Australian Government
Australian Transport Safety Bureau

Hydraulic system malfunction, return and evacuation, involving Airbus A330, VH-EBC

94 km west-north-west of Sydney Airport, New South Wales, on 15 December 2019

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Addendum

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Safety summary

What happened

On 15 December 2019, an Airbus A330-202 aircraft, registered VH-EBC and operated by Qantas Airways, departed Sydney, New South Wales on a scheduled passenger service. About 7 minutes after departure, the flight crew were alerted to a problem with one of the aircraft's 3 hydraulic systems. The flight crew followed the required checklists and decided to return to Sydney. Following an uneventful landing, the flight crew stopped the aircraft on a taxiway. Shortly after, the auxiliary power unit (APU) was started and the bleed air selected on to maintain air conditioning in the aircraft cabin, and the aircraft was towed to the terminal.

After the aircraft arrived at the terminal, a haze/smoke began to form in the cabin and flight deck, followed by passengers and crew experiencing physical symptoms. After consultation with the customer service manager and the first officer, the captain commanded an evacuation.

The first of 2 aerobridges had already been connected to the aircraft when the evacuation command was given. At this time, some passengers were already standing and had retrieved their cabin baggage. Slides were successfully deployed on 3 exits, and the second aerobridge was then connected to another exit. Two of the other 3 exits were not used and the slide was not successfully deployed at the other exit. Of the passengers who used the escape slides, one received serious injuries and 5 received minor injuries.

What the ATSB found

The rudder servo flexible pressure hose from the aircraft's green hydraulic system ruptured during the flight, which resulted in a hydraulic fluid leak towards the rear of the aircraft. The rupture was due to a combination of corrosion and fatigue cracking of the stainless streel braid in the hose.

Following a significant period of time after landing, the hydraulic fluid was ingested into the APU air intake, which led to atomised hydraulic fluid contaminating the aircraft cabin and flight deck through the air conditioning system. Although cabin crew members had smelt an odour they thought was related to the hydraulic system failure or similar fumes prior to arriving at the terminal, they did not convey this information to the flight crew.

The evacuation occurred at a unique time when cabin crew members had completed their shut-down duties and the aircraft was at the terminal with all the doors disarmed. Although cabin crew had covered a similar scenario during their initial training, in subsequent evacuation training the doors would always be armed. This may have been contributory to 2 of the cabin crew not rearming their door prior to opening it during the evacuation. In contrast, 2 of the other cabin crew members had verbalised what they would do if they were required to evacuate and were successful in executing their procedures without hesitation.

Some passengers (who used the aerobridges or the slides) retrieved their cabin baggage after the evacuation command was given. In addition, some passengers who evacuated using the slides carried their cabin baggage down the slides. As a result, the evacuation was delayed and the risk of injury to themselves and others was increased. The ATSB also found that information provided to passengers via the safety briefing and during the evacuation about what to do with cabin baggage in an evacuation and the use of escape slides was limited and inconsistent.

In addition, the primary evacuation commands practiced by cabin crew to instruct passengers in an evacuation did not include phrases such as 'leave everything behind' and 'jump and slide'. Consequently, passengers would generally not receive specific guidance until they reached an exit, which could potentially slow an evacuation. The operator also did not have a procedure for a rapid disembarkation, which would allow for rapid deplaning at a slower and more controlled pace than an emergency evacuation.

What has been done as a result

Qantas introduced a procedure for A330 flight crew to refrain from turning the APU bleed on until an engineering inspection had occurred following a hydraulic system leak. The operator also introduced a periodic replacement program for the pressure supply line to the hydraulic servo for all 3 hydraulic systems.

In addition, Qantas introduced periodic training that required cabin crew members to physically demonstrate the procedures for an evacuation at the terminal. It also amended its passenger safety briefing video showing passengers how to descend the escape slide. The operator advised it was also looking to incorporate ‘leave everything behind’ into its primary evacuation commands, and developing a procedural framework for the rapid disembarkation of passengers in circumstances where an evacuation and the use of escape slides may not be necessary.

Safety message

The management of passengers in an emergency situation is the last line of defence in avoiding injury and fatalities, therefore it is important that passengers are well informed through the provision of sufficient and accurate communication about what they may be required to do.

The timing of this occurrence highlights the necessity for crew members to remain prepared to react to an emergency at any time, until everyone has disembarked the aircraft. Using a method such as the silent review prompts cabin crew members to mentally rehearse emergency procedures, which ensures they are ready to act in case of an emergency.

Communication between the cabin crew and flight crew is essential in abnormal situations, and it is important for information to be relayed as soon as it becomes available. Cabin crew should be trained to recognise and report to the flight crew any unusual smells, sounds and sights, including the use of common terminology to describe odours.

Contents

The occurrence

Hydraulic system failure and return to Sydney

On the morning of 15 December 2019, an Airbus A330-202 aircraft, registered VH-EBC and operated by Qantas Airways, departed Sydney, New South Wales, on a scheduled passenger service to Perth, Western Australia. On board were 2 flight crew, 8 cabin crew and 222 passengers. The first officer (FO) was the pilot flying (PF) and the captain was the pilot monitoring (PM).[1]

The pre-flight preparations, boarding taxi and take-off were uneventful and the aircraft departed Sydney at 0844 Eastern Daylight-saving Time.[2]

At about 0851, a 'green' hydraulic system leak (HYD G SYS LEAK) message was displayed on the aircraft's electronic centralised aircraft monitor (ECAM). The flight crew monitored the leak and noted that the hydraulic fluid level for the green system was fluctuating and decreasing. As per the required ECAM actions, they turned off the engine-driven pumps for the green hydraulic system. At 0854, the flight crew advised air traffic control (ATC) of a hydraulic problem and requested to level off at flight level (FL) 230.[3]

At 0855, the pressure in the green hydraulic system started dropping and soon after the ECAM displayed a green hydraulic system[4] low pressure warning (HYD G SYS LO PR). The flight crew completed the required actions and decided to return to Sydney.

The captain took the role of PF and the FO the role of PM. The FO advised ATC and the operator about the return to Sydney and a requirement for a tow after landing. The captain informed the customer service manager (CSM)[5] and made a public announcement (PA) to the passengers, advising of the decision to return to Sydney.

The flight crew reviewed the ECAM status page and the inoperative systems. They also completed all checklist items, carried out an arrival briefing, and commenced descent. The weather for their arrival was reported to be clear visibility, with some scattered low cloud, wind from the north-west at about 8 kt, and a temperature of 24° C.

The flight crew later stated they had considered whether to issue a PAN[6] call, but decided they were not experiencing a situation that required urgency. Although the aircraft had lost one hydraulic system, there were still 2 other hydraulic systems available and they were not expecting any problems with landing the aircraft or exiting the runway after landing.

During the approach, the flight crew conducted the landing gear gravity extension procedure that was required due to loss of hydraulic control of the aircraft landing gear, which resulted in the landing gear doors remaining open for landing.

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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 Eastern Daylight-saving Time (EDT): Coordinated Universal Time (UTC) + 11 hours.

3 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 230 equates to 23,000 ft.

4 The Airbus A330 has 3 independent hydraulic systems, each identified by a different colour (green, blue, yellow).

5 The customer service manager (CSM) is the most senior cabin crew member on board the aircraft and manages the aircraft cabin on behalf of the captain.

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.

In response to the flight crew's advice about the hydraulic failure, ATC activated an alert phase[7] and 2 aviation rescue fire fighting service (ARFFS) vehicles (known as a tenders) were dispatched to attend the aircraft.

At 0927 the aircraft landed on runway 34 left and the captain taxied the aircraft off the runway onto the high-speed taxiway exit B9, using differential braking to steer the aircraft as the nose-wheel steering was unavailable.[8]

Events on the ground prior to the evacuation

The aircraft remained parked on a taxiway due to the nose-wheel steering being unavailable, and the flight crew confirmed to ATC that a tow to the terminal was required. While waiting for the tug to arrive to tow the aircraft, the flight crew started the auxiliary power unit (APU).

When the engineers and tug arrived at the aircraft, the flight crew shut down both engines (at 0936) and selected APU bleed air[9] on to enable air conditioning and electrical power to be maintained in the cabin. Engineers completed an inspection of the exterior of the aircraft and, aside from the landing gear doors remaining open, observed nothing of note. At 0947, a tug started towing the aircraft back to the terminal.

The ARFFS requested that the captain contact the fire commander, who was now in attendance and following the aircraft back to the terminal. After speaking to the captain, the ARFFS fire commander stood down the other tender in attendance and accompanied the aircraft back to the terminal.

After the aircraft had stopped on the taxiway, the CSM recalled smelling a very strong mechanical oil smell that they thought, based on previous experience, was attributable to the hydraulic and nose-wheel steering problem. At that time, the CSM discussed the smell with the R1[10] cabin crew member, who also recalled smelling something they described as being like 'cooking oil'. Both cabin crew recalled thinking the smell was nothing of concern and did not contact the flight crew or other cabin crew at that time.

The FO reported that they told the captain that they could smell something strange during the tow to the terminal but had thought that the smell was smoke or diesel fumes from the tug. The FO again discussed the smell when the aircraft arrived at the terminal.

Just prior to the aircraft reaching the terminal, the cabin crew received the standard instruction from the flight crew to 'disarm doors and crosscheck'. In response, the cabin crew disarmed all doors and completed a call back to the CSM. The L3 cabin crew member recalled that, just before the call back, when they were crossing over to complete their crosscheck procedure, they said to the R3 cabin crew member that they could smell something similar to 'dirty socks'. During the call back, the L3 cabin crew also advised the CSM that they could now see a 'haze' forming in the cabin. Other cabin crew also recalled they could see a haze, mist or smoke in the cabin at about this time.

The aircraft arrived at the terminal at 0957:53 and was parked at gate 10, facing towards the south. At this time the wind direction was from the north at a speed of about 7 kt, which resulted in the wind blowing from the aft to the front of the aircraft.

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[7] Alert phase (ALERFA): an emergency phase declared by the air traffic services when apprehension exists as to the safety of the aircraft and its occupants.

[8] A330 nose-wheel steering is lost with a green hydraulic system leak. VH-EBC was not equipped with the alternate nose-wheel steering system that is supplied by the yellow hydraulic system. This was an optional system available from Airbus and not required to be fitted.

[9] Bleed air: compressed air taken from the compressor section of the APU, which is utilised for the aircraft's air conditioning system.

[10] Cabin crew members are referred to as per their position on the aircraft, as described in Figure 1.

The flight crew reported that, soon after stopping at the terminal, they noticed an acrid smell in the flight deck and they started to experience irritation to the eyes and throat, prompting them to open the flight deck windows. The captain recalled seeing a haze in the flight deck and the FO recalled seeing mist or smoke in the flight deck.

Soon after the call back in the cabin, the captain and the CSM had a conversation over the interphone about the haze and smell in the aircraft.[11] During the call, the CSM asked other cabin crew nearby at the L2 and R2 doors about the severity of the haze, and then advised the captain that the conditions were getting worse and that they needed to 'get out'. The captain recalled that the CSM had confirmed the need to evacuate, however the CSM did not recall specifically speaking about an evacuation. Following the discussion with the CSM, the captain confirmed the need to evacuate with the FO, to which the FO agreed.

Emergency evacuation at the terminal

Emergency evacuation command

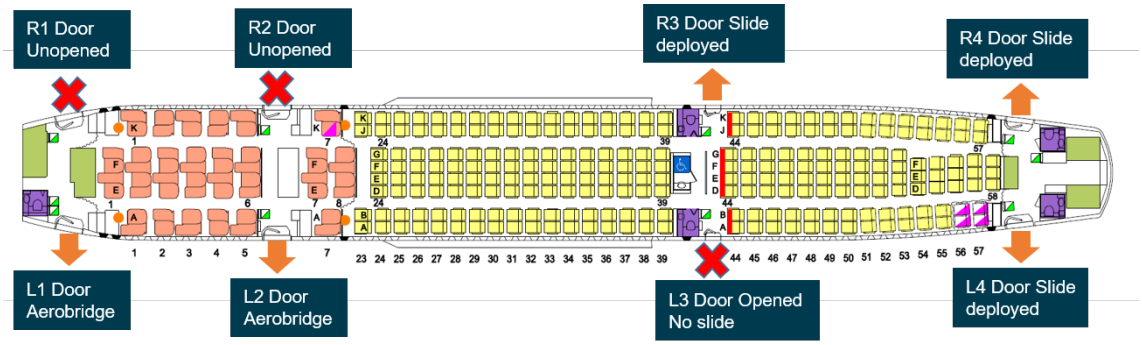
The captain ordered an evacuation over the PA system and the FO declared a MAYDAY[12] to ATC, stating they had 'smoke in the cabin'. The MAYDAY broadcast started at 1000:08 but the exact time of the evacuation command could not be determined.

Prior to the emergency evacuation command, both aerobridges[13] for the L1 door and the L2 door were in the process of being connected to the aircraft. The aerobridge at L1 was connected and the door started to be opened at 1000:18 and was fully open at 1000:22. Closed-circuit television (CCTV) showed the CSM ending the call to the captain at this time. Passengers were reportedly already standing, and some had retrieved their cabin baggage.

Exit availability and use

Figure 1 shows the 8 exits on the A330 aircraft. Five exits were used during the evacuation; 2 exits connected to the aerobridges (L1 and L2), and 3 other exits which had escape slides deployed (R3, L4 and R4).

