 'Ramp Clear Mode' button becoming active, indicated by the buttons having a green border and text. The leading hand believed the 'Move Mode' and 'Ramp Clear Mode' buttons had become active after the refresh of the screen as a result of their original change.
- The visual aids incorporated into the flight management mobile application alone are not effective in preventing a configuration misalignment.

Load controller comments

The load controller provided the following comments:

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[3] Cargo, such as baggage or freight.

- They thought using the messaging system was the best way to communicate with the leading hand given they had just made the change in the system and thought they had a direct line of communication via the messaging system.
- The GLIR is automatically generated by the system.

Leading hand comments

The leading hand provided the following comments:

- Making changes to the load plan is considered a last resort and only if necessary. This is emphasised given this incident.
- Once the changes were made in the LCS, they assumed the changes were accepted and did not double check the figures accurately. Cross checking the LDR and the actual load is part of the procedure.
- There have been instances in the past where the load plan has not been practical, but it can be difficult to predict because they do not always know about the size of the bags, for example.

AMCO comments

The AMCO provided the following comments:

- To receive messages within the system, you must add and subscribe to the flight you are currently loading. Because the leading hand was not subscribed to the flight, they did not receive the messages.
- It is possible to enter into flights within the system without subscribing as it is not a compulsory screen. It is also possible to enter flights without realising you have not subscribed.
- The load controller advised based on the fuel usage, the aircraft would be in trim for landing.

Previous occurrences:

A search of the ATSB database of previous loading related occurrences involving incorrect load or weight on the aircraft were detected, particularly when procedures were not followed during the process and discrepancies were not identified in the load sheet:

- Loading related event, Bali, Indonesia, 26 May 2014 (ATSB investigation AO-2014-110).[4] A Boeing 737 aircraft was being loaded at Bali Airport for a flight to Melbourne, Victoria. Due to the time restrictions, the ground staff were unable to load all of the bags for the flight before aircraft had to be prepared for departure. The load controller assessed a total of 93 bags had been loaded and the flight documents produced were using that figure. About 30 minutes after the aircraft departed Bali, the ground handler advised network operations and load control the final baggage numbers were incorrect. The total number of bags loaded onto the aircraft was 189 instead of 93, which an estimated additional weight of about 1,600 kg. Prior to loading, the ground crew were under time pressure due to the flight already being delayed, breakdown of a baggage belt, scheduled closure of the runway, and impending airport curfew.
- Loading event, Sydney Airport, New South Wales, 8 September 2016 (ATSB investigation AO-2016-119).[5] An Airbus A320 was being loaded at Sydney for a flight to Brisbane, Queensland. The leading hand received the deadload weight statement (DWS) and checked the containers. The third container number (1483) did not match the number listed on the DWS (4183), nor the container card (4183). The leading hand assumed the freight handler had inadvertently transposed the numbers incorrectly and amended the card and DWS with 1483 and continued loading. When the aircraft was unloaded in Brisbane, it was found that the incorrect container (1483) was delivered and was nearly 650kg heavier than container 4183. The loading procedure if the DWS is incorrect is the container must not be loaded onto the aircraft. The

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[4] www.atsb.gov.au/publications/investigation_reports/2014/aair/ao-2014-110/

[5] www.atsb.gov.au/publications/investigation_reports/2016/aair/ao-2016-119/

leading hand noted the short turnaround time and the flight was the last one of the day led to procedures being bypassed.

Safety analysis

The first step for users in the LCS is to subscribe and add themselves to the flight. This is undertaken to ensure the messages are received by people within the network, such as AMCOs, load controllers, freighters, and leading hands. This is not a compulsory page in the LCS and can be skipped when opening a particular flight. The leading hand had not subscribed to the system, meaning they did not receive the messages from the load controller about the aircraft being out of trim due to the movement of baggage from section 21 back to section 31.

When the baggage from section 21 was moved to section 31 by the leading hand in the LCS, the system locked. This was indicated on the LCS display by the buttons being greyed out and the load control status at the top of the screen changing to ‘LL’. This did not provide clear indications that the load distribution change needed acceptance by the load controller before proceeding with loading the aircraft. The leading hand was not sure what the load control status meant. Furthermore, as the system returned to open when they reset the system they did not realise that changes had been made in the LCS.

The load controller received an error message in the system because the number of bags moved by the leading hand meant that the aircraft was out of balance. The load controller attempted to contact the leading hand via the messaging system but was unaware the leading hand was not subscribed to the system so the messages were not received.

The operator had two procedures for load control to notify the leading hand that changes have been made in the LCS. The 'deadload change ramp tolerance’ in the standard operating procedures for the flight management mobile application required that load control make a phone call to advise the leading hand or the AMCO that they had denied a change request through the LCS. The second procedure, which is in the controlling document used by load control, for ‘out of balance operations’ required that load control communicated the requirements to the leading hand (which was normally done through the messaging system within the LCS). In this incident, the load controller used the messaging system which was not effective as the leading hand was not subscribed to the system.

Once the loading is completed, it is the leading hand’s responsibility to confirm that the LDR reflects how the aircraft has been loaded. Although the leading hand did check, they did not detect the error until after the aircraft had departed.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The leading hand was not subscribed to the load control system, meaning they did not receive the messages from load control about the aircraft being out of trim and subsequent change to the load distribution.
- Although the load control system locked after the leading hand made changes to the load distribution, it did not provide sufficient feedback to the leading hand to indicate that the changes needed to be accepted by the load controller before proceeding.
- Although the controlling document for load controller noted that contacting the leading hand was required due to an out of balance situation, another document regarding the loading system specified a phone call was to be made.
- The leading hand did not accurately cross check that the aircraft was loaded in accordance with the LDR.

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.

Operator

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

Safety bulletin: subscribing to flights

The operator has issued a safety bulletin for leading hands to subscribe to the flight management system.

> *Due to recent occurrences throughout the network, it has highlighted the requirement to ensure leading hands subscribe to flights which they are assigned to, in the Flight Manager Program.*
>
> *Subscribing to a flight attaches your contact details to the flight.*
>
> *This will allow messages to be sent between you and load control. Once subscribed to a flight you will receive a conformation pop up message. You can subscribe to more than one flight at a time.*

Safety bulletin: changes to deadload

The operator has also issued a safety bulletin about making changes to deadload:

> It is very important that changes made to the planned deadload remain at a minimum, and they must only be made if deemed absolutely necessary – i.e. if there are concerns with the safety of the flight or there is restricted volume in the aircraft hold.
>
> If changes are required above the pre-determined Deadload Change Ramp Tolerances, the Leading Hand/AMCO/Delegate should contact the Load Controller for the flight by using the message screen in the Ramp Application, or if this is not possible, by phone. It is important to read and acknowledge all messages received from the Load Controller.

System functionality

> New system functionality is being introduced where a leading hand allocates him/herself to a flight and therefore no one else has access.

Safety message

This incident highlights the importance following procedures and communication have during the loading process. Communication when there is an error is particularly important to ensure all team members share the same understanding of the error and the correction. The ATSB report: *Aircraft loading occurrences - July 2003 to June 2010* identified loadsheet errors as contributing to these occurrences.

General details

Occurrence details

Date and time:	13 December 2016 – 0950 CST	
Occurrence category:	Incident	
Primary occurrence type:	Loading related	
Location:	Adelaide Airport	
	Latitude: S 34° 56.70' S	Longitude: 138° 31.83' E

Aircraft details

Manufacturer and model:	Boeing 737	
Registration:	VH-VUF	
Operator:	Virgin Australia Airlines	
Serial number:	34168	
Type of operation:	Air Transport High Capacity	
Persons on board:	Crew – 6	Passengers – 154
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	

Turboprop aircraft

In-flight smoke in the cockpit involving GIE Avions de Transport Regional ATR72, VH-VPJ

What happened

On 22 February 2017, at 1433 Eastern Daylight-saving Time (EDT), a Virgin Australia ATR 72-212A aircraft, registered VH-VPJ, departed Port Macquarie Airport, New South Wales (NSW) to operate scheduled flight VA1188 to Sydney, NSW. There were four crew and 23 passengers on board.

At 1453:35, during cruise at Flight Level (FL) 180,[1] the Centralized Crew Alerting System (CCAS) alerted the flight crew to a failure of the number one static inverter (Figure 1).[2] The CCAS then displayed multiple messages indicating a loss of power to systems associated with the number one static inverter. The aircraft electrical system power transfer function automatically transferred these systems to the number two static inverter and the CCAS warnings extinguished.