Figure 1: Cabin layout showing doors used during the evacuation



Source: Qantas, annotated by the ATSB

More specifically, the following occurred at each exit:

- The L1 door was open at 1000:22, with passengers beginning to evacuate about 5 seconds later through this exit and via the aerobridge.

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[11] Due to conflicting accounts, it could not be confirmed who initiated this communication. The call was between the flight deck and CSM only.

[12] 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.

[13] An aerobridge is a covered portable walkway for the transfer of passengers between an airport terminal and an aeroplane.

- The doors at L4 and R4 were opened at 1000:38, with the slides deployed and ready for use soon after. Both L4 and R4 doors were armed by the cabin crew members before opening and the slides deployed successfully. The cabin crew at these exits recalled checking outside the aircraft both prior to and then following the evacuation command. They also verbalised to each other the need to rearm their doors prior to opening them.
- The door at R3 was initially opened at 1000:29. However, the door was opened in the disarmed mode and the cabin crew member then closed, rearmed, and reopened the door and the slide deployed successfully at 1000:54.
- The door at L3 was opened at 1000:35 but the slide was not deployed. The cabin crew member at L3 recalled that they checked outside conditions before opening the door. However, because the door was still disarmed, the slide was not deployed. They then declared their exit blocked, and directed passengers to available exits.
- The second aerobridge was connected to the L2 door and was open at 1001:18. The cabin crew member at the L2 door reported that they did not check outside conditions as per their procedure; they assumed that an aerobridge would be available, and waited for this to be connected. Until that occurred, they directed passengers to the L1 door. The aerobridge operator knocked at the door for about 10 seconds before the L2 turned around to acknowledge the operator and open the door.
- The cabin crew member at R2 reported that the haze/smoke they could see inside the cabin may have indicated that there was a fire outside. They recalled that, although they checked outside conditions, which were clear, they decided to block their exit and they directed passengers to the exits attached to the aerobridge at L1 and, when it opened, the aerobridge at L2.
- The cabin crew member at R1 recalled seeing vehicles outside when they checked outside conditions and declared their exit blocked. They recalled that they did not continue to check outside conditions but instead directed passengers to the aerobridge at L1.

Of the 222 passengers, 129 utilised the 2 aerobridges to exit and the other 93 left via the 3 available escape slides. The last passenger using the aerobridge at L1 exited at 1001:30 and the last passenger using the aerobridge at L2 exited at 1002:04. The last passenger using the slides exited R3 at 1002:39.

During the evacuation, the FO exited the flight deck with their torch and entered the cabin. At this stage, the CSM had briefly left the L1 door area. When the FO came into the cabin, a passenger was attempting to re-enter the aircraft to retrieve a bag and the FO directed them to leave the aircraft. The FO exited the aircraft via the nearest available exit (the aerobridge at L1) at 1001:43 and proceeded to the tarmac via a ladder attached to the aerobridge. Once on the tarmac, they provided ARFF personnel with information about passenger numbers and advised that there were no dangerous goods onboard.

Handling of cabin baggage

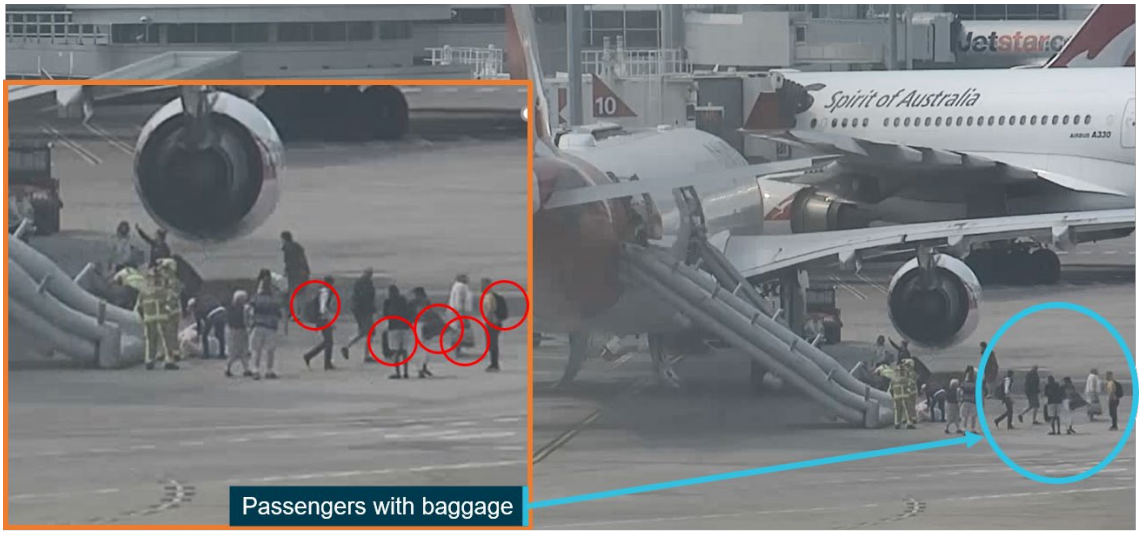
As the evacuation occurred at the terminal, some passengers had already retrieved, or started to retrieve, bags prior to the evacuation command. Video footage captured by passengers after the evacuation command showed passengers retrieving cabin baggage from overhead baggage compartments (Figure 2).

Figure 2: Still image of passenger video taken during the evacuation

Passengers collecting cabin baggage from overhead lockers during the evacuation.
Source: Channel 7

Cabin crew at doors with escape slides deployed reported that some passengers arrived at the doors carrying bags. The cabin crew stated that they advised those passengers to leave their bags and, when they did, the passengers were generally compliant, with a number of passengers leaving their bags in the galley area on the way to their exit. However, video footage showed several passengers taking bags down the escape slides (Figure 3). CCTV and video footage taken by passengers also showed that at least 40 of the 129 passengers who exited via the 2 aerobridges were carrying cabin baggage (such as a small suitcase or backpack).

Figure 3: Still image showing passengers evacuating with cabin baggage



Source: Sydney Airport Corporation Limited, annotated by the ATSB

Use of escape slides

Cabin crew reported that many passengers did not know how to use the escape slides when they reached the exits, with some passengers pausing to ask what to do and others descending the escape slides by kneeling or lying down.

Of the passengers who used the escape slides, one passenger was seriously injured and 5 others received minor injuries. The serious injury involved tendon ruptures in both knees. The other passenger injuries ranged in type and severity, and included but were not limited to knee sprain/strains, friction burns to the hands, and cuts/abrasions to the elbow. All of the injuries occurred during the use of the slides. Other passengers reported anxiety and chest pain.

Of the 222 passengers, there were 12 passengers who were listed on the flight manifest as requiring special assistance, including infants, children and others. As far as could be determined, most of these passengers evacuated using an aerobridge, although one of the 4 infants was carried down a slide.

Emergency service response

The ARFFS fire commander reported that, when the aircraft stopped at the terminal, all ARFFS crew members left their vehicle. The commander could smell and taste oil (which they thought was a hydraulic fluid) in the air and noticed a golden coloured fluid on the aircraft 'tail pipe' (that is, near the APU). In response, the fire commander set up an exclusion zone around the rear of the aircraft.

The fire commander proceeded to the nose wheel of the aircraft and was speaking with an engineer when the airport's crash alarm activated in response to the MAYDAY call. The fire commander reported that they initially thought that the crash alarm was a test, as it was usual for a test of the alarm to occur around the same time each Sunday. About 3–5 seconds after the alarm, the fire commander recalled hearing a loud bang and seeing the aircraft escape slides deploy.

At this time both ARFFS crew members and the 2 engineers that had approached the aircraft were at the nose wheel. Due to the activation of the crash alarm, all the other ARFFS tenders responded from their stations.

The ARFFS reported assisting passengers at the bottom of the escape slides, directing passengers 15–20 m away from the aircraft on both sides, and organising a triage area.

Post evacuation actions

After all passengers had evacuated the aircraft, the cabin crew and captain checked the cabin of the aircraft. During this period, a paramedic tending to the seriously injured passenger at the bottom of the R3 slide asked one of the cabin crew for an emergency first aid kit. The cabin crew member called for the R3 cabin crew member to obtain the kit and the R3 cabin crew member slid the kit down the slide.

Cabin crew members reported that, after checking the cabin, they considered using the escape slides to evacuate the aircraft. However, when they consulted the captain, the captain advised that they could exit via the aerobridge if they preferred. Therefore, the captain and all cabin crew evacuated the aircraft through the aerobridges. The captain proceeded to the tarmac to assist passengers before returning to the aircraft cabin.

CCTV footage showed that, following the full evacuation of passengers from the aircraft, multiple cabin crew members re-entered the aircraft via the L1 aerobridge to retrieve cabin baggage and other items. Other staff members, including engineering staff, also entered the aircraft cabin before it had been deemed safe by the ARFFS. The last cabin crew member (who had re-entered the cabin) left the aircraft at 1007:53.

Two ARFFS personnel entered the aircraft wearing breathing apparatus to assess the cabin air with the purpose of deeming the aircraft safe at 1012:13.

Context

Personnel information

Flight crew

The captain and first officer (FO) both held an Air Transport Pilot (Aeroplane) Licence (ATPL) and were appropriately qualified for the flight.

The captain had been flying with the operator for about 30 years, initially on the Boeing 737 type aircraft, and undertaking a number of senior roles within the organisation, before moving onto the Airbus A330 type aircraft about 3.5 years prior to the occurrence. They had accumulated about 20,100 flight hours, of which 8,238 hours were on the A330. The captain last completed a cyclic simulator training session (which included a hydraulic system failure) in July 2019, and emergency procedures training (which covered land evacuations) in August 2019.

The FO had been flying with the operator for 15 years and had recently transitioned from the Boeing 747 type aircraft to the A330 in October 2018. They had a total of about 12,200 flight hours, of which 900 hours were on the A330. The FO completed emergency procedures training in February 2019 and last completed a cyclic simulator training session (which included a hydraulic system failure) in September 2019.

Cabin crew

There were 8 cabin crew on board, with one cabin crew member stationed at each of the 8 aircraft doors. All cabin crew were qualified to operate on the A330. The cabin crew had a varied level of flying experience, ranging from 11 months to 30 years flying with the operator (Table 1).

Table 1: Cabin crew experience and date of last emergency procedures (EP) training

Door position	Experience with the operator based on start date	Date of last EP training
L1	27 years	July 2019
R1	4 years	April 2019
L2	11 months	February 2019
R2	11 months	December 2019
L3	28 years	December 2018
R3	12 years	December 2019
L4	30 years	October 2019
R4	24 years	April 2019

The cabin crew member stationed at L1 was the customer service manager (CSM).

Aircraft information

General information

The Airbus A330-202 (A330) is a twin engine, wide-body (dual aisle) medium-to-long-range air transport operation aircraft.

VH-EBC, serial number 0506, was manufactured in 2003 by Airbus, with a total time in service of 67,833 flight hours. VH-EBC was brought onto the Australian aircraft register in 2003 by Qantas Airways, and was one of 28 A330 type aircraft utilised by the operator.

The passenger seating capacity on VH-EBC was 271, including 28 business class seats and 243 economy seats.

Hydraulic system description

The Airbus A330 has 3 independent hydraulic systems designated as green, blue and yellow (see also Appendix A). The operational pressure is 3,000 psi. The 3 hydraulic systems are powered by 4 engine-driven pumps and there are 3 electrical pumps that can automatically act as backup for each hydraulic system.

If green hydraulic system pressure is lost, the only functions that are not performed by the other systems are emergency power generation, nose-wheel steering and landing gear extension. With nose-wheel steering lost for taxiing, it was possible to steer the aircraft using a differential braking technique. However, if the flight crew did not have experience with this technique, the A330 *Flight Crew Techniques Manual* (FCTM) stated it was preferable to request a tow to return to the terminal. The loss of the green hydraulic system prevented the landing gear from being extended by normal means, necessitating a gravity free-fall extension to the down position.

Hydraulic system monitoring

The hydraulic system monitoring unit (HSMU) and the electronic centralised aircraft monitor (ECAM) monitored the condition of the hydraulic system continuously. If a fault occurred, an ECAM message and associated aural alert informed the flight crew.

When the green system hydraulic fluid reservoir quantity falls below 17 L, the indication of the fluid level on the ECAM hydraulic system page will change from a green line to 2 amber lines. It also triggers a hydraulic system leak message.

For the occurrence involving VH-EBC, the messages displayed on the ECAM related to the hydraulic system leak and their timings included:

- HYD G SYS LEAK (0851)
- HYD G ENG 1+2 PUMPS LO PR (0854)
- HYD G SYS LO PR (0854) (recorded flight data indicated that this occurred at 0854:57)
- HYD G RSVR LO LVL (0919).