At 1453:43, the cockpit master warning activated and the CCAS displayed an electrical smoke warning. The flight crew immediately donned their oxygen masks and enacted the smoke checklist memory items. As the flight crew fitted the oxygen masks, they detected a strong electrical type burning odour and observed faint wispy smoke within the cockpit. After conducting the memory items, the flight crew then completed the electrical smoke checklist. The checklist included selecting the avionics vent exhaust mode to overboard. After completing this selection, the flight crew reported the smoke quickly dissipated. Flight data shows the electrical smoke warning extinguished at 1454:56.

After completing the electrical smoke checklist, the captain identified Williamtown Airport about 65 km (35 NM) south east of the aircraft and elected to divert the flight to Williamtown.

At 1455, the captain contacted air traffic control (ATC) and declared a MAYDAY.[3] The captain advised that they intended to divert to Williamtown Airport. ATC cleared the flight to descend and track directly to Williamtown.

After contacting ATC, the captain requested that the senior cabin crew (SCC) report to the aircraft interphone using the cabin public announcement system. The SCC heard the announcement, but due to muffling caused by the captain's oxygen mask, they did not understand the request. The second cabin crewmember heard the announcement more clearly and communicated the request to the SCC. The SCC contacted the flight deck using the aircraft interphone. The captain advised them of the emergency and that the flight was diverting to Williamtown. The SCC advised the other cabin crewmember of the diversion and commenced securing the cabin.

After securing the cabin, the SCC returned to their seat and contacted the flight deck. The captain provided them with a full briefing, advising the nature of the emergency and to expect a precautionary disembarkation[4] after landing. Recognising the high workload of the flight crew, the

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[1] Flight level: 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] Static inverter: a component of the aircraft electrical system which changes direct electric current to alternating current.

[3] MAYDAY: an internationally recognised radio call announcing a distress condition where an aircraft or its occupants are being threatened by serious and/or imminent danger and the flight crew require immediate assistance.

[4] Precautionary disembarkation: a disembarkation of the aircraft using the normal aircraft exits in as timely a manner as possible. Passengers are briefed to clear exit paths, leave belongings on the aircraft and that the precautionary disembarkation may become an evacuation at any time. Passengers in emergency exit rows are briefed on their actions during the precautionary disembarkation and possible evacuation.

SCC advised the captain that they would conduct the passenger briefing tasks on behalf of the flight crew. The captain instructed the SCC to begin the precautionary evacuation once the seat belt sign extinguished after landing.

As the aircraft descended through 10,000 ft, the flight crew removed their oxygen masks. The captain found the remaining odour very strong and elected to refit the oxygen mask. The captain identified that the aircraft was too high to commence an approach to Williamtown and conducted a descending orbit to lose height prior to commencing a visual approach for runway 12. While approaching runway 12, the captain found the oxygen mask blurred their vision. The captain briefly handed control of the aircraft to the first officer and removed the oxygen mask.

At 1512, the aircraft landed on runway 12. After landing, ATC instructed the flight crew to taxi the aircraft to Bay 11. Once the aircraft stopped and the flight crew shut the engines down and extinguished the seat belt sign, the SCC initiated the precautionary disembarkation. The SCC used the cabin public address system to direct passengers to disembark the aircraft using the cabin door. Emergency services personnel met the disembarking passengers and guided them clear of the aircraft to a safe area.

After shutting down the engines, the flight crew noticed the smell intensifying. The captain elected to immediately vacate the flight deck. The flight crew followed the last passenger and the cabin crew in vacating the aircraft through the cabin door.

The aircraft was not damaged and no persons were injured during the incident.

Figure 3: Number one static inverter

Source: Operator

Captain comments

The captain provided the following comments:

- Time was lost due to difficulties with the first officer refitting their headset after donning the oxygen mask. The oxygen mask also created difficulties in communication between the flight crew and cabin crew. Managing these communication difficulties added to the flight crew workload during the emergency.
- While the company did not operate the ATR 72 to Williamtown and the captain had not previously operated there, the captain commented that the best place for an aircraft with smoke in the cockpit is on the ground. The long runway, available emergency services and clear weather between their position and the airport enabled the captain to quickly elect to divert to Williamtown.

Senior cabin crew member comments

The senior cabin crew (SCC) provided the following comments:

- They had not expected and were not prepared for the communications difficulties caused by the flight crew's use of oxygen masks. Their voices were heavily distorted which led to difficulty in understanding information. After the initial briefing from the captain, the SCC did not realise there was a smoke issue and believed the aircraft was experiencing an unspecified 'leak'. After the initial briefing, they began to prepare the cabin for a possible depressurisation.
- Due to the communications difficulties caused by the flight crew oxygen masks, the SCC did not realise that they were being requested to contact the flight crew and did not immediately respond.
- The aircraft interphone does not allow the flight deck to address all cabin crew at the same time. Therefore, the SCC was required to relay information to the other cabin crewmember. This made it difficult for the other cabin crewmembers to be fully aware of the progress of the incident and increased the SCC's workload.
- Cabin preparation procedures for the precautionary disembarkation require that the SCC use designated Cabin Preparation cards. These cards provide guidance for full and reduced cabin preparation procedures and associated passenger briefings. The cards were located under the SCC's seat and were inaccessible while seated. As the SCC was unable to leave their seat during the period between receiving the full briefing from the captain and landing, they were unable to access these cards.

Engineering examination

The manufacturer of the static inverter conducted an engineering investigation of the failed static inverter. The investigation found that the failure of the number one static inverter and associated smoke and odour was caused by a failure of the C603 capacitor within the number one static inverter.

The aircraft manufacturer also noted that the operator experienced two previous static inverter failures in November and December 2016. These failures were caused by failure of a C311 capacitor.

Vendor Service Bulletin

On 22 June 2016, the manufacturer of the static inverter released vendor service bulletin *SB 1-002-0102-2173-24-36*.

This service bulletin identified an issue with capacitor C311 which led to instances of reduced reliability and premature failure, sometimes with associated smoke emission. As part of this service bulletin, the C311 capacitor is replaced with a modified capacitor of increased reliability.

The service bulletin recommended that the modification be incorporated at the next shop visit for the static inverter units. After completion of the service bulletin modifications the static inverters are designated as 'Amendment E' status.

From October 2016, a retrofit campaign was undertaken by the static inverter manufacturer to refit all in-service static inverters to 'Amendment E' standard.

In December 2016, the aircraft manufacturer advised operators of the vendor service bulletin. The bulletin was classified as a minor change and did not imply safety concerns.

Continued static inverter issues

Following reports of failures of 'Amendment E' static inverters, the aircraft manufacturer identified an issue with additional capacitors within the static inverter. These capacitors are of the C60x (C601 through C605) series. Failures of these capacitors also led to failure of the static inverter unit and associated smoke emission.

Static inverter failure

In the event of failure of a static inverter, the power transfer function automatically transfers power of the associated electrical systems to the second static inverter.

The operator’s Minimum Equipment List allows dispatch of an aircraft with an unserviceable static inverter for a period of up to two days.

Safety analysis

A C603 capacitor within the number one static inverter failed in a manner consistent with other C60x series capacitor failures. Failure of the capacitor resulted in failure of the static inverter and smoke being emitted into the cockpit.

Difficulties in communication with the flight deck led the SCC to initially believe the flight crew were managing an unspecified ‘leak’. Therefore, the SCC began preparing for a possible depressurisation. However, as the required actions were similar to those required for the smoke event in progress, the misunderstanding did not impact on the management of the cabin during the incident.

The Cabin Preparation cards were inaccessible during the period that procedures directed the SCC to use them. However, as the SCC was able to complete the required actions without reference to the cards this did not impact on their ability to prepare the cabin for landing and the precautionary disembarkation.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The C603 capacitor within the number one static inverter failed leading to failure of the static inverter and associated smoke.
- Difficulties in communication caused by oxygen mask use led to misunderstandings between the flight crew and cabin crew and increased flight crew workload.
- The Cabin Preparation cards were inaccessible to a seated cabin crewmember.

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.

Operator

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

- Verifying the integrity of the Power Transfer function across the ATR fleet. The operator advised that after completing this campaign no adverse findings were reported.
- The operator has initiated a retrofit campaign to route all in-service static inverters to the vendor to have the modification to both the C311A and the C60x capacitors completed (‘Amendment E’ and ‘Amendment F’ (see *Aircraft manufacturer*) standard).
- The operator has initiated a fleet wide inspection and operational test of the oxygen mask integrated microphone.
- The operator has undertaken a risk assessment for single and dual static inverter failure.

Aircraft manufacturer

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

Short term actions:

- Replacement of C311 capacitor resulting in service units being modified to Amendment E standard. New production units have been modified and the retrofit process is on-going.
- Change in the manufacturing process with 'burn in' test on C60x capacitors resulting in units being modified to 'Amendment F' standard. New production units have been modified. The retrofit process is being prepared.

Mid-term actions:

- A design change is under development including the replacement of the C60x capacitors. The redesigned unit will be identified with a new part number. The design change certification expected to be complete before the end of quarter 2, 2017.

Safety message

This incident underlines the value of effective training and procedures. Despite the communications difficulties and the inaccessible cabin preparation cards, the cabin crew were able to effectively prepare the cabin during the diversion and manage the subsequent precautionary disembarkation. This enabled all aircraft occupants to disembark the aircraft quickly and without injury.

General details

Occurrence details

Date and time:	22 February 2017 – 1456 ESuT	
Occurrence category:	Incident	
Primary occurrence type:	Smoke	
Location:	77 km NW of Williamtown Airport, NSW	
	Latitude: 32° 09.40' S	Longitude: 151° 30.03' E

Aircraft details

Manufacturer and model:	ATR - Gie Avions De Transport Regional ATR 72-212A	
Registration:	VH-VPJ	
Operator:	Virgin Australia	
Serial number:	1169	
Type of operation:	Air Transport High Capacity - Passenger	
Persons on board:	Crew – 4	Passengers – 23
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	

In-flight engine shutdown involving Bombardier DHC-8, VH-XKI

What happened

On 18 April 2017, at about 0934 Western Standard Time (WST), a Bombardier DHC-8-315 aircraft, registered VH-XKI, departed from Meekatharra Airport, Western Australia (WA), for a charter flight to Leinster, WA. There were two flight crew, two cabin crew and 49 passengers on board.

The aircraft had departed from Perth Airport, WA, at about 0540 that morning, on a charter flight to Leinster, with Meekatharra as the alternate airport. While the aircraft was en route to Leinster, the flight crew received an updated weather report, which indicated there was fog present at Leinster. The flight crew conducted one approach at Leinster and as they did not get visual with the runway, they diverted to Meekatharra. While on the ground at Meekatharra, the captain received a report from their[1] operations department in Perth that the weather at Leinster had improved. The captain elected to depart Meekatharra with sufficient fuel for the flight to Leinster while maintaining Meekatharra as the alternate airport.

The captain reported that the aircraft performed as normal during the take-off run. After take-off, the landing gear was retracted, followed by the flap.[2] At some point between retracting the flap and 1,000 ft above ground level, the flight crew experienced a vibration through the airframe and noticed a change in the pitch of the aircraft noise (deep pitch sound). The flight crew noticed the right propeller was at about 500 RPM (normal governed flight range is 900–1200 RPM) and the engine torque was excessively high.[3] The low propeller RPM and high engine torque led them to conclude the malfunction was an 'unscheduled feather'[4] incident.[5]

While the aircraft climbed to the lowest safe altitude, the flight crew shutdown the right engine, in accordance with their emergency operating procedures. Once at their lowest safe altitude, the flight crew engaged the autopilot, completed the checklist actions and made a PAN[6] radio broadcast to air traffic control. Noting that the aircraft was above the maximum landing weight, the flight crew reviewed the performance charts, and concluded that the runway at Meekatharra was suitable for an emergency landing and elected to return. The flight crew briefed the cabin crew that they were going to land overweight with one engine shutdown and therefore to prepare the cabin for an emergency landing. The aircraft landed without incident. No persons were injured and the aircraft was not damaged.

Unscheduled autofeather

The autofeather system meets the regulatory requirements for an automatic take-off thrust control system, and in the event of an engine failure, the system:

- trims the opposite engine power by a pre-determined amount to permit continued safe take-off without pilot intervention

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[1] Gender-free plural pronouns: may be used throughout the report to refer to an individual (i.e. they, them and their).

[2] Movable surface forming part of the trailing edge of the wing, which alters wing camber, cross section and area in order to exert a powerful effect on low-speed lift and drag.

[3] Engine torque limits were 90% maximum continuous, 100% maximum 5 minutes, 115% maximum 20 seconds.

[4] Feathering: the rotation of propeller blades to an edge-on angle to the airflow to minimise aircraft drag following an in-flight engine failure or shutdown.

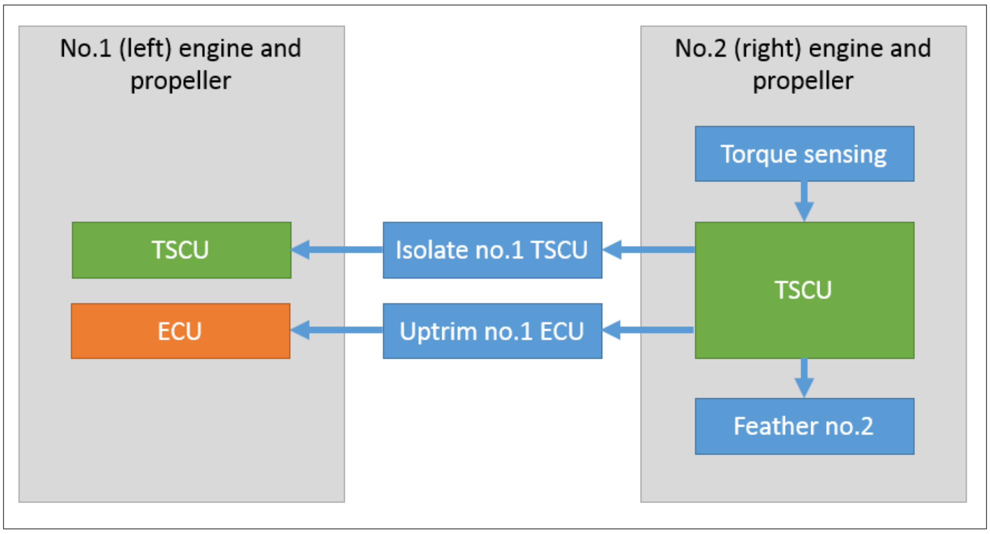
[5] The aircraft was fitted with an auto-feather system, which will automatically feather the propeller of a failed engine within specified operating parameters.

[6] PAN PAN: 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.

- feathers the propeller of the failing engine to minimise the drag after a three second time delay.

In the event of an engine failure on take-off (less than 29 per cent torque sensed), the failed engine torque signal conditioning unit (TSCU) initiates autofeathering by switching its logic from ‘arm’ to ‘arm and fail.’ A relay signals the engine control unit (ECU) of the other engine to increase power (uptrim) to compensate for the failed engine (Figure 1). After 3 seconds, the TSCU logic transitions from ‘arm and fail’ to ‘fail and feather’. This isolates the second engine’s TSCU to disable its autofeather system to ensure both propellers cannot be feathered at the same time, and energises the failed engine feathering solenoid to feather the propeller of the failed engine.

Figure 4: Autofeather overview for no.2 (right) engine failure



Source: ATSB (information from aircraft manufacturer)

Aircraft inspections

The operator’s maintenance organisation downloaded the flight data recorder for analysis by the engine manufacturer. It was determined that an uptrim signal was sent to the left engine by the right engine TSCU and the right engine experienced an over-torque event of 146% for 25 seconds.[7] Both engine control units provided several fault codes, which were investigated with no defects found. The right engine TSCU and propeller hub and blades were replaced in accordance with the directions from the respective manufacturers. The right engine reduction gearbox[8] and oil system were inspected with no defects found. In addition, the right engine electronic controller was replaced for troubleshooting purposes.