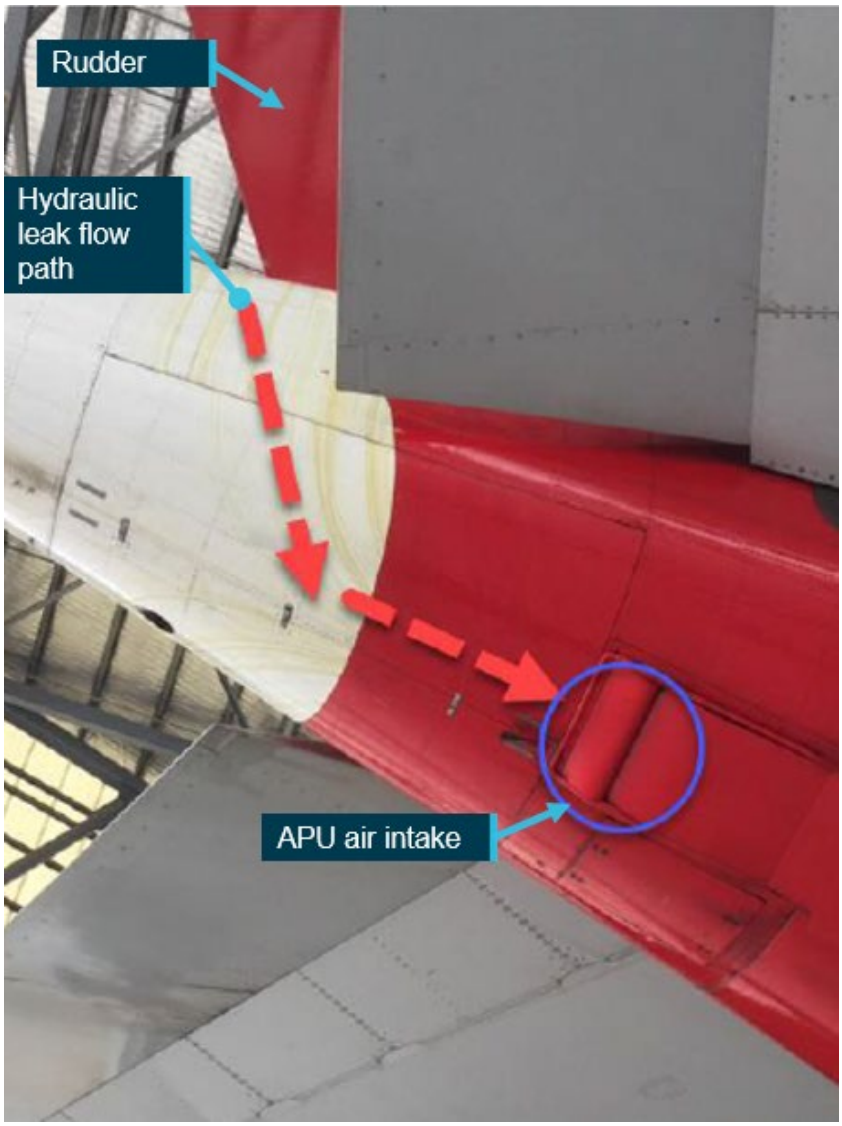
When these messages displayed, they were accompanied by a checklist of actions and considerations for the flight crew.

The flight crew took the necessary actions indicated by each of the checklists, including a landing gear gravity extension. The crew were also aware that there may not be nose-wheel steering available, as this was communicated via the ECAM.

Engineering inspection

The aircraft was inspected by the operator’s engineers after the evacuation to identify the source of the hydraulic leak. There was evidence of residual hydraulic fluid on the tail flowing down towards the auxiliary power unit (APU) air intake (Figure 4).

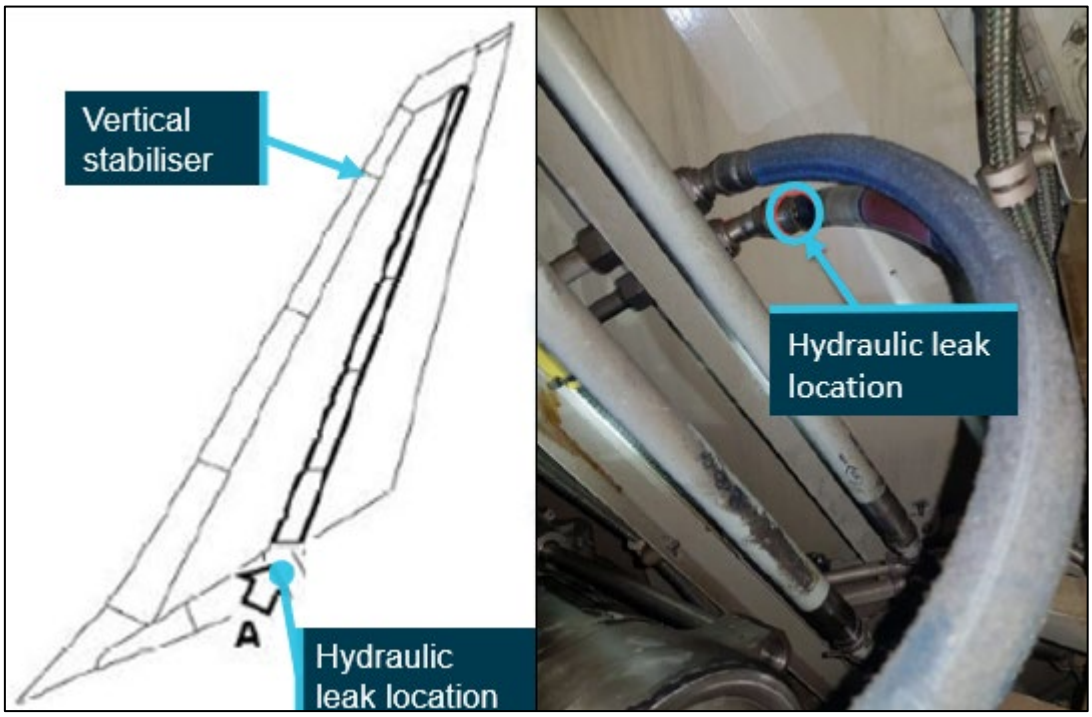
Figure 4: Tail of VH-EBC showing hydraulic fluid leak towards APU air intake



Source: Qantas, annotated by the ATSB

The operator's engineers examined the internal sections of the vertical stabiliser and identified the hydraulic leak emanating from a flexible hose connected to the centre rudder hydraulic servo, which was powered by the green hydraulic system rudder servo pressure hose. The leak occurred near where the hose joined a 45° end fitting (Figure 5). Apart from this leak, there was no discernible visual defects.

Figure 5: Location and position of green system rudder servo hoses and position of leak



Source: Qantas, annotated by the ATSB

The green hydraulic system rudder servo high pressure hose (part number AE2464379H0316) is a flexible hose constructed of 3 layers:

- a seamless extruded Teflon resin inner tube
- an outer braid consisting of densely packed small diameter stainless steel wires
- a blue Teflon abrasion sleave.

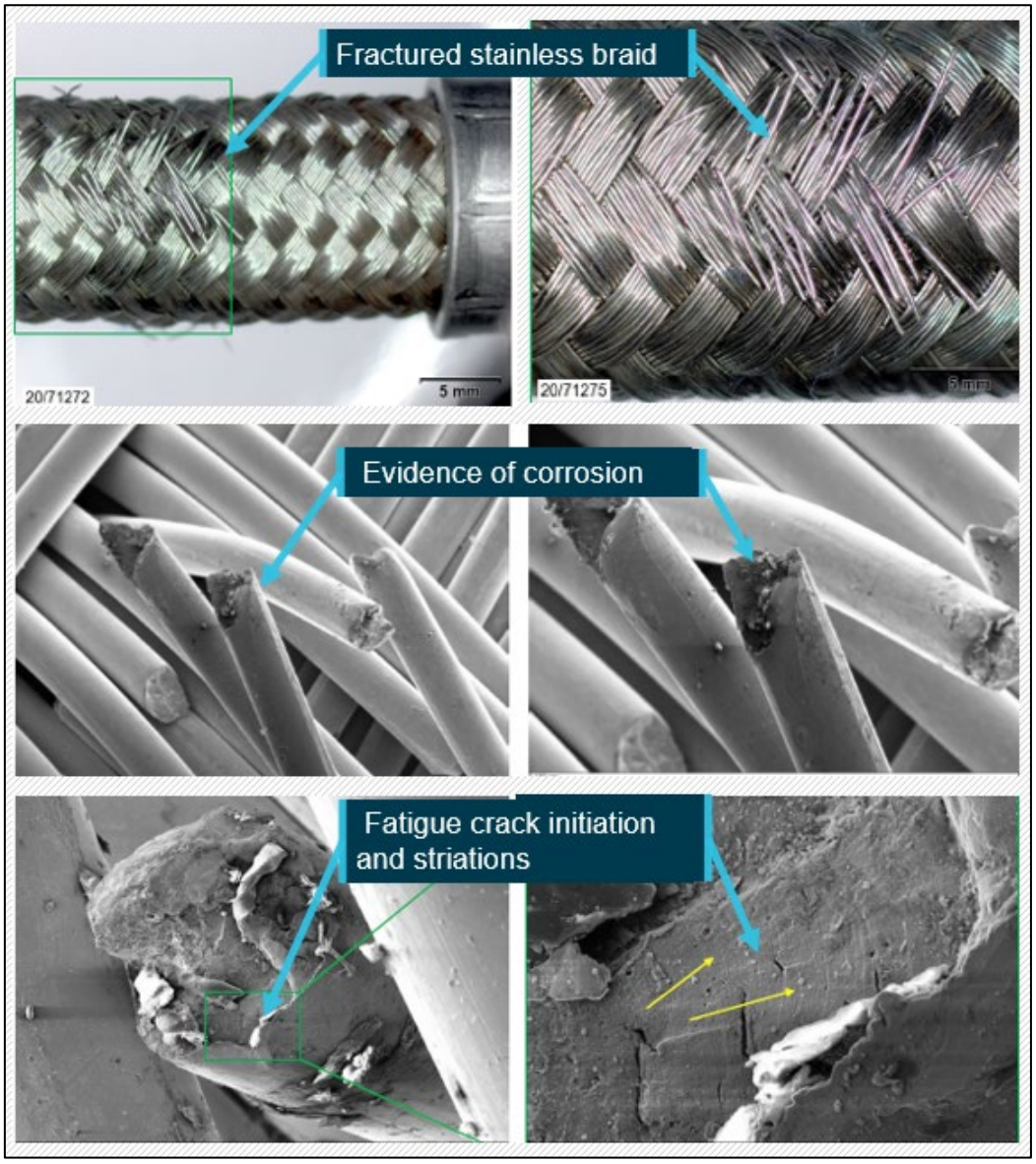
The purpose of the stainless steel braid is to reinforce, and prevent rupture of, the inner tube, which is exposed to high pressure fluid in normal operation.

The failed hydraulic hose was removed from the aircraft and sent to the aircraft manufacturer for a detailed examination. That examination identified:

> The leakage was confirmed between 45° fitting and metallic label. The outer steel braid of the hose was found damaged. The fractured wires of the steel braid exhibit corrosion attack and corrosion products. Fatigue striations were detected indicating a fatigue fracture. The fractures of the wire originated from corrosion attack and fails due to fatigue load and corrosion. No other mechanical damage could be identified which could act as crack starting points.

Figure 6 shows the hydraulic hose stainless steel braid fractures, with evidence of corrosion and fatigue cracking at varying degrees of magnification.

Figure 6: Hydraulic hose steel braid fracture surface showing corrosion and fatigue cracks



Source: Airbus, annotated by the ATSB

Hydraulic hose failure history

Each of the 3 independent hydraulic systems had 2 rudder servo flexible hoses (one pressure and one return). The hoses were considered to be an on-condition part with no life limit. The Airbus A330 recommended maintenance program stipulated a visual inspection of the rudder servo flexible hoses every 24 months. The last inspection conducted by the operator on VH-EBC was completed in June 2019.

At the time of the occurrence, this was the operator's second A330 hydraulic loss occurrence involving a hydraulic system rudder servo pressure hose in the previous 4 years. The first occurrence was on 6 May 2019 and involved the green system; on that occasion no fluid was ingested into the APU air intake. That occurrence involved an aircraft that was a similar age, flight hours and flight cycles as VH-EBC. Both of the failed hoses were original fitment during manufacture in 2003.

The ATSB is aware of another rudder servo pressure hose failure on another operator's A330 that resulted in hydraulic fluid entering the APU air intake and then the aircraft cabin and flight deck via

the air conditioning system. That serious incident occurred in 2014 and involved an A330 with a similar serial number and manufacture date to VH-EBC (see *Related occurrence*) and a hose with the part number AE2464373H0316. The failure occurred at a similar point on the hose as the VH-EBC occurrence, near the 45° end fitting. Examination of the hose identified that the rupture was due to fatigue failure of the metal braid. There was no indication of corrosion. The hose was original fitment during manufacture in 2003.

The ATSB requested hydraulic hose failure history information from Airbus. The manufacturer stated:

> It is difficult to have a comprehensive view of all cases, as not all are reported to Airbus as per Occurrence reporting rules, only those cases which had an impact on a system would be reported.
>
> Airbus has regularly to demonstrate to the EASA that the safety objectives are still met and that the situation is not degrading...
>
> The hose PN AE2464379H0316 that failed on MSN 506 [VH-EBC] was fitted on A330-200 aircraft (ST7 variant) from MSN 181 to MSN 555 only but only about 220 of those are still operated worldwide. From A330 MSN 555 onwards…, the hydraulic system has been modified and those involved hoses are not installed anymore.
>
> Airbus do not have information about exact failure rates, what they have recovered is the number of parts that have been ordered during a 3 years period, those orders cannot be linked directly with a failure but it gives an idea. Moreover, please note that there are 3 hoses per aircraft (for blue, green, yellow hydraulic lines) and that it is common practice to order some spares in addition to the parts needed.
>
> Here are the figures Airbus could retrieve:
>
> 68 parts PN AE2464379H0316 [green rudder servo hydraulic pressure hose]

The A330 has mandatory flexible hose replacements for areas identified as having a high in-service failure rate. However, according to Airbus, the rudder servo flexible hoses did not require mandatory replacement based on the in-service failure rate. Other than the 2014 serious incident, the manufacturer advised that it had not investigated any other occurrences involving failures of this type of rudder servo flexible hose.