In 2002 the aircraft manufacturer published an in-service engineering and technical support letter titled ‘Autofeather arming and uncommanded autofeather events’. The purpose of the letter was to identify uncommanded autofeather events and suggest solutions. The maintenance organisation referred to this letter for troubleshooting and completed the procedures for ‘autofeather during power applications’ and ‘autofeather during take-off or climb with the system armed (uncommanded).’ No defects were found. It was determined from the flight data analysis that a heavy landing inspection was not required. After several engine ground runs were conducted at take-off power with the autofeather system armed, without any faults, the aircraft was flown to Perth. The flight to Perth was reported as uneventful and the aircraft was returned to service.

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[7] The over-torque was likely the result of the engine attempting to maintain normal propeller operating speed at the time that the propeller was attempting to feather.

[8] The reduction gearbox is installed between the engine and the propeller and reduces the high rotational speed of the turbine engine to the slower rotational speed of the propeller.

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.

Operator

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

Maintenance inspections

The operator's continuing airworthiness management organisation has scheduled recurrent inspections of the reduction gearbox oil system and are following up with the engine manufacturer for their findings concerning the removed engine electronic controller and torque signal conditioning unit.

Safety message

The aircraft captain reported that they felt the incident was handled well by the flight crew and cabin crew. They found that the use of automation was effective in reducing their workload while responding to the malfunction. Despite the fact that both cabin crew were relatively new to the company, the captain could clearly hear them making their emergency landing calls to the passengers in accordance with their emergency operating procedures. The captain reported that the incident was completely unexpected, which highlighted to them the need for, and benefit of, regular simulator training.

General details

Occurrence details

Date and time:	18 April 2017 – 0934 WST	
Occurrence category:	Incident	
Primary occurrence type:	Propeller / rotor malfunction	
Location:	Meekatharra Airport, Western Australia	
	Latitude: 26° 36.70' S	Longitude: 118° 32.87' E

Aircraft details

Manufacturer and model:	Bombardier Inc. DHC-8-315	
Registration:	VH-XKI	
Serial number:	587	
Type of operation:	Charter – passenger	
Persons on board:	Crew – 4	Passengers – 49
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	

Piston aircraft

Fuel starvation involving Cessna 210, VH-HZE

What happened

On 6 February 2017 at around 0730 Australian Eastern Daylight-saving Time (AEDT), the pilot of a Cessna 210 aircraft, registered VH-HZE, departed Mildura Airport, Victoria, for Broken Hill Airport, New South Wales (NSW), to conduct a private business flight under visual flight rules.[1]

The pilot had been to the airport the previous afternoon to prepare the aircraft, which included filling the two fuel tanks.

After arriving in Broken Hill an hour after departure, the pilot was joined by two work colleagues. From Broken Hill, they flew for 40 minutes to Katalpa Station, NSW, to visit clients. After Katalpa, they flew 30 minutes to Pine View Station, NSW, to visit other clients. From Pine View Station, the pilot flew 45 minutes back to Broken Hill to drop off their two work colleagues. After departing Broken Hill, the pilot tuned the radio to Mildura aerodrome weather information service (AWIS) to check the weather. The weather was cloudy, but suitable for a visual approach.

Approximately 70 NM (130 km) from Mildura, the pilot listened to the AWIS again. The AWIS advised that there was broken[2] cloud at Mildura at 4,000 ft and visibility was 10 km.

Passing 12 NM (22 km) on approach to Mildura, the pilot made a broadcast to advise that they were approaching the airport. The pilot reported that during the approach, the AWIS indicated that the cloud base was varying between 1,000 ft and 3,000 ft. Therefore, the pilot decided to approach Mildura overhead to observe the conditions.

Approaching the airport, the pilot noticed the weather was overcast over the airport, but clear on the northern side of the Murray River.

The pilot manoeuvred the aircraft initially to the east and then to the north of Mildura for about 20 minutes before they set up for a straight-in approach for runway 18. Once established on the approach, they started descending. They were about to make a broadcast that they were joining a straight-in approach to runway 18 when the engine stopped. The pilot then made a MAYDAY[3] call to Melbourne Centre.

The pilot had been flying the aircraft with the fuel tank selector set to both tanks. They cycled the selector to the right tank and switched on the auxiliary fuel pump, but there was no response from the engine. The pilot noticed that their fuel flow computer was indicating 90 L of fuel remaining when the engine failed.

The pilot decided not to attempt to land on the runway as they would have had to fly over a populated area and instead identified Amaroo Road as suitable for a forced landing. On approach, they noticed there were powerlines on both sides of the road and changed their landing site to a nearby paddock.

The pilot landed the aircraft in the paddock and collided with a fence during the ground roll. Once the aircraft had stopped, the pilot selected the master switch to off and exited the aircraft uninjured. The aircraft was substantially damaged (Figure 1).

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[1] A set of regulations that permit a pilot to operate an aircraft only in weather conditions generally clear enough to allow the pilot to see where the aircraft is going.

[2] Used to describe an amount of cloud covering the sky of between five and seven okta (eighths).

[3] An internationally recognised radio call announcing a distress condition where an aircraft or its occupants are being threatened by serious and/or imminent danger and the flight crew require immediate assistance.

Figure 1: Damage to HZE

Source: Pilot

Pilot comments

The pilot provided the following comments:

- At most, the trip would take 4 to 4.5 hours, so fuel was not expected to be an issue.
- The fuel selector was selected to both tanks.
- There were no abnormal engine indications, or sounds from the engine to indicate that the engine was about to fail.

Fuel management

The pilot reported they filled the tanks with around 197 L the evening before. This was consistent with the amount of fuel they believed was used from the last flight, around 200 L. Overall, after refuelling, the total amount of useable fuel on board should have been 435 L. Their planned fuel flow was about 75 L per hour. Therefore, their planned endurance with full fuel tanks was just under six hours. The pilot recorded they were flying for four hours and 15 minutes before the engine failed.

The pilot reported that the aircraft was parked with the left wing low at the fuel point and when they refuelled the fuel tanks in the wings, so they might have stopped before the tanks were full. However, the pilot reported that the fuel gauges indicated the tanks were about full. The pilot advised that they visually checked the fuel levels the next morning, but did not use a dipstick. The fuel caps are on the wing tips which makes visually checking the fuel level difficult.

The aircraft was installed with a fuel flow computer known as an EDM 930 (also known as a JPI). The fuel flow computer tracks the fuel flow to the engine to calculate fuel remaining. The pilot must enter the fuel on board the aircraft at the start of the flight, as the computer does not take fuel measurements from the fuel tanks.

After the engine is started, there is a prompt on the computer to enter whether any fuel was added to the aircraft. If no fuel is added to the tank, the user can exit the screen, otherwise they can choose ‘next’ to select ‘yes’ if fuel was added which automatically resets to a quantity of 435 L.

Upon approach, the fuel gauge indicated the left tank was near empty, but the right was half full.

The Cessna fuel system is designed so fuel can be drawn from either the right tank or the left tank or from both tanks at the same time. The pilot advised that they normally flew with the fuel selector on both tanks. They advised that during the cruise at 4,000 ft, they had leaned the fuel mixture.

After the accident, an inspection was conducted which found the left fuel tank was empty and the right tank had 25 L of fuel remaining, half of which was useable. The Cessna 210 manual states that if the aircraft is flown out-of-balance when fuel tanks contents are one quarter full or less, then the fuel tank outlets can uncover, causing fuel starvation and engine stoppage. The fuel selector was selected on ‘right tank’, but the pilot had advised that this was selected after the engine had failed.

Weather

The Bureau of Meteorology provided a weather report with the aerodrome forecasts.

The amended aerodrome forecast (TAF)[4] which was valid at the time of the accident was broken clouds at 1,500 ft, with rain and visibility was greater than 10 km. It also forecast intermittent periods of broken cloud at 600 ft with visibility of 5,000 m with rain. These conditions were still suitable for a visual flight.

Previous occurrences

A search of the ATSB’s database found 12 occurrences in 2016 where fuel starvation led to an engine failure. Two examples are:

- On 18 April 2016, a Lancair ES aircraft took off from an airstrip near Mansfield, Vic. and was climbing to about 500 ft when the engine lost power (ATSB investigation AO-2016-037[5]). The pilot established the aircraft in a glide and conducted a forced landing. The maintenance personnel assessed the reason for the power loss was fuel starvation as the aircraft was parked on an incline prior to taxi and fuel may have drained away.
- On 12 August 2016, the pilot of a Cessna 172 was conducting powerline inspections near White Cliffs, NSW (ATSB occurrence 201602162). After finishing checking a powerline, the engine lost power and the pilot conducted a forced landing. The engineering inspection revealed the engine failed due to a lack of useable fuel in the left fuel tank.