Skydrol hydraulic fluid

The hydraulic fluid utilised in the Airbus A330 is a fire-resistant phosphate ester-based fluid known as Skydrol.

According to the material safety data sheet, Skydrol is toxic to humans and animals. If it is heated to decomposition, it emits acrid smoke and fumes. If smoke and fumes are carried via the air conditioning system into the aircraft cabin and flight deck, occupants have been known to experience irritant effects to the eyes and respiratory system. There have also been other reported symptoms affecting the central nervous system, which can include dizziness, lack of concentration and coordination.

The first aid treatment suggested for inhalation of Skydrol is to have the person breath fresh air, and if breathing difficulty is experienced to provide oxygen; and in both cases seek medical assistance if necessary.

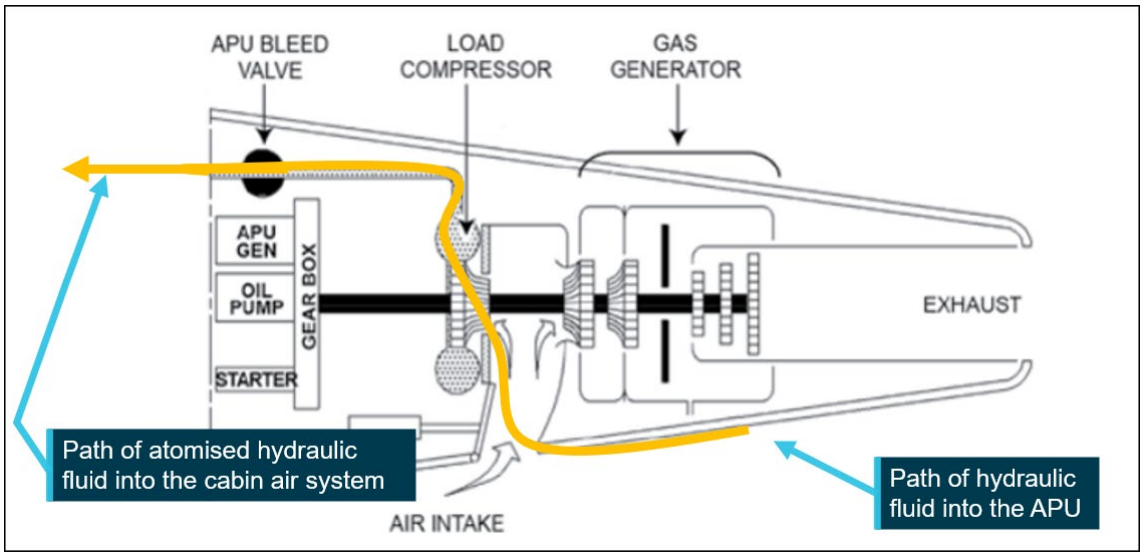
Auxiliary power unit (APU) and bleed air intake

Figure 7 is a schematic of the APU showing the air intake that was the entry point for the hydraulic fluid ingress. The air intake provides inlet air to the APU gas generator and also the load compressor. The load compressor provides pressurised air to the cabin air conditioning system when the aircraft is on the ground and the APU bleed air valve is open.

There is an air intake diverter and fluid gutters installed in and around the APU air intake. Together with the diverter, the fluid gutters form a frame that protrudes from the fuselage skin around the air intake opening. The frame is designed to minimise fluid ingress into the APU air

intake. However, when the aircraft is on the ground some fluid may bypass the frame due to the lack of airflow.

Figure 7: A330 APU schematic showing air intake and path of the atomised hydraulic fluid contamination into the cabin



Source: Airbus, annotated by the ATSB

The operator's *Flight Administration Manual* (FAM) contained guidance to flight crew on APU management after arrival at an airport. Although it did not specifically address the situation faced by the flight crew on this occasion, it did include information about the use of the APU to supply air conditioning when the outside air temperature exceeded 21 °C or there was inadequate ventilation inside the aircraft.

The flight crew of VH-EBC used their discretion and decided that, given the time that it might take to tow the aircraft to the terminal, the APU bleed was selected on to maintain passenger and crew comfort.

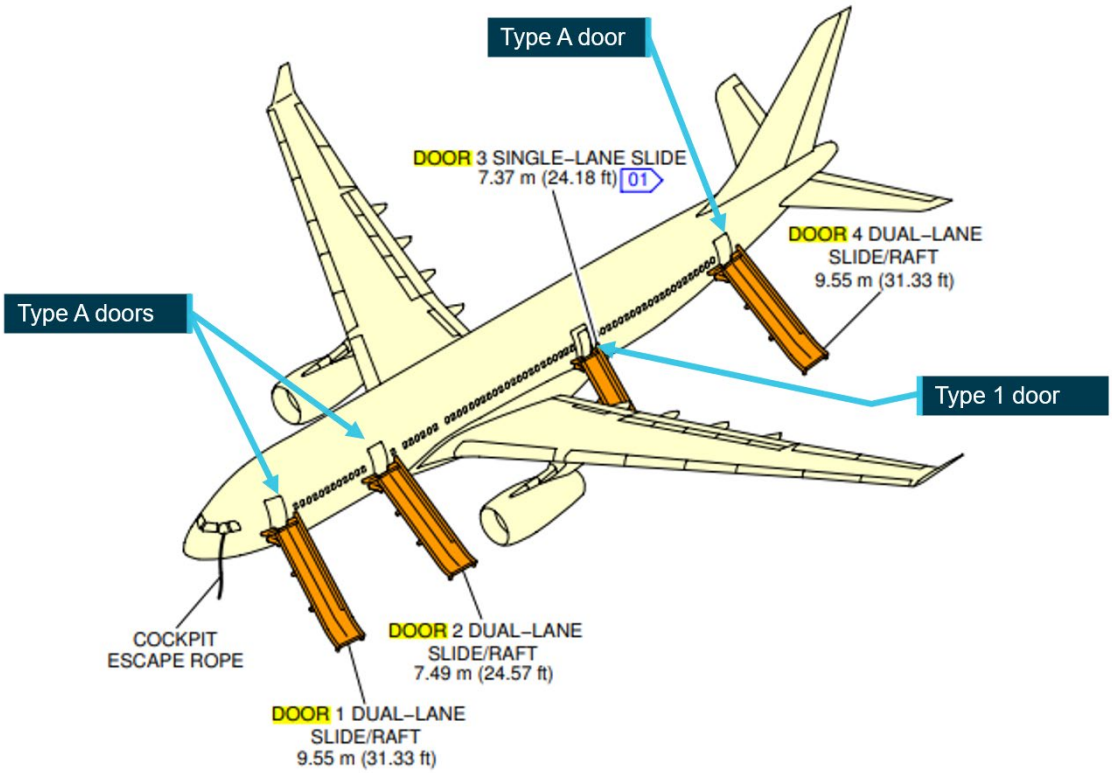
Emergency exits and escape slides

Types of doors

The A330-202 type aircraft has 6 type A doors (3 on each side), and 2 type 1 doors (one on each side) (Figure 8). All 8 doors are equipped with emergency escape slides and are designed for use in an emergency evacuation.

The differences between a type A door and a type 1 door are that the type 1 door is smaller, equipped with a single lane slide (as opposed to dual lane), is a slide only exit, and the slide cannot be used as a raft.

Figure 8: Location of A330-200 type A and type 1 doors

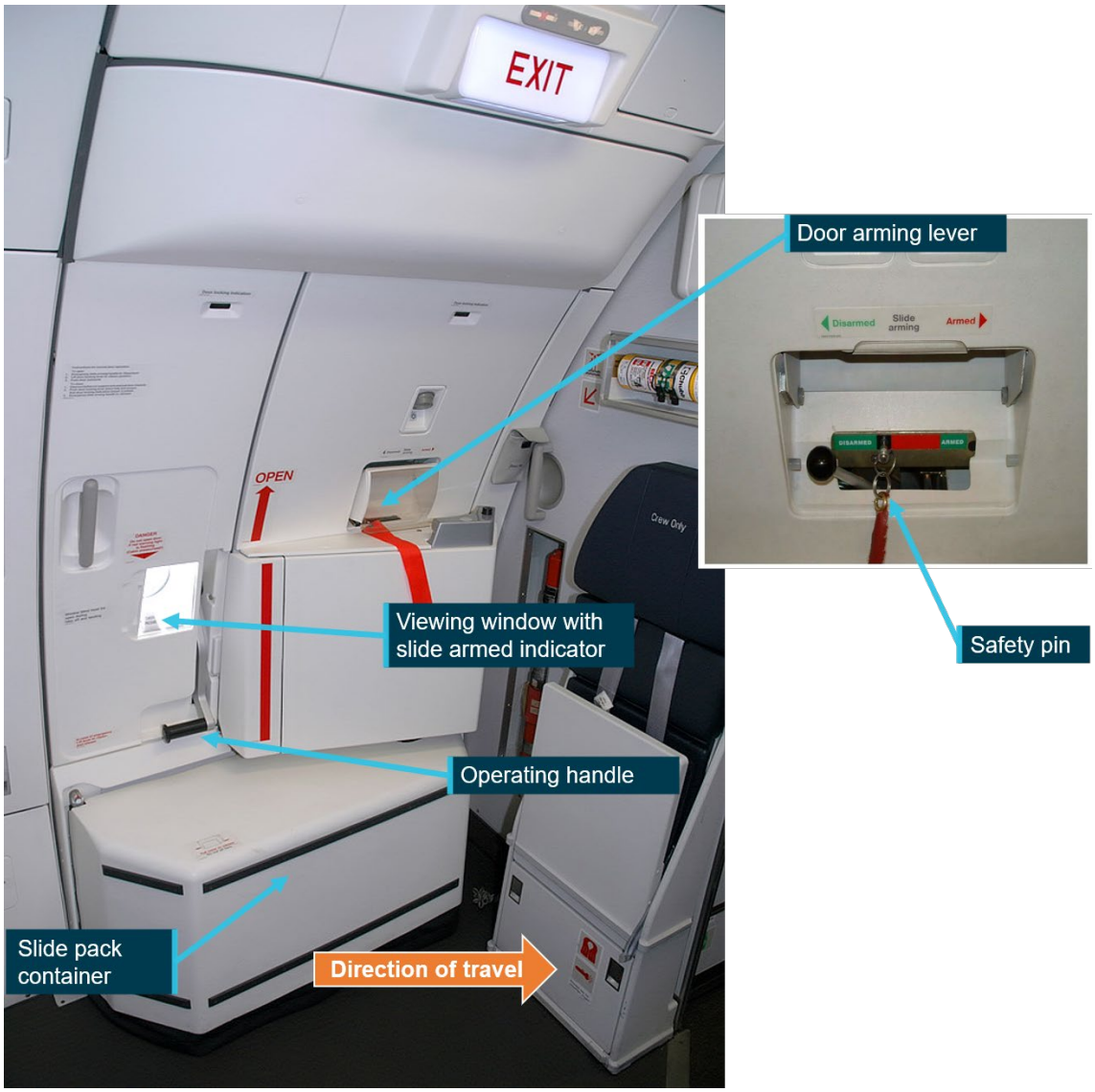


The left and right sides of the aircraft have identical slide configuration.
Source: Airbus, annotated by the ATSB

Door arming and disarming

For all 8 doors, the door had to be armed to enable the escape slides to automatically deploy. To arm a door, the slide arming lever (Figure 9) is placed into the armed position. When the lever is put into this position, the girt bar (a horizontal metal rod attached to the escape slide) is connected to the floor brackets on both sides of the door. When the door is opened, the slide pack will then be pulled out from the door container and fall under gravity, triggering the automatic escape slide inflation mechanism. If the automatic inflation fails, the escape slide can be manually inflated. Opening the door from the outside disarms the door and the escape slide will not deploy.

Figure 9: Type A door arming lever location and related features



Source: Qantas and Airbus, annotated by the ATSB

To ensure that the aircraft doors were prepared for an emergency, the operator's procedures required the cabin crew to arm the doors just after the aircraft started to move from its parking position (just after pushback). The procedure required the CSM to make an announcement to the cabin crew instructing them to 'arm doors and crosscheck'.

After the door was armed, the cabin crew member removed the safety pin (shown with the red tag in Figure 9), moved the arming lever into the armed position and placed the safety pin in a pouch located at the door. Therefore, when the door was armed there was no red tag visible to the cabin crew.

The doors remained armed until the aircraft had landed, and the cabin crew were instructed by the flight crew to disarm the doors. The public announcement (PA) from the flight crew typically occurred when the aircraft was in close vicinity of the terminal. After receiving the instruction, the cabin crew disarmed their doors and completed a crosscheck, ensuring that the doors were in the disarmed position. When the doors were disarmed, the reverse procedure was undertaken and the safety pin was re-inserted following the movement of the arming lever into the disarmed position.

The exits are disarmed to allow the aircraft doors to be opened and connected to aerobridges or stairs for passenger disembarkation, and to avoid any injuries to personnel outside the aircraft if there was an inadvertent slide deployment.

At the time of the captain's evacuation command on VH-EBC, all doors had already been disarmed.