Safety analysis

The pilot thought the aircraft had been filled to the maximum fuel level because they had considered how much the fuel was used the previous flight, which was 200 L, and the tanks did not appear to take more fuel at 197 L. The ground where the aircraft was refuelled was on an incline which meant the aircraft had its left wing down, so the left tank may have appeared full before it actually was, as the refuelling points are on the end of the wing. The aircraft was parked on level ground overnight, to ensure fuel did not leak out through the breather. The following morning, the fuel was checked visually in the tank, but not physically by using a dipstick. Therefore, it is uncertain whether the aircraft was filled with the maximum fuel level.

The pilot was using the fuel flow computer for fuel usage monitoring, however, it does not provide a direct reading of fuel contents from the fuel tanks, only fuel flow. The fuel remaining is calculated by the computer by subtracting the fuel consumed in-flight from the fuel manually entered by the pilot at the start of the flight. Only the fuel gauges provide the pilot with an indication of the actual amount of fuel left on board.

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[4] 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 reference point.

[5] https://www.atsb.gov.au/publications/investigation_reports/2016/aair/ao-2016-037/

While circling Mildura Airport attempting to find a break in the clouds to land, the pilot conducted numerous turns with both fuel tanks were selected. However, as the left tank was likely to be empty at that time, it is probable the right fuel tank outlet was uncovered during the manoeuvring, resulting in fuel starvation and subsequent engine failure.

Given the fuel burn rate and the remaining usable fuel on board, the aircraft had about 10 minutes of flying time remaining before complete fuel exhaustion.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The engine failed due to fuel starvation when the limited amount of fuel remaining in only one of the two tanks became unusable during manoeuvring.
- Prior to departure, the aircraft's fuel tanks were probably not full. However, the pilot selected full fuel tanks on the fuel flow computer and therefore the fuel flow computer provided the pilot with a higher reading of fuel on board than what was actually on board.

Safety message

The investigation is a reminder of the importance of monitoring fuel levels prior to – and during – the flight. When monitoring the fuel levels, it is important to note the limitations of flight instruments. The ATSB has published a report *Avoidable Accidents No. 5 - Starved and exhausted: Fuel management aviation accidents* which outlines strategies in fuel management.

General details

Occurrence details

Date and time:	6 February 2017 – 1637 EST	
Occurrence category:	Accident	
Primary occurrence type:	Fuel starvation	
Location:	11km N of Mildura	
	Latitude: 34° 07.82' S	Longitude: e.g. 142° 06.32' E

Aircraft details

Manufacturer and model:	Cessna 210N	
Registration:	VH-HZE	
Serial number:	P21000859	
Type of operation:	Private	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Substantial	

Runway excursion involving Gippsland Aeronautics GA-8, VH-AZH

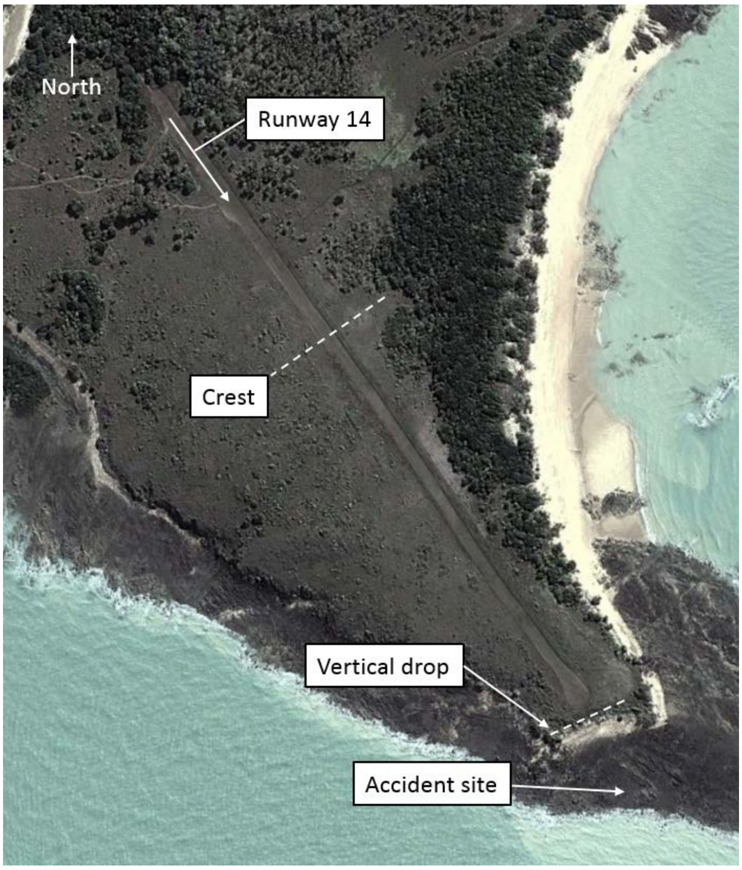
What happened

On the afternoon of 23 March 2017, the pilot of Gippsland Aeronautics GA-8 Airvan, VH-AZH, prepared for a departure from Avoid Island aeroplane landing area (ALA)[1] (Figure 1), Queensland (Qld) for a passenger charter flight to Mackay, Qld.

The company had elected to split the load of five passengers and cargo between two aircraft, a Cessna 206 and the GA-8.[2] On board the GA-8 were the pilot and three passengers, along with 30 kg of cargo and 92 kg of fuel, resulting in a take-off weight of 1,521 kg.[3]

While preparing for the departure, the pilot observed a 5–10 kt wind from the south-east and elected to use runway 14 for take-off. Runway 14 was a grass runway, 800 m long and included a slight rise in the middle. At the end of the runway was a vertical drop of about 2 meters down to a rocky beach.

Figure 5: Avoid Island ALA



Source: Google Earth, annotated by ATSB

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[1] Aeroplane landing area: An area of ground suitable for the conduct of take-off and landing of aeroplanes.

[2] The Cessna 206 can be fitted with up to five passenger seats, the GA-8 can be fitted with up to seven passenger seats.

[3] The structural maximum take-off weight of VH-AZH was 1,905 kg.

At about 1555 Eastern Standard Time (EST), the pilot in the GA-8 commenced the take-off run ahead of the Cessna 206. During the take-off run, the pilot maintained slight back pressure on the control column to minimise the weight on the aircraft nose wheel. The rotation[4] speed for the take-off was 58 kt. The pilot elected to use a point about half way along the runway as the decision point for the continuation of the take-off, this point was located just after the crest in the runway. As the aircraft passed the decision point, the pilot noted that the airspeed was about 40 knots and engine indications were normal. As the aircraft performance was satisfactory, the pilot elected to continue the take-off.

As the aircraft continued on the downhill side of the crest, the aircraft encountered a soft patch of runway surface, resulting in a slight deceleration. As performance quickly returned, the pilot did not consider this to be an issue.

As the aircraft approached the end of the runway, just prior to reaching the rotation speed, the pilot felt a significant deceleration. The pilot identified that insufficient runway remained to stop the aircraft, and in an attempt to avoid the aircraft falling over the vertical drop, elected to continue the take-off.

The aircraft did not take-off before overrunning the runway and became airborne as it passed over the vertical drop at a speed of about 50 kt. While manoeuvring to avoid large rocks and obstacles (Figure 2), the pilot maintained a nose high attitude to minimise the effect of any impact. The aircraft was unable to maintain height and descended over about a further 100 m until the landing gear and underside of the rear fuselage impacted rocks. As the aircraft decelerated, the impact through the rudder pedals forced the pilot’s ankle against the control column.

Figure 6: Accident site

Source: Operator, annotated by ATSB

After the aircraft came to rest, the passengers began to evacuate the aircraft. The pilot secured the aircraft and assisted the passengers with the evacuation. After securing the aircraft, the pilot then contacted the pilot of the Cessna 206 and advised them not to attempt to take-off.

The pilot of the Cessna 206 taxied that aircraft to the end of runway 14, contacted emergency services and provided assistance to the occupants of the GA-8.

The pilot of the GA-8 suffered a fractured ankle, the passengers were uninjured in the accident.

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[4] Rotation: the positive, nose-up, movement of an aircraft about the lateral (pitch) axis immediately before becoming airborne.