Operation of aircraft doors in an emergency

The operator's *Aircrew Emergency Procedures Manual* (AEPM) stated that, for the operation of the A330 type A doors in an evacuation, cabin crew were required to:

1. Check outside to ensure the door is safe to open.
2. Open door in ARMED Mode.
3. Lift Door Handle rapidly fully up and release it.
4. The door power assist will open the door.
5. The slide will automatically deploy and inflate.

The operation of the type 1 door was almost identical in a land evacuation, aside from a cover that had to be lifted from the handle to open the door.

The aircraft manufacturer's recommended procedure[14] for cabin crew to use when operating the exits in an emergency evacuation was similar. However, the recommended procedure required that the cabin crew check that the door was armed prior to checking outside conditions and operating the door.

Use of the escape slides in an emergency

In a section titled 'Safe Slide Use', the AEPM stated:

> In an evacuation using an escape slide, to reduce the chance of injury, a Crew member should:
>
> - Jump well clear of the girt bar area, (this is to avoid contact with the area where the slide is attached to the aircraft resulting in possible injuries).
> - Drop into seated position with legs straight, feet shoulder width apart and toes pointed back.
> - Lean well forward by placing their hands on their knees to slow the descent. Using this technique also ensures hands are to be kept clear of the slide fabric avoiding possible friction burns.
> - Be aware that deceleration pads at the bottom of the slide will assist them returning to a standing position.
> - Keep moving to let their momentum carry them away from the bottom of the slide.

The operator's procedures also included instruction on how to assist passengers with special needs when evacuating via the slides; however, there was no guidance provided in relation to evacuation with infants.

Research conducted by the United States Federal Aviation Administration (FAA) in 2001[15] indicated that, for passengers carrying infants, faster egress could be achieved by jumping onto the evacuation slide. There was no definitive guidance provided about appropriate boarding and carrying positions, although it was suggested that the best position would be that which was most comfortable for the person carrying the child, as long as support was provided to the child's head and neck.

The operator's cabin crew and flight crew practiced an escape slide descent during their initial training and they watched a video explaining safe slide descents to maintain currency each year.

---

[14] Airbus A330/A340 *Cabin Crew Operating Manual* (2018)

[15] Corbett, C.L. (2001). *Caring for Precious Cargo, Part I: Emergency aircraft evacuations with infants onto inflatable escape slides* (DOT/FAA/AM-01/18). Washington, DC: Office of Aerospace Medicine.

Emergency procedures

Smoke / mist in cabin procedure

The *Quick Reference Handbook* (QRH), located on the flight deck, contained checklists for various emergencies and abnormal events, including a checklist for smoke / fumes / avionics smoke. The procedure applied to events in flight and on the ground, and the initial actions on the first page focussed on smoke / fumes events while in flight.

The second page of the procedure started with:

- If AIR COND smoke suspected:

  APU BLEED……OFF

The procedure then provided additional actions for that scenario and other scenarios.

Fumes event procedures

In 2015, the International Civil Aviation Organization (ICAO) provided detailed guidance about training and reporting of fumes events.[16] It stated:

> Various types of fumes, smoke, haze and mist may contaminate the cabin and flight deck air supply system. Outside air may be contaminated with engine oil, hydraulic fluid, engine exhaust, ground service vehicle exhaust, fuel, de-icing fluid or ozone. Recirculation fans are another potential source of contaminated air.
>
> Of all of these potential contaminants in the cabin and flight deck, particular concerns have been raised regarding the negative impact on flight safety when crew members are exposed to oil or hydraulic fluid fumes or smoke, and experience acute symptoms in flight. Due to the potential flight safety implications, it is beneficial to provide guidance and instructional material to enable crew members to promptly recognize and respond to suspected air supply system-sourced fumes…
>
> Crew members use a wide variety of terms to describe oil and hydraulic fluid fumes. Often, oil fumes do not smell like oil. Instead, they are typically described as smelling like dirty socks/smelly feet, foul, or musty. Hydraulic fluid often has a distinctive and recognizable odour that is often described as acrid.

It recommended that training be provided to cabin crew in 'odour descriptors'. It stated:

> Cabin crew members should attempt to identify and locate the source of the fumes (i.e. air supply system or cabin equipment/item) and attempt to identify the type (e.g. dirty socks, musty/mouldy, acrid) and intensity (e.g. mild, moderate or strong) of the fumes.

This same information was replicated in guidance issued by the Civil Aviation Safety Authority (CASA) in 2018.[17]

The operator's AEPM stated:

> If fumes are suspected in the cabin, initial actions include:
>
> **Protect yourself** – limit personal exposure to fumes. Consider removing yourself from the area.
>
> **Communicate** – via Emergency All Stations Call. It is vital that information is relayed to the Flight Crew as a priority. This assists in providing the information required to adequately assess and deal with the event.
>
> **Limited access to the area and exposure to crew/passengers.**
>
> **Investigate and monitor as directed by Flight Crew** – should a return to area be necessary, consider using a PBE [portable breathing equipment]. Note that PBE use may compromise communications efforts.

---

[16] ICAO Circular 344-AN/202 Guidelines on Education, Training and Reporting Practices related to Fume Events

[17] Cabin safety bulletin 13 - Management of odours, smoke and fumes during flight released November 2018

The operator's *Cabin Crew Operating Manual* (CCOM) detailed the following guidance in relation to fumes in the cabin:

> **9.9.2 Cabin Fumes Considerations**
>
> Fumes caused by oil contaminated bleed air have been described as having a strong odour similar to 'dirty socks', and possibly a blue smoke haze or mist. However, a fumes event may not necessarily be characterised by visible smoke. A fumes event may be characterised experiencing any of the following symptoms:
>
> - Cough, wheeze, shortness of breath, chest tightness, difficulty with speech;
> - Sore throat, burning throat, difficulty swallowing, nasal irritation, runny nose, eye irritation, chest pain, palpitations;
> - Dizziness, headache, sensation changes or weakness anywhere in the body, difficulty balancing, loss of hearing, difficulty concentrating; and/or
> - Nausea and/or vomiting.
>
> Crew are advised that they should seek a medical consultation if any of the above symptoms occur following a fumes event. Fume odour can appear strong initially and mistakenly appear to subside with further exposure. A conservative approach should be adopted during all events. Refer to … the AEPM for the initial actions in a fumes event.

The same guidance was detailed in the flight administration manual (FAM) applicable to the flight crew, with the only difference being that there was no instruction to refer to the procedure detailed in the AEPM.

Communication in an emergency

The operator's AEPM stated that, if there was a situation that required 'URGENT' simultaneous contact with all stations, including the flight deck, this was to be achieved by pressing the PRIO ALL call button on any of the interphone handsets in the cabin. The flight crew could either use the overhead guarded emergency call button or press the EMER CALL on the flight deck interphone handset.

If an emergency occurred that only required the flight deck to be informed, the CSM or other cabin crew members could make a call to the flight deck using the PRIO CAPT on the interphone handset. This call will be between the cabin crew member and the flight crew only and will not include the other stations in the cabin.

When contact was made about the haze/smoke in the cabin and flight deck on VH-EBC, the call was reported to be an emergency call between the captain and CSM. An 'emergency all stations call' that would include all cabin crew was not utilised.

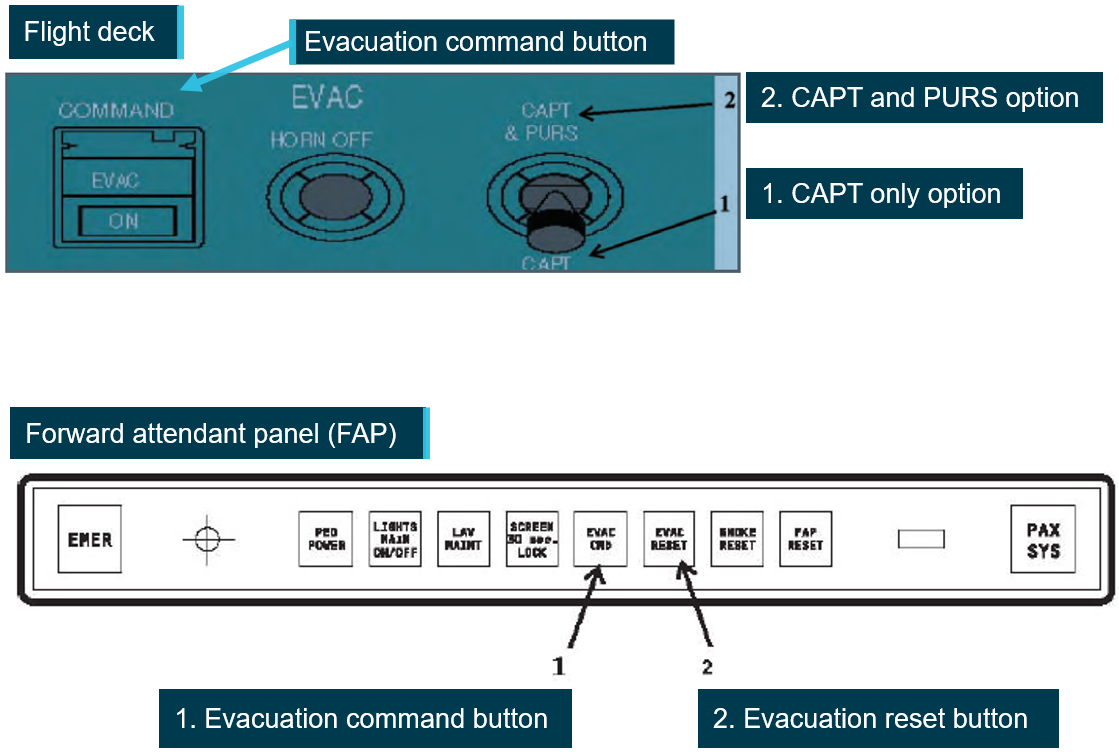
Evacuation signal

According to the AEPM, the captain was responsible for initiating an evacuation. The AEPM stated that the captain should do so by as many means as possible. The 3 possible methods listed were:

- PA **"Evacuate, Evacuate, Evacuate"**.
- Verbal evacuation order by Flight Crew Member entering cabin.
- Emergency Evacuation Signal System (as installed).

The emergency evacuation signal system was an option on the A330 and was installed on VH-EBC. The system itself could be used as a means of initiating an evacuation and alerting passengers to an emergency. To operate the system, there was a guarded command switch located in the flight deck and on the forward attendant panel at L1 in the cabin (Figure 10).

Figure 10: Evacuation signal controls



Source: Qantas, annotated by the ATSB

Figure 10 shows a switch in the flight deck that could be set to either CAPT, or CAPT & PURS. This selection would determine whether or not the aural alert for the cabin could be activated in the flight deck only (set to CAPT) or also by the button at the forward attendant panel (CAPT & PURS). It was the operator's normal practice to have the switch set to CAPT & PURS.

In either setting, when the command switch was pressed by the captain, an aural alert (like an alarm with repeated high pitch tones) would sound in the cabin and visual indications would appear on the flight deck overhead panel (red flashing light) and on all cabin attendant indication panels located in the cabin (red flashing light and the word EVACUATION).

Although the AEPM provided information to cabin crew about how the evacuation signal functioned, there was no procedure documented in Qantas's manuals that detailed when the cabin crew were required to (or advised to) activate the evacuation signal.

When the evacuation occurred on VH-EBC, the captain issued the command via the PA. Neither the cabin crew nor the captain operated the evacuation signal.

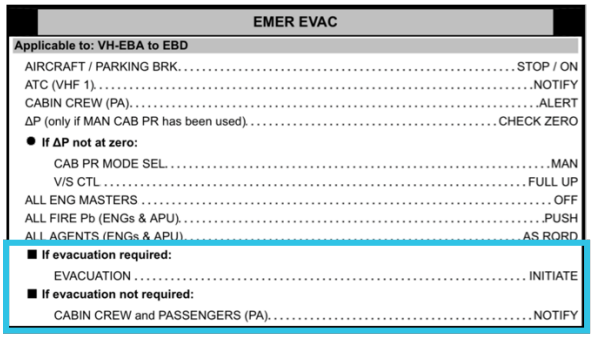
Flight crew evacuation checklist

The QRH included a checklist for an evacuation (on the back page). The checklist detailed the sequence of actions to be taken by the flight crew in an emergency evacuation.

The evacuation checklist was also documented in other flight crew manuals within the operator's suite. Following this evacuation, the operator found that the QRH checklist in the *Flight Crew Operating Manual* (FCOM) had been expanded to include 'Press the EVAC COMMAND' for the initiation of the evacuation (Figure 11). This additional action was not included in the actual QRH on the aircraft.