Pilot comments

The pilot of VH-AZH provided the following comments:

- The pilot landed on runway 14 at Avoid Island ALA about 15 minutes prior to the accident flight. After landing, the pilot taxied the full length of the runway before turning around to return to the threshold of runway 14 to meet the passengers. While taxing, the pilot did not detect the soft patches in the runway. The pilot observed that the grass was dense and about 100 mm in length.
- Performance calculation charts in the GA-8 pilot operating handbook did not provide for a runway with long wet grass and both an uphill and downhill component. Therefore, the pilot had used the 'worst case' scenario when calculating the take-off distance required[5] for runway 14 at Avoid Island ALA. The pilot calculated the take-off distance required to be 590 m when assuming a two percent upslope for the entire take-off run and short dry grass.
- The wind conditions at the time of the take-off were not consistent. A change in wind speed or direction may have contributed to the accident.
- The company chief pilot operated from Avoid Island ALA three days prior to the accident flight and found the ALA to be in good condition.

Operator comment

The operator of VH-AZH provided the following comments:

- After the accident, the grass on the runway was mowed and the runway was inspected. The operator found the significant deceleration toward the end of the take-off run was the result of an area of soft runway surface and mud. During the pilot's taxi after the previous landing, and during the accident take-off run, this area had been concealed by grass.
- The pilot had received training at Avoid Island ALA and had recently operated to the ALA.

Weather and prior rainfall

The pilot reported 5–10 kt of wind from the south-east, cloud at about 1,500 ft and patches of drizzle in the Avoid Island area at the time of the accident.

Avoid Island did not have recorded weather observation data. Weather stations at nearby locations, Middle Percy Island and St Lawrence (Figure 3), reported the below rainfall totals[6] over the days prior to, and the day of the accident (23 March).

Table 1: Rainfall totals at Middle Percy Island and St Lawrence

Date	Middle Percy Island	St Lawrence
20 March	20.0 mm	16.2 mm
21 March	81.0 mm	70.8 mm
22 March	44.6 mm	66.4 mm
23 March	23.2 mm	36.4 mm
24 March	3.4 mm	46.2 mm
Total	**172.2 mm**	**236.0 mm**

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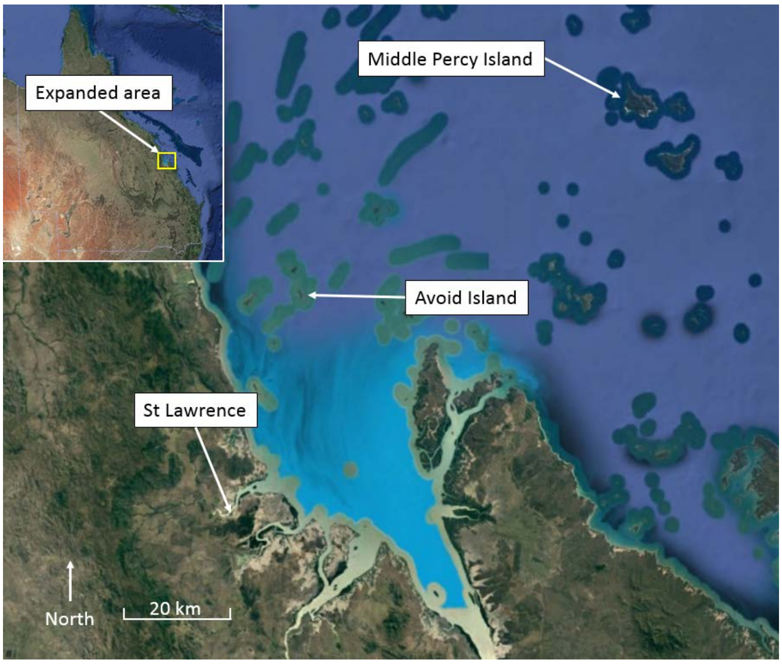
[5] Take off distance: The horizontal distance required for an aircraft to accelerate from stationary, take-off and climb over a 50 ft (15 m) obstacle. As runway 14 at Avoid Island ends with small bushes, the remaining climb to 50 ft may be calculated to be conducted over the beach and water after clearing this obstacle.

[6] Daily rainfall for the listed day is the 24 hour total rainfall from 0900 on the day prior until 0900 on that day.

Figure 3: Avoid Island location



Source: Google Earth, annotated by ATSB

Safety analysis

The Chief Pilot had visited the island three days prior to the accident flight and found the ALA in good condition, however, rainfall over the intervening period created soft patches in the runway surface.

The operator chose to split the load between two aircraft to provide more margin for the operation and the pilot calculated that sufficient runway was available for the GA-8 take-off. However, the soft patches, along with wet grass, prevented the aircraft from completing the take-off in the runway available.

Findings

- The soft patches in the runway surface, concealed by grass, very likely degraded aircraft performance during take-off. The location of the soft patches towards the end of the runway prevented the aircraft taking off before the runway end.

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 action:

Aeroplane landing area management

- The operator has taken over management of maintenance of the Avoid Island ALA. This will enable the operator to ensure that the ALA is suitable for proposed operations.
- The operator is investigating the feasibility of works to improve drainage on the ALA.

- The guidance documents for all regularly used ALAs have been updated and significantly expanded.
- More rigorous pilot training of ALA operations will be conducted in future. The operator is investigating the use of an ALA which simulates the conditions of Avoid Island ALA and also has a cross runway to provide for crosswind training and assessment.

Safety message

When operating from an ALA, the pilot must take great care to ensure that the ALA condition is suitable for the proposed operation. ALA operations can present numerous and varied challenges which may affect the safety of flight. In this case, the Chief Pilot had visited the island just three days prior, however, rainfall over those three days had greatly impacted on the serviceability of the ALA. In addition, the dense grass present created difficulties in identifying the soft patches of runway.

The Civil Aviation Safety Authority advisory publication: *CAAP 92-1 Guidance for aeroplane landing areas* provides the following information on the use of ALAs:

> *The surface of a landing area should be assessed to determine its effect on aeroplane control and performance. For example, soft surfaces or the presence of long grass (over 150 mm) will increase take-off distances while moisture, loose gravel or any material that reduces braking effectiveness will increase landing distance.*

General details

Occurrence details

Date and time:	23 March 2017 – 1555 EST	
Occurrence category:	Accident	
Primary occurrence type:	Runway excursion	
Location:	50 km NW of Hollins Bay ALA (Avoid Island), Queensland	
	Latitude: 21° 58.83’ S	Longitude: 149° 39.87’ E

Aircraft details

Manufacturer and model:	Gippsland Aeronautics GA-8	
Registration:	VH-AZH	
Serial number:	GA8-07-111	
Type of operation:	Charter - passenger	
Persons on board:	Crew – 1	Passengers – 3
Injuries:	Crew – 1 (Serious)	Passengers – 0
Aircraft damage:	Substantial	

Hard landing involving Cessna 182, VH-JXX

What happened

On 1 April 2017, the pilot of a Cessna R182 aircraft, registered VH-JXX, conducted a private flight from Broken Hill to Bathurst, New South Wales, with one passenger on board.

The aircraft arrived overhead Bathurst Airport at about 1130 Eastern Daylight-saving Time (EDT) and the pilot elected to join the circuit on a left downwind for runway 35. The pilot reported that the approach was normal, and that they aimed to touch down slightly beyond the runway threshold.

Due to a crosswind of about 8 kt, the pilot recalled that the left main wheel touched down immediately before the right. The propeller then struck the runway and the nose landing gear collapsed. The aircraft skidded a short distance before coming to rest on the runway.

The aircraft sustained substantial damage and the pilot and passenger were uninjured (Figure 1).

Figure 7: VH-JXX showing damage to the propeller and nose landing gear

Source: Aircraft owner

Pilot comments

The pilot commented that the approach seemed normal, all indications were normal, and the landing did not feel particularly hard. The first time they were aware something was not normal was when the nose of the aircraft contacted the runway. They had lowered the landing gear on downwind and confirmed the green light indicated the gear was safely down and locked, and had also verified the main wheels were down by doing a visual check.

Post-accident inspection

An aircraft maintenance engineer inspected the aircraft after the accident. The nose landing gear had collapsed and the gear doors were broken. The cowl flaps were damaged, the firewall was buckled and the area under the floor in the area near the pedals was bent. There was no evidence of any fault other than the damage sustained in the impact.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The aircraft probably landed in a nose-low attitude resulting in a propeller strike and damage to the nose landing gear.