Figure 11: Flight crew evacuation checklists

QRH on aircraft

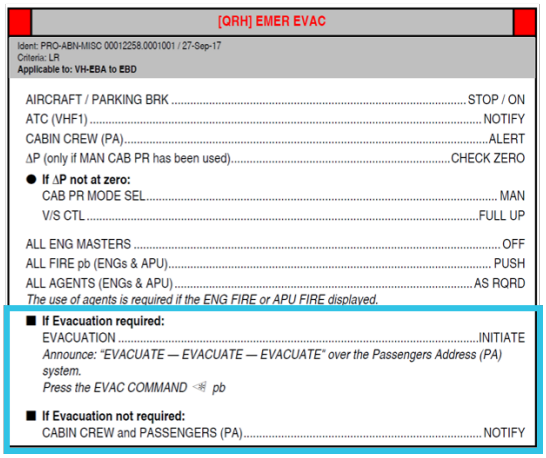


EMER EVAC

Applicable to: VH-EBA to EBD

AIRCRAFT / PARKING BRK ..... STOP / ON
ATC (VHF 1) ..... NOTIFY
CABIN CREW (PA) ..... ALERT
ΔP (only if MAN CAB PR has been used) ..... CHECK ZERO
● If ΔP not at zero:
CAB PR MODE SEL ..... MAN
V/S CTL ..... FULL UP
ALL ENG MASTERS ..... OFF
ALL FIRE Pb (ENGs & APU) ..... PUSH
ALL AGENTS (ENGs & APU) ..... AS RQRD
■ If evacuation required:
EVACUATION ..... INITIATE
■ If evacuation not required:
CABIN CREW and PASSENGERS (PA) ..... NOTIFY

QRH in FCOM



[QRH] EMER EVAC

Ident: PRO-ABN-MISC 00012258.0001001 / 27-Sep-17
Criteria: LR
Applicable to: VH-EBA to EBD

AIRCRAFT / PARKING BRK ..... STOP / ON
ATC (VHF1) ..... NOTIFY
CABIN CREW (PA) ..... ALERT
ΔP (only if MAN CAB PR has been used) ..... CHECK ZERO
● If ΔP not at zero:
CAB PR MODE SEL ..... MAN
V/S CTL ..... FULL UP
ALL ENG MASTERS ..... OFF
ALL FIRE pb (ENGs & APU) ..... PUSH
ALL AGENTS (ENGs & APU) ..... AS RQRD
The use of agents is required if the ENG FIRE or APU FIRE displayed.
■ If Evacuation required:
EVACUATION ..... INITIATE
Announce: "EVACUATE — EVACUATE — EVACUATE" over the Passengers Address (PA) system.
Press the EVAC COMMAND pb
■ If Evacuation not required:
CABIN CREW and PASSENGERS (PA) ..... NOTIFY

Source: Qantas, annotated by the ATSB

On this occasion, the captain initiated the evacuation before referring to the emergency evacuation checklist in the QRH.

Flight crew land evacuation procedures

The operator's AEPM contained a land impact drill that detailed actions to be taken by the flight crew if an evacuation was required. As well as completing the evacuation checklist, both the captain and FO had additional actions they had to undertake. The captain was required to monitor and oversee the evacuation, and when all assistance had been rendered, evacuate the aircraft. The FO was required to enter the cabin and repeat the evacuation command, exit the aircraft through the first available exit, and report to emergency services. Both the captain and FO were also required to supervise the welfare of passengers until relieved by rescue personnel.

For the evacuation involving VH-EBC, the flight crew reported that, and were observed to, complete the land impact drill as per the documented procedure.

Cabin crew land evacuation procedures

The operator's AEPM also detailed actions that the cabin crew were required to undertake in the event of an emergency evacuation (see Appendix B*)*. Key actions to evacuate passengers included:

- commence evacuation commands (after the evacuation order is given)
- check door/exit is safe to open and open the exit (including checking for fire/obstructions)
- guard exit until the escape slide is correctly inflated
- direct passengers using appropriate commands and try to ensure that passengers do not take cabin baggage when evacuating
- if a door/exit is unusable, redirect passengers; and continually reassess the door/exit for suitability.

Key actions after passengers had evacuated included:

- take a torch and check the cabin for remaining passengers, communicating with crew so as not to duplicate areas that have been checked
- evacuate through the closest available exit and take a megaphone if located at their station
- assist passengers on the ground (including administering first aid and directing passengers to safe areas).

Procedures for an evacuation at a terminal

The operator's AEPM procedure for an evacuation at a terminal highlighted additional considerations for cabin crew. These included the use of stairs and aerobridges if available, checking outside for vehicles and obstructions, and a reminder to rearm doors prior to opening, if the area outside the aircraft was clear.

Post evacuation procedures

The AEPM contained additional procedures for after an evacuation. These procedures required both the flight crew and cabin crew to assist on the ground until relieved by emergency services personnel. For the cabin crew, the procedures required them to:

- Assist passengers away from slides.
- Direct passengers toward the blue flashing light. If a blue flashing light is not visible direct passengers upwind. *Note: Blue flashing light used in Australia only.*
- Marshall passengers away from the aircraft and treat injured – begin First Aid.
- Strictly enforce NO SMOKING.
- Protect passengers from fire, fuel and vehicles.

In addition, the operator's procedures advised of other considerations following an evacuation on land. These included:

- Remain clear of the aircraft, upwind and marshall passengers together.
- Do not re-enter the aircraft under any circumstances, unless in liaison with the Fire Commander/Police Officer…

Flight and cabin crew emergency procedures training

There was a regulatory requirement for annual proficiency testing of crew in the execution of emergency procedures. Appendix IV of Civil Aviation Order (CAO) 20.11 detailed what should be covered in the proficiency test, which included evacuation procedures and exit operation in normal and emergency mode. Civil Aviation Regulation (CAR) 217 required that each crew member undergo 2 checks of their competency each year.

Prior to July 2014, the operator's cabin crew undertook 2 days of assessment and training each year. After July 2014, this was changed to 1 day of training and assessment, with a second check of competency undertaken via computer-based training and assessment.

The operator had covered all the documented evacuation procedures in initial training, which included an evacuation at the terminal. However, there was no explicit regulatory requirement for operators to conduct the evacuation at the terminal procedure on a regular basis during annual recurrent training and assessment, and it was not included the operator's 3-year recurrent training matrix approved by CASA. The operator advised that the procedure had not been covered outside of initial training for a number of years.

Additionally, cabin crew reported that, during their annual training and assessment, the door would always be in the armed mode during an evacuation scenario, and therefore they did not need to rearm the door before opening it during the exercise.

In July 2003, there was an evacuation of one of the operator's Boeing 747 aircraft (VH-OJU) at Sydney Airport following a fire in the landing gear after the aircraft had arrived at the gate.[18] At the time of that evacuation, the 12 aircraft doors had been disarmed and one of the doors was connected to an aerobridge. During the evacuation, 8 of the 11 doors were opened by the cabin crew by rearming the door prior to opening. The other 3 exits were not armed first and were declared blocked by the cabin crew members at those doors.

[18] ATSB investigation 200302980, Boeing 747-438, VH-OJU Sydney Aerodrome, NSW 2 July 2003

The ATSB investigation report into the July 2003 occurrence stated:

> The operator indicated that during the 2002 – 2003 bi-annual EP training, a land evacuation at the terminal was practiced. The scenario for the exercise was a wheel well fire warning after engine shut down procedures had been completed. During the exercise the doors were disarmed, so door rearming by cabin crew was required.

Silent review

The use of a silent review is a well-known tool utilised by cabin crew to assist them to mentally prepare for an emergency situation.

The operator's CCOM documented the requirement for cabin crew to undertake a silent review of emergency procedures and equipment during take-off and landing, during the no-contact phase[19] of flight. A mnemonic 'OLDABC' was used as a prompt for cabin crew to remember emergency procedures:

- **O**peration of exits
- **L**ocation of emergency equipment
- **D**rill (impact)
- **A**ble-bodied and disabled passengers
- **B**race position and signal
- **C**ommands

The cabin crew stationed at the rear exits (R4 and L4) on VH-EBC reported conducting a similar review with each other after the aircraft had arrived at the terminal. Within the context of an abnormal event, they recalled discussing that the doors were disarmed, where the assist handles were for each door (as they were different on each side of the aircraft), and their evacuation commands. In addition, prior to the call to evacuate, both cabin crew members checked outside conditions and reported to each other what they could see, which at the time included a fire tender in the vicinity of the L4 door. Once the evacuation command was made, the crew member at R4 reportedly yelled to the L4 crew member to arm their door before opening it.

Evacuation commands to passengers

Operator commands at the time of the occurrence

The operator's AEPM provided commands for use by crew members in a land evacuation (Figure 12). It included core commands and other recommended commands.

[19] The no-contact phase occurs within the sterile flight deck period during take-off and landing. No communication between the cabin and the flight deck is permitted during this time.

Figure 12: Operator's documented evacuation commands

A330 B747-400 B787

Commands for Land Evacuation		
After Evacuation Ordered	**Once Door/Exit is Useable**	**Re-Direction**
Evacuate, Evacuate, Evacuate. Seatbelts OFF. High Heels OFF.	Come This Way. Get Out.	Blocked Exit. Go Forward. Go Back. Go Across.
Other Recommended Commands		
Leave Everything Behind Hurry, Hurry. Stay Close Together. Jump and Sit/Stay on your Feet, Keep Moving. Move Faster. Jump, Jump.		

End A330 B747-400 B787

Source: Qantas

Although none of the core commands specifically referred to cabin baggage, the cabin crew had the option of using the command 'leave everything behind' as required. The operator also provided recommended actions for cabin crew to take if passengers attempted to take cabin baggage during an evacuation. The AEPM stated:

> Where possible during an evacuation, passenger baggage must remain onboard the aircraft as it has potential to slow the evacuation, damage the escape slide and injure other passengers at the bottom of the slide. However, considerations should be given to avoiding:
>
> - Piling up of baggage in exits, aisles and crossovers and in front of the flight deck door.
> - Confrontation with passengers over baggage (the result which may impede the evacuation).
>
> Possible strategies for dealing with baggage if it is surrendered at the door include:
>
> - Throwing it on to seats (if configuration permits).
> - Throwing it out of the aircraft forward or aft of the slide (away from the base of the slide) in an evacuation only.
>
> CAUTION: Be alert for people moving around the base of the slides or under the aircraft.
>
> Note: The crew member should not compromise their position in the doorway to retrieve a bag.

The cabin crew on VH-EBC reported that the core commands were practiced and rehearsed during training and the other recommended commands (in Figure 12) were those that could be used by cabin crew depending on the situation.

All the cabin crew on VH-EBC reported that, during the evacuation, they used the core commands for a land evacuation. The cabin crew at the doors where escape slides had been deployed (R3, L4 and R4) reported that passengers arrived at their exits with cabin baggage, and/or were unsure of how to use the slides. Consequently, they started to use instructions like those in the recommended commands, such as 'leave your bags' or 'jump and slide', but only when the passengers had reached their door. The cabin crew member at R3 recalled changing their commands to 'sit and slide' when they assessed that there was less urgency to evacuate.

The cabin crew members at blocked exits (R1, R2 and L3 and for a period L2) reported using the re-direction commands such as 'go across' in addition to other core commands, but reported they

did not use the command 'leave everything behind' prior to passengers reaching the other doors with their cabin baggage.

The passenger who was seriously injured with injured knees when using the slide at R3 recalled hearing the commands 'get out, come on go'. They advised that they heard no other instruction on how to use the escape slide during or prior to the evacuation. They stated that they stood at the slide, sat down and then someone tugged them and they ended up going fast and chaotically down the slide, and ended up landing on the tarmac on their knees when they arrived at the bottom.

One cabin crew member also advised that the AEPM commands had changed since they started with the operator. They thought the 'old commands', which included instructions about slide use, may have been useful to passengers prior to reaching the exit.

Operator's previous commands and change process

The operator completed a review of its evacuation commands in June 2004 following the occurrence that resulted in the evacuation of the Boeing 747 VH-OJH at a terminal in July 2003. The ATSB report stated:

> The cabin crew reported a number of difficulties in applying the evacuation procedures, particularly those regarding cabin luggage. Some were unsure as to whether the priority should be to get the passengers off the aircraft as quickly as possible and ignore cabin baggage, or to insist that all cabin baggage be left on the aircraft. Other cabin crew, who followed operator procedures and insisted that cabin baggage be left behind, reported a build-up of baggage in the aisles and around doorways, potentially slowing passenger movement from the aircraft…
>
> The [AEPM] procedure did not specify commands to leave cabin baggage behind. The on-board safety cards located in each seat depicted a bag with a circled cross through it next to a passenger evacuating, symbolising that bags were not to be taken during evacuations.

Following the occurrence, the operator conducted a review of its cabin crew commands. Figure 13 shows the operator's commands at the time of the review (and the time of the July 2003 occurrence).

Figure 13: Operator's previous land and ditch commands

Land Commands	Ditch Commands
Evacuate, Evacuate Evacuate. Unfasten seatbelts. High heels off. Come this way. Form two lines/form one line. Jump and sit. Hurry. Stay close together. Move faster. Jump, jump, jump. Stay on your feet.	Fit lifejackets. They are located under your seats. High heels off. Evacuate. Evacuate. Evacuate. Unfasten seat belts. Come this way. Form two lines. Stay on your feet. Pull tags. Walk toward the end of the raft. Sit down.

Source: Qantas

The review included:

- an examination of 16 other airlines' commands for land and water evacuations
- a survey of 50 random passengers at the Sydney domestic airport to determine what commands those passengers would expect to hear

- extensive internal review and a change management process, which included obtaining and reviewing feedback from CASA.

As a result, the review team recommended that a change be made to the commands to split them into 'core commands' and 'other recommended commands', as well as adding the command 'leave everything behind and get out' to the other recommended commands. There were also commands that were recommended for use in a precautionary disembarkation (see *Procedure for precautionary disembarkation*).

The changes made to the commands as per the recommendations are reflected in Figure 12, excluding commands for a precautionary disembarkation.

Research and guidance about evacuation commands

Commands instructing passengers to leave cabin baggage behind

Guidance produced by a number of sources including CASA, the aircraft manufacturer, ICAO, and the International Air Transport Association (IATA) recommended that cabin crew use commands during an evacuation that instruct passengers to leave their cabin baggage behind. This is to reduce delays, and reduce the potential for passengers blocking aisles and exits and/or damaging escape slides.