General details

Occurrence details

Date and time:	1 April 2017 – 1128 EDT	
Occurrence category:	Accident	
Primary occurrence type:	Hard landing	
Location:	Bathurst Airport, New South Wales	
	Latitude: 33° 24.57' S	Longitude: 149° 39.12' E

Aircraft details

Manufacturer and model:	Cessna Aircraft Company R182	
Registration:	VH-JXX	
Serial number:	R18201396	
Type of operation:	Private – Pleasure/Travel	
Persons on board:	Crew – 1	Passengers – 1
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Substantial	

Helicopters

Collision with water involving Robinson R44, VH-SCM

What happened

On 23 April 2017, the pilot of a Robinson R44 Raven II helicopter, registered VH-SCM, conducted a short local charter flight from a helicopter landing site (HLS) on top of a boat at Talbot Bay, Western Australia (Figure 1). The pilot dropped off three passengers and then returned the helicopter alone to the boat. The pilot then remained seated in the helicopter, with the engine running, while two new passengers embarked. The helicopter's doors had been removed previously.

At about 0940 Western Standard Time (WST), the helicopter lifted off from the boat rooftop HLS. The pilot conducted a descent from the HLS, which was about 20 ft above the water, to about 5 ft above the water and applied forward cyclic[1] so the helicopter would accelerate.

As the helicopter's airspeed approached about 50 to 60 kt, the low rotor RPM warning horn sounded. The helicopter started to yaw[2] to the left and the pilot applied right pedal to correct the yaw. About 1 second later, the front of the helicopter skids collided with the water and the helicopter rolled over into the water.

The pilot and two passengers released their seatbelts and exited the helicopter underwater, but sustained minor injuries. After they exited the helicopter they inflated their lifejackets and swam about 50 m to shore.

Figure 1: Location of accident site

Source: Google earth – annotated by ATSB

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[1] The cyclic pitch control, or cyclic, is a primary flight control that allows the pilot to fly the helicopter in any direction of travel: forward, rearward, left, and right.

[2] Term used to describe motion of an aircraft about its vertical or normal axis.

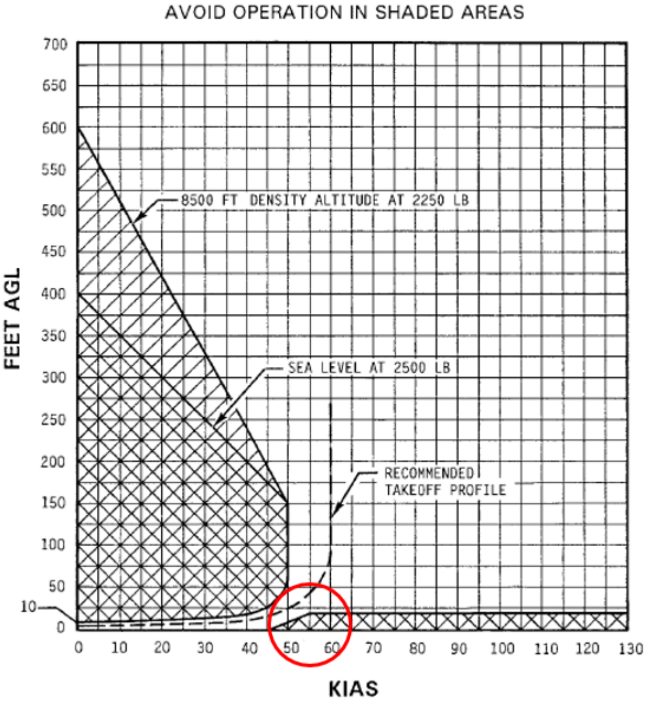
Departure profile

The pilot commented that their intention, in accordance with the height-velocity curve (Figure 2) published in the aircraft's pilot operating handbook, was to descend and remain in ground effect[3] until the helicopter had sufficient forward speed to achieve translational lift.[4]

The pilot reported rolling the cyclic and collective frictions off, ensuring the governor was on, rolling the throttle on until 102 per cent RPM was achieved, then lifting off into the hover, which was their normal lift-off procedure. The pilot then applied forward cyclic to accelerate the helicopter and descend from 20 ft to about 5–10 ft above the water level. The pilot was about to commence a climb (but had not yet raised collective[5] or applied aft cyclic) when the low rotor RPM warning horn sounded, indicating that the rotor RPM had reduced below 97 per cent. The helicopter struck the water about 300 m from the take-off site, at an airspeed the pilot estimated to be about 50 to 60 kt.

The pilot commented that although the helicopter was fitted with floats, they had no time to deploy them. The pilot and passengers were wearing life jackets, which they inflated after the helicopter collided with the water.

Figure 2: Robinson R44 II height-velocity curve



Source: Robinson R44 II Pilot's operating handbook

Helicopter performance

The helicopter all up weight was 1,044 kg, which was 90 kg below the maximum take-off weight of 1,134 kg. At that weight, with the air temperature 33 °C, high relative humidity, nil wind and at sea level, the helicopter was within the performance limitations to hover both in and out of ground effect. The pilot had conducted the previous flight in the same way only minutes earlier with an

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[3] When hovering within about one rotor diameter of the ground, the performance of the main rotor is affected by ground effect. A helicopter hovering in-ground-effect (IGE) requires less engine power to hover than a helicopter hovering out-of-ground-effect (OGE).

[4] Translational lift occurs when clear, undisturbed air, flows through the rotor system from wind or forward speed.

[5] Collective: 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.

additional passenger and the extra ten minutes of flight fuel on board, taking off in the same direction with nil wind, and had not had any issues with the helicopter's performance.

The maximum manifold pressure (or engine power) available for the flight based on the conditions was 25.9 inches. The pilot reported setting about 23 to 24 inches.

Helicopter maintenance

The Civil Aviation Safety Authority reviewed the helicopter log books and did not identify any anomalies. The helicopter engine had five cylinders removed, repaired or replaced in the preceding 50.8 hours due to low compression and high oil consumption. The engine had a total time of 1,778.2 hours since new, with a time between overhaul of 2,000 hours for that model engine.

Safety analysis

The helicopter was below the published maximum take-off weight and within the published weight limits for hovering in and out of ground effect. In addition, the speed at which minimum power is required is about 55 kt for the R44 II, therefore the power required at the accident speed was less than the power required to hover. In the reported calm conditions, the helicopter should have had sufficient power available to maintain rotor RPM. The ATSB was unable to determine the cause of the RPM decay.

The take-off profile recommended by the manufacturer was for the helicopter to achieve a height of 25 ft at an airspeed of 50 kt. However, the helicopter was still at 5–10 ft at 50–60 kt, which provided the pilot with very little reaction time to the low rotor RPM warning.

The pilot reported that there was no outstanding maintenance on the maintenance release (which was not retrieved from the helicopter) and that the helicopter had been running normally on the previous flight only minutes before the accident flight. As the helicopter had not been recovered from the water at the time of the ATSB investigation, no inspection of the engine had occurred.

The helicopter had recently undergone significant engine maintenance, mostly working on the cylinders, and was using more oil than normal, but not an abnormal amount for a running-in period. The pilot had topped up the oil prior to the first flight of the day. The pilot did not observe any warnings after the low rotor RPM horn sounded, but there was very little time before the helicopter collided with the water. The pilot commented that even a small drop in engine performance, such as from a magneto failure, would have been difficult to recover from at 5–10 ft above the water.

The pilot commented that as there was no wind, the water surface was glassy and they may not have been able to assess the height of the helicopter above the surface accurately. Operating at an estimated 5 ft above the water did not allow time to react in case of an engine failure or temporary reduction in performance.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The rotor RPM decayed below 97 per cent at 5–10 ft above the water and the pilot was unable to recover control of the helicopter, resulting in a collision with the water.
- The helicopter was below maximum take-off weight and had sufficient power to hover in and out of ground effect with the engine operating normally.

Safety message

According to the FAA rotorcraft handbook, pilots should avoid the low altitude, high airspeed portion of the height-velocity diagram, because their 'recognition of an engine failure will most likely coincide with, or shortly occur after, ground contact. Even if you detect an engine failure, there may not be sufficient time to rotate the helicopter from a nose low, high airspeed attitude to one suitable for slowing, then landing.'