All guidance, except that from CASA, also specifically advised that the commands should occur at the beginning of the evacuation. One reason for this was that it was too late to provide this instruction when the passenger had reached the exit with their cabin baggage. All sources also suggested that passengers be advised in the pre-flight safety briefing about leaving cabin baggage behind during an evacuation.

An ATSB research report *Evacuation Commands for Optimal Passenger Management* (2006) detailed the results of a survey of Asia Pacific and Australian airline operators. In response to a question about what instructions were given to passengers in relation to cabin baggage, all but one of the operators surveyed stated they employed a command to direct passengers to leave their cabin baggage behind during an evacuation. It was also noted that in previous research conducted by the NTSB,[20] there had been instances where passengers and cabin crew had argued during an evacuation about taking cabin baggage and this had caused disruption to the evacuation flow.

The research report also noted the ATSB report into the July 2003 evacuation involving VH-OJH indicated similar problems with cabin baggage and passenger flow. In addition, the research report highlighted that there may be a need to remind passengers, in an operator's pre-landing announcement, about leaving cabin baggage behind if required to evacuate. However, at the time of the 2006 survey, most operators (including the operator of VH-OJH) did not provide such information in the pre-landing announcement.

Commands for escape slide use

Escape slides are designed to enable a quick and safe egress for passengers and crew in an emergency. To help facilitate an expeditious exit, cabin crew are trained to be assertive and use short, concise commands to get passengers out of the aircraft as quickly and safely as possible.

When transport aircraft are certified, testing is conducted to ensure that an evacuation can be undertaken within 90 seconds using half of the exits. A successful evacuation is not only affected by the configuration or design of the aircraft itself, but also procedural aspects. This includes the actions taken by cabin crew to influence the speed of the evacuation, including the use of commands.

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[20] National Transportation Safety Board 2000, 'Safety Study: Emergency Evacuation of Commercial Airplanes', NTSB/SS-00/01 PB2000-917002, Washington DC, USA.

In the NTSB's *Safety study: Emergency Evacuation of Commercial Airplanes* (2000), speed was identified as the primary reason airlines utilised the command 'jump and slide' at exits. The NTSB noted that it was not aware of any aircraft being certified with a 'sit and slide' procedure, and it concluded that evacuations involving slide use could be delayed if passengers sat at exits before boarding a slide or if crew commands did not direct passengers how to get onto a slide. The report recommended that the FAA review airline procedures and training programs to ensure that the commands used for slide evacuations were consistent with the commands used for slide evacuations during certification.

The ATSB research report *Evacuation Commands for Optimal Passenger Management* (2006) also discussed commands for slide use. It stated:

> The reason for commands that encourage passengers to 'Jump' or 'Jump and slide' when evacuating is to achieve the required flow rate of 70 people per lane per minute down the slide (FAA, 1990). This rate could not be achieved if a procedure of 'Sit and slide' was used, as the act of sitting takes valuable time. One study found that if 100 passengers were to sit on the slide, they would take 33 seconds longer to evacuate than 100 passengers who jumped (see Johnson, 1984)…
>
> 'Jump and sit' may cause confusion, as it is possible that some passengers might interpret this to mean that either jumping or sitting is acceptable… The command 'Jump and slide' may increase the speed of the evacuation, and could therefore have an impact on the injuries sustained by passengers. This is not likely to be a key issue in a genuine emergency situation, such as where a post-crash fire is present. However, in precautionary emergency evacuations, where the airframe is evacuated 'just in case', it is possible that passengers will not tolerate a higher injury rate…

In addition to conducting a survey, the ATSB 2006 research report also involved conducting trials of different types of evacuation commands in a simulator. In aircraft with dual lane slides, such as the A330, the report also noted:

> The results showed that evacuations without dual-lane flow commands were faster, but more disorganised. With a larger passenger load, dual-lane flow commands could be useful for managing the evacuation in a more orderly and less congested fashion.

The improvisation of commands was also discussed in the ATSB research report in the context of an operator permitting cabin crew to use commands they thought were appropriate when instructing passengers to fit life jackets, rather than having trained them to say scripted commands. The report noted 'the danger of this approach was that it is widely recognised in the literature on learning and skill acquisition that over-training can often be required to ensure competence in infrequent events.'

Other guidance in ICAO's *Manual on Information and Instructions for Passenger Safety* (2018) advised:

> Once cabin crew members open the exits and verify that assisting evacuation means (e.g., slide, slide-raft) are ready for use; they should instruct passengers to move towards the usable exits. At exits equipped with dual-lane slides, cabin crew members should instruct passengers to divide into two lines at the doorway to evacuate as many passengers as possible simultaneously in pairs.

Procedure for a rapid disembarkation

A rapid disembarkation (sometimes known as a rapid deplaning or precautionary disembarkation) is a procedure used in an abnormal situation that has the potential to escalate into an emergency, and where passengers and crew need to deplane quickly as a precautionary measure.

A rapid disembarkation usually happens at the airport and the emergency exits and slides are not used unless it is decided that this is necessary, in which case this will be done in a controlled

manner with commands such as ‘sit and slide’ used to instruct passengers about slide use. As it is a rapid egress from the aircraft, passengers will be instructed to leave their belongings behind.[21]

Rapid disembarkation procedures are commonly used among Australian and other overseas operators, and assessed by CASA when an operator is applying for an Air Operator’s Certificate (AOC). Both ICAO in its manual *Cabin crew safety training manual* and *Manual on Information and Instructions for Passenger Safety,* and IATA in its *Cabin operations best practices guide* reference a rapid disembarkation as an alternative procedure to an evacuation.

Qantas previously had a rapid disembarkation procedure (which they termed a precautionary disembarkation), which was in both the AEPM and the QRH and was included in crew emergency procedures training and assessment. The operator advised the ATSB that the process to remove the precautionary disembarkation procedure began in 2012 with a risk assessment, and the process was finalised in 2017. In 2020, the operator provided the following summary to the ATSB regarding the reason for removal of the procedure:

> A number of previous safety investigations between 2005 and 2013 had identified that the precautionary disembarkation procedure was not effective in managing the actual disembarkations as designed and expected.
>
> The organisation recognised that our events had become less routine and more unique. We therefore needed to provide crew with a formal framework that provided the flexibility to manage these events safely and effectively, in a wide range of circumstances.

The operator also provided a flight operations memo dated June 2017, which was distributed to flight crew, that explained some limitations and additional reasoning for the removal of the procedure:

> It is acknowledged that there may be some highly unusual instances where options are limited and outside the scope of company policy where the Capt determines that neither an evacuation or a non-routine disembarkation is appropriate. In such cases the captain retains the authority under CAR 145[22] and 224 to deplane passengers using escape slides or any other means.
>
> Additionally, a number of abnormal events (eg smoke in the cabin) have occurred at the terminal while attached to an aerobridge. In these situations, it was identified that the 'Precautionary Disembarkation' lacked the necessary flexibility to effectively manage the deplaning of passengers.
>
> Accidents around the world continue to demonstrate that the use of escape slides pose a significant risk to injury to passengers. While this is justified in emergency scenarios (when grave or imminent danger to occupants) the injury risk is no longer considered acceptable during non-emergency events.'

The precautionary disembarkation procedure was replaced by a ‘non-routine disembarkation’ in 2017, which was classified as a normal procedure and therefore not referred to in the AEPM or the QRH. A non-routine disembarkation was documented in both the CCOM and the FCOM. Text in the CCOM stated:

> A Non-Routine Disembarkation is a process to be used when it is not possible for passengers to disembark the aircraft in a routine or normal manner but where there is insufficient risk to passenger or aircraft to justify continuation of alert phase and/or evacuation. The pace of a Non-Routine Disembarkation is slower than that of a routine disembarkation, to ensure passenger safety. A Non-Routine Disembarkation may be upgraded to an evacuation if the situation requires and in this instance, all primary escape routes, providing they are safe, must be opened.

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[21] European Aviation Safety Agency (EASA), (2019) *Frequently Asked Question (FAQ) n.99876. What is the difference between ‘rapid disembarkation’ and ‘evacuation’?* What is the difference between ‘rapid disembarkation’ and ‘evacuation’? | EASA (europa.eu)

[22] CAR 145 stated that ‘…the pilot in command of an aircraft shall pay due regard to all dangers of navigation and collision and to any special circumstances which may render a departure from those rules necessary in order to avoid immediate danger.’

With the removal of the precautionary disembarkation procedure, the only procedural option available to flight crew to rapidly disembark or to get passengers out of an aircraft quickly was to use the evacuation procedure, which involved using escape slides.

Following the occurrence involving VH-EBC, and as part of its safety action, the operator provided details of non-technical skills training that demonstrated how the evacuation procedure could be adjusted by a captain in different scenarios. The event used as an example occurred during engine start in Cairns in February 2019. After the passengers had been loaded onto a Boeing 737 aircraft, there was an engine overheat indication and subsequent fire warning. In response, the captain decided that an evacuation was required. This was due in part to the unavailability of stairs after the aircraft had returned to the bay, and partly because there was no other procedural option whereby the slides were permitted to be used for disembarkation. It was reported that in this instance the captain adjusted the evacuation procedure by nominating exits for use on the right side of the aircraft only, and advised the cabin crew that the over-wing exits were not required. This event was utilised as an example of where the captain used their authority under CAR 145, which permitted the captain of an aircraft to adjust the emergency procedure to avoid immediate danger.

Airbus also previously had a rapid disembarkation procedure documented in its version of the CCOM, however this procedure was removed in 2008. When asked about the reason for the removal of the procedure, the manufacturer advised:

> The precautionary evacuation procedure was deleted for the following reasons: In the case of obvious rapid disembarkation on the stand initiated by the flight crew, specific airline procedure for both aircraft and on ground activities should apply.

Research and previous safety investigation reports advocating the use of a rapid disembarkation procedure is provided in Appendix C.

Passenger safety briefing

Regulatory requirements for passenger safety briefings

CAO 20.11 (*Emergency & life saving equipment & passenger control in emergencies*) stated an operator shall ensure all passengers are provided with an oral safety briefing before each take-off. The order detailed a list of items that passengers must be briefed on, including the location of emergency exits. There was no specific requirement to provide passengers with information about what to do with cabin baggage in an emergency, or the use of the escape slides.

CAO 20.11 also required that a safety briefing card was available for passengers on regular public transport (RPT) aircraft with a seating capacity of more than 6 (including crew). The card was required to contain additional information on several matters, including diagrams of emergency exits and the methods of operating the exits.

Guidance on passenger safety briefings

ICAO in its manual on *Information and Instructions for Passenger Safety* provided guidance on how and what safety related information should be provided to passengers prior to and during flight. In respect to information about passenger cabin baggage and slide use, it was suggested that the pre-flight safety demonstration contain information about what to do with cabin baggage and belongings in case of an evacuation, and provide information on the location of emergency exits. It also suggested other information that could be included such as how to evacuate with infants and children.

CASA had produced similar guidance, including the following guidance on the content of the passenger briefing card in CAAP (Civil Aviation Advisory Publication) 253-2 V2.0 *Passenger safety information: Guidelines on content and standard of safety information to be provided to passengers by aircraft operators* (initially released in 2004, with the same text repeated in the revised version in 2018):

> **Evacuation slide use.** The card should contain instructions consistent with the manufacturer's recommended procedures (e.g. for passengers to jump outward in the seated position with legs extended, and not to stop and sit at the door sill). Use of the slide or other assist means should be consistent with the exits on that aircraft. Removal of high heels prior to using an escape slide is recommended.

Operator's safety briefing

The operator used an audio-visual presentation to relay safety information to passengers. At the time of the occurrence, the video showed people travelling to different locations around the world and provided the required instructions to passengers in the different contexts, none of which were in an aircraft.

Figure 14 shows still images from the video where information was provided about cabin baggage in an emergency, and the use of emergency escape slides. There was no information provided to passengers about the use of the escape slide with infants.

Figure 14: Still images from the operator's passenger safety video

Source: Qantas

The audio provided the following information, which matched the subtitles in the video:

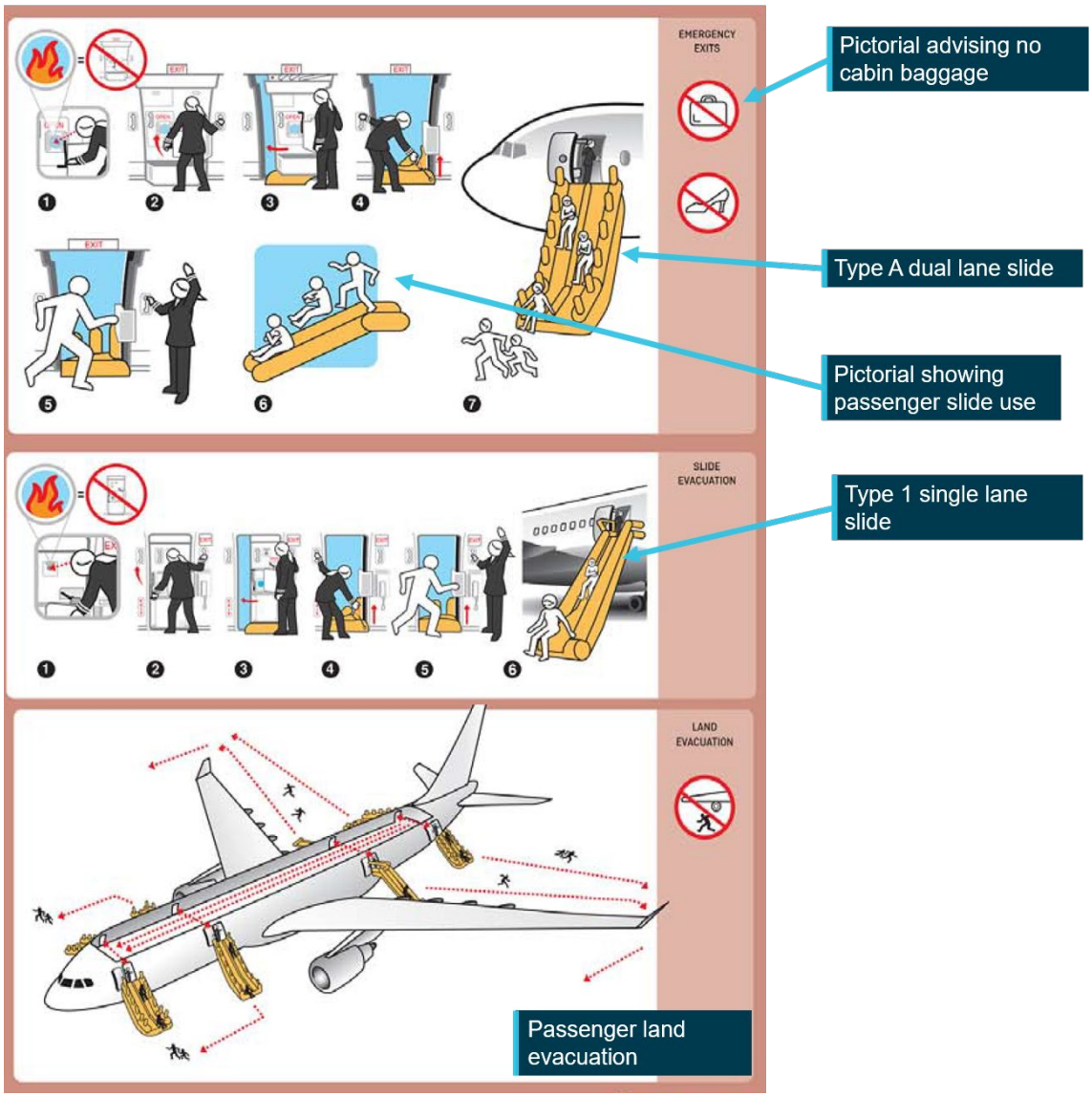
> It also has escape slides and life rafts which the crew will operate in an emergency. If you have to evacuate leave all items behind. Slide leaning forward with your hands on your knees.

As evident in the figure, the images in the video were not consistent with the subtitles or the audio.

Operator's safety briefing card

The operator provided a copy of its A330 safety briefing card utilised at the time of the occurrence. Figure 15 shows the pictorials on the card that provided information about cabin baggage and the use of escape slides in a land evacuation.

Figure 15: Excerpt of operator's A330 safety briefing card



Source: Qantas, annotated by the ATSB

Related occurrence

There was one previous serious incident involving an A330 where, following the failure of a rudder servo pressure hose, hydraulic fluid entered the APU air intake and then the aircraft cabin. It occurred at Karachi International Airport on 4 October 2014 and involved an A330-243 with serial number 0518. The serious incident was investigated by the United Arab Emirates Air Accident Investigation Sector, General Civil Aviation Authority.[23] The report's synopsis stated:

> On 4 October 2014, Emirates Airline flight EK609, from Jinnah International Airport (JIAP), Karachi, Pakistan, to Dubai International Airport (OMDB), the United Arab Emirates, with 14 crewmembers and 68 passengers onboard was operated by an Airbus A330 Aircraft, registration A6-EAQ. As preparations for departure were completed the flight crew sensed an odor accompanied by a yellow hydraulic system low pressure indication on the electronic centralized aircraft monitoring (ECAM) system.
>
> The odor was due to hydraulic fluid mist that entered the cabin and cockpit through the airconditioning system. The source of the hydraulic fluid mist was leakage from a fractured hose that provides

[23] AAIS Case No: AIFN/0016/2014, Airbus A330-243, A6-EAQ, Hydraulic Fluid Mist and Protective Breathing Equipment Fire in the Passenger Cabin, Karachi International Airport, 4 October 2014.

> hydraulic pressure to the rudder yellow system actuator. The leaking hydraulic fluid entered the auxiliary power unit (APU) from where it entered the airconditioning system. Examination of the hose concluded that the cause of the fracture was, most probably, fatigue failure of the metal braiding, followed by fracture of the hose PTFE core pipe.
>
> The mist filled the cockpit and cabin and caused difficulty in breathing, throat discomfort, and eye irritation for some occupants…
>
> Based on initial information, the Commander [captain] decided to return the Aircraft to the stand and disembark the passengers and crew using steps. The Commander requested information about the situation in the cabin from the L4 cabin crewmember, who stated that visibility in the cabin was now limited to four rows. On receiving this information, the Commander decided to order an evacuation while the Aircraft was at its final pushback position.
>
> The Air Accident Investigation Sector (AAIS) determined that the cause of the dense mist was the failure of a yellow hydraulic system rudder servo hose that allowed leaking hydraulic fluid to enter the APU, become heated and atomized, and then to be fed into the Aircraft airconditioning system. The cause of the hydraulic hose failure was not determined by the Investigation…
>
> A contributing factor to the Incident was that the flight crew were unable to identify the source of the mist/smoke and decided to leave the APU running in case it became necessary to shutdown both engines.

During the 2014 occurrence, the aircraft had not yet commenced taxiing for departure. The atomised hydraulic fluid appeared to enter the cabin and flight deck via the APU about 1 minute after the yellow hydraulic system low pressure warning. In the case of VH-EBC, the atomised hydraulic fluid appeared to enter the cabin and flight deck via the APU about 2 minutes after the aircraft stopped at the terminal.

The investigation report included the following recommendation which was issued to Airbus:

> SR49/2016
>
> Assess the risk of amending the existing SMOKE/FUMES/AVNCS SMOKE and SMOKE/FUMES REMOVAL checklists to distinguish between inflight and on-ground smoke scenarios, and insert text in the checklists to differentiate between the aircraft be on the ground or inflight.

Airbus responded to the recommendation (Appendix D), and reiterated that the procedure for smoke/fumes inflight was suitable for use on the ground.

Safety analysis

Introduction

About 7 minutes after departure from Sydney, the flight crew became aware that there was a problem with the A330 aircraft's green hydraulic system. The flight crew followed the required checklists and decided to return to Sydney rather than continue to Perth. After landing, the crew shut down the aircraft's engines and started the auxiliary power unit (APU) in preparation for being towed to the terminal. The APU bleed was selected on to enable air conditioning in the cabin.

Approaching the terminal, the aircraft doors were disarmed by the cabin crew as per the normal procedure. Soon after the aircraft stopped at the terminal, a haze/smoke was evident and worsening in the cabin and flight deck, with some crew and passengers experiencing physical symptoms. After consultation with the customer service manager (CSM) and the first officer (FO), the captain commanded an evacuation. The evacuation was called at about the time one aerobridge was being connected and a second was in the process of being positioned at the aircraft, therefore the passengers evacuated via both aerobridges and escape slides.

This analysis first considers the hydraulic hose failure. It then discusses the communication between the cabin crew and flight crew, and the overall management of the evacuation of the passengers, including the use of escape slides at the terminal, and aspects of passenger behaviour.

In addition, the analysis discusses a number of additional safety factors identified during the investigation, which relate to the operator's passenger safety briefings, commands used in an evacuation, and other procedural aspects such as the unavailability of a rapid disembarkation procedure.

Hydraulic hose failure

The source of the hydraulic issue related to the loss of hydraulic fluid from a ruptured green system rudder servo hydraulic hose. Materials analysis conducted by the manufacturer indicated that the hose failure was due to a combination of corrosion and fatigue cracking of the stainless streel braid. Once the stainless steel braid failed, this left the inner Teflon hose structurally unsupported, resulting in high pressure hydraulic fluid rupturing the inner Teflon hose.

This occurrence was the operator's second occurrence involving a failure of the same hose type, fitted to the same position on 2 different aircraft with a similar age, flight hours, and cycles. Those occurrences were 6 months apart on 2 of the oldest A330s in the operator's fleet. A similar failure had occurred on a yellow system hose on an aircraft of the same age involving another operator.

The aircraft manufacturer did mandate a calendar time replacement of some other hydraulic hoses (located in the wheel wells of the aircraft) that had a higher failure rate. However, the green system rudder servo hydraulic hose was not a mandatory replacement. Rather, it was an on-condition part that either had to have an identified visual defect or fail before it was required to be replaced. The hose had been visually inspected about 5 months prior to failure. However, the identification of any defect other than a hydraulic leak was not likely as the failed hose did not have any visual defects externally, even after it had failed.

Although the failure of the same hose on 2 different aircraft in the same fleet may indicate an underlying issue, there was not enough worldwide data to indicate an emerging trend to warrant a mandatory calendar replacement of the part. That said, there is nothing preventing individual operators from introducing a replacement program based on their own historic in-service fleet-wide analysis.

Hydraulic fluid ingestion into the APU

The flight crew were unaware that there was hydraulic fluid leaking into the tail cone area of the aircraft and out onto the lower surface of the empennage. Engineers who inspected the aircraft after landing, and prior to it being towed to the terminal, did not notice any leaking hydraulic fluid on or around the aircraft. It is possible there was limited hydraulic fluid present during these inspections, and more fluid was later forced from the failed hydraulic hose as the aircraft was turned to park at its allocated gate, with the nose-wheel hydraulic actuator movement pushing residual fluid out.

The hydraulic fluid from the hose leak at the rudder servo ran down the tail and was ingested into the open APU air intake. The APU was started and the bleed air selected on while the aircraft was on the taxiway, 22 minutes prior to the aircraft arriving at the terminal. About 2 minutes after the aircraft stopped at the terminal, the low pressure suction at the APU air intake drew hydraulic fluid into the APU load compressor, enabling the air conditioning system to deliver atomised hydraulic fluid to the aircraft flight deck and cabin.

The aircraft was fitted with an air intake diverter and fluid gutters to minimise the likelihood of fluid entering the APU air intake. These features would prevent fluid intake in most cases when the aircraft was on the ground. No significant fluid appeared to enter the air intake while the aircraft was stationary on the taxiway (for 11 minutes after the APU was started) and while it was being towed (about 11 minutes). However, as evidenced in this case and the other similar serious incident involving an A330 in 2014, the diverter and gutters can be bypassed by leaking hydraulic fluid in some situations when the aircraft is stationary on the ground. In the case of VH-EBC, the wind direction when the aircraft was parked at the terminal may have assisted the hydraulic fluid ingestion (the wind was blowing from the aft to the front of the aircraft when parked).

Communication between the cabin and flight crew

The cabin crew members at the L1 and L2 doors reported smelling something unusual when the aircraft had stopped on the taxiway, and during the tow to the terminal. When the aircraft arrived at the terminal and the cabin crew commenced the procedure to disarm the doors, the cabin crew member at L3 reported that they could smell ‘dirty socks’; however, they did not communicate this to the CSM, instead reporting only about the haze that could be seen in the cabin. The FO had also smelt something unusual and reported this to the captain, however they had not provided the same descriptions as the cabin crew.

It is vitally important that cabin crew provide the flight crew information about unusual smells in the cabin with as much detail and common terminology as possible (such as using an odour descriptor). If the flight crew on this occasion had been provided with information that there was an unusual smell (particularly one that the CSM had associated with a hydraulic system problem or one which may have indicated a fumes event), this may have raised the threshold for considering the relevance of the smell in relation to the hydraulic event.

Regardless of the source of the unusual odour (it may not have been related to the hydraulic leak), this information may have prompted the flight crew to turn the APU bleed air off, as this action forms part of the smoke/fumes procedure. If the APU bleed had been turned off this would have resulted in very limited hydraulic fluid mist contamination of the aircraft cabin.

Aircraft evacuation

Use of evacuation signal

The captain issued the evacuation command via the public announcement (PA) system, stating the required words (‘evacuate, evacuate, evacuate’). The announcement was effective in alerting the cabin crew and passengers of the need to evacuate the aircraft.

The operator's procedure required a captain to initiate an evacuation using all available means, which in this case included the use of the emergency evacuation signal (alarm) that was fitted to VH-EBC as well as making the PA. The use of the evacuation signal is a secondary method to alert crew and passengers that there is a need to evacuate the aircraft, which provides additional assurance that passengers and crew are made aware of a need to evacuate in case the PA command is not fully effective.

In this case, the captain did not activate the emergency evacuation signal. Not all of the other A330 aircraft in the operator's fleet had the evacuation signal fitted. In addition, the *Quick Reference Handbook* (QRH) located in the flight deck of VH-EBC did not include the use of the evacuation signal in the evacuation checklist, even though this was in the operator's other operational documents for flight crew. Therefore, even if the captain referred to the checklist, they would have had to recall that they were on an A330 that had this function fitted.

The emergency evacuation signal could also be activated on the flight attendant panel in the cabin on VH-EBC. However, there was no procedure detailing when the cabin crew should ensure the signal was activated. This removed an additional redundancy. In situations where a flight crew did not or could not activate the signal, the cabin crew will be unlikely to activate it without a procedure that details when they should do so.

Decision to use exits

When the captain ordered the evacuation, they