Robinson Helicopter Company Safety Notice SN-19, Flying low over water is very hazardous, stated that 'Many pilots do not realize their loss of depth perception when flying over water.'

General details

Occurrence details

Date and time:	23 April 2017 – 0940 WST	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	Talbot Bay, Western Australia	
	Latitude: 16° 21.00' S	Longitude: 123° 55.00' E

Helicopter details

Manufacturer and model:	Robinson Helicopter Company R44 II	
Registration:	VH-SCM	
Serial number:	11157	
Type of operation:	Charter – passenger	
Persons on board:	Crew – 1	Passengers – 2
Injuries:	Crew – 1 Minor	Passengers – 2 Minor
Aircraft damage:	Substantial	

Remotely Piloted Aircraft

Collision with terrain involving Yamaha RMAX

What happened

On 6 April 2017, the operators of a Yamaha RMAX[1] remotely piloted aircraft system (RPAS) (Figure 1) were conducting aerial spraying about 23 km west of Canberra, Australian Capital Territory. One operator was acting as the remote pilot in command of the RMAX and the other was mixing chemical, ferrying it to the aircraft and loading it into the chemical tanks, or canisters, on the aircraft.

Figure 8: Yamaha RMAX

Source: Yamaha

The aircraft had been operating normally that day for about 1 hour and 15 minutes of flight time. At about 1400 Eastern Standard Time (EST), the aircraft was about 2 to 3 m above the ground returning to land, when the pilot and loader heard a ‘clunk’. The aircraft started yawing to the left and descending. The pilot selected opposite direction yaw input (right rudder servo), but the aircraft did not respond. The aircraft collided with terrain upright but in a nose-down attitude and then rolled onto its side, resulting in substantial damage (Figure 2). The pilot did not receive any warnings on the aircraft’s ground control station prior to the accident.

Subsequent inspection revealed that the tail rotor had separated from the aircraft and landed about 30 m from the rest of the aircraft.

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[1] Yamaha RMAX is a remotely piloted helicopter, body length 2.75 m (3.63 m including rotor), with a load capacity of 28 kg.

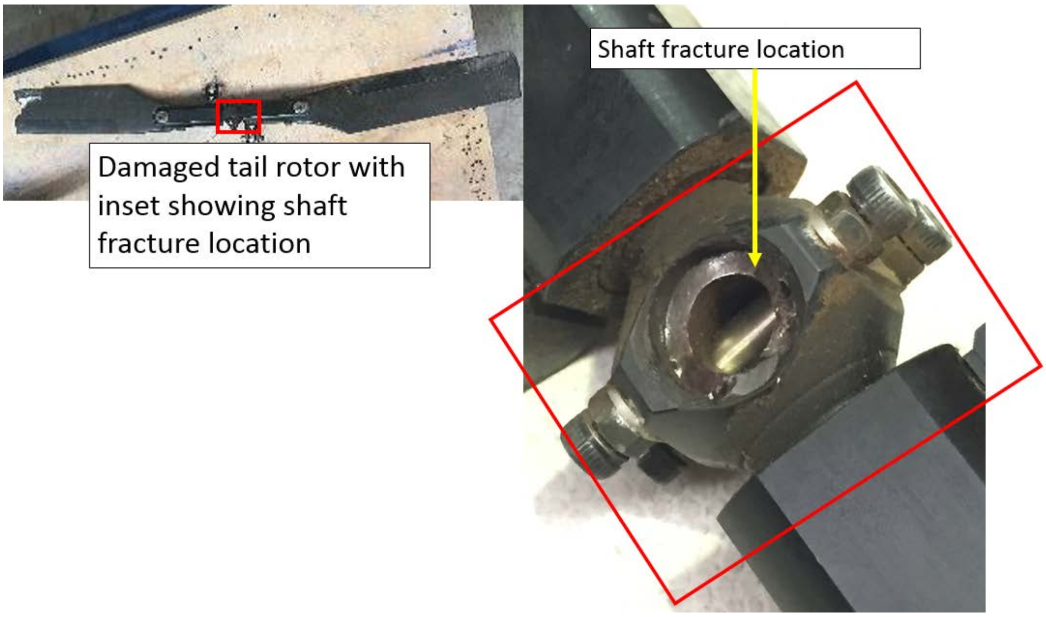
Figure 2: Damage to the RMAX

Source: Yamaha

Post-accident inspection

The manufacturer found that the tail rotor shaft had fractured, resulting in the tail rotor detaching from the aircraft (Figure 3).

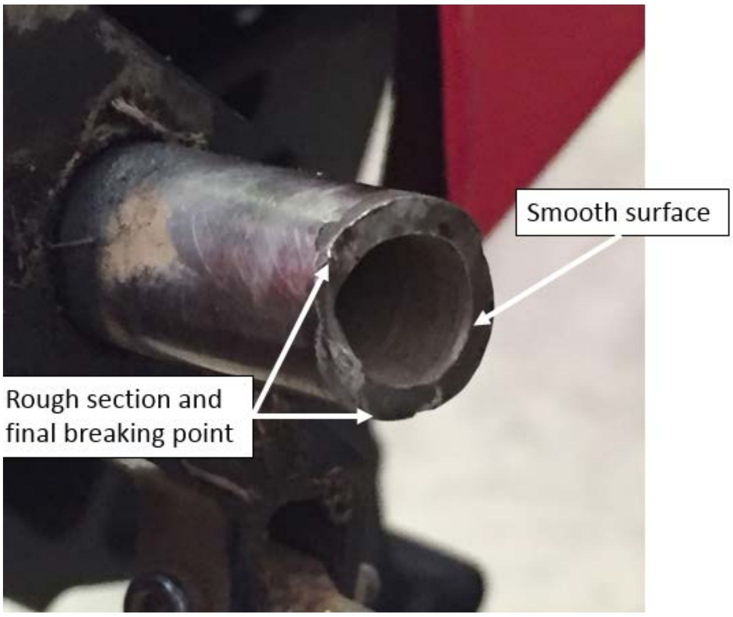
Figure 3: Tail rotor showing fracture location



Source: Yamaha

The manufacturer assessed that the fracture had probably existed for some time, as one section of the fracture site was smooth, indicating a pre-existing fracture. Another section of the fracture was rough indicating the failure occurred during the accident flight (Figure 4). The tail rotor blade (Figure 3) probably struck the tail cover after the shaft failed, as this allowed excessive movement in the tail rotor head.

Figure 4: Fractured tail rotor shaft



Source: Yamaha

Manufacturer investigation report

The manufacturer had conducted routine maintenance on the aircraft in October 2016. At that time, they found chips in the tail rotors and a broken antenna (fitted to the tail of the aircraft). The manufacturer replaced the antenna and tail rotor blades but was unable to determine how long the aircraft had been operating with the damage to the blades. Damage to the tail rotor blades may have caused an imbalance and extra load on the tail rotor shaft.

The manufacturer found the following factors may have contributed to the failure of the shaft:

- Impact with a small branch at the time the blades sustained chip damage.
- Possibly flying with rotor blades out of balance after the first impact, for an unknown period.
- Other damage to the aircraft indicative of mishandling during transport, which may have resulted in stress fractures to the rotor shaft.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The tail rotor drive shaft probably failed due to an existing fracture, resulting in the aircraft colliding with terrain.

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 safety action in response to this occurrence.

Aircraft manufacturer

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

Communication and reporting hub

Yamaha Motor Australia (YMA) is implementing an online form so that operators can send information and notification of incidents directly to Yamaha operations and maintenance departments.

YMA will modify operator’s manuals to better reflect handling standards.

Safety message

This accident highlights the importance of reporting all incidents and accidents, particularly to ensure adequate inspection and maintenance is conducted before returning the aircraft to operations.

General details

Occurrence details

Date and time:	6 April 2017 – 1400 EST	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	23 km W of Canberra, Australian Capital Territory	
	Latitude: 35° 17.03' S	Longitude: 148° 56.62' E

Aircraft details

Manufacturer and model:	Yamaha RMAX	
Registration:	N/A	
Serial number:	N/A	
Type of operation:	Aerial work – aerial agriculture	
Persons on board:	Crew – 0 (Unmanned)	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Aircraft 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
Aviation Short Investigations Bulletin Issue 61
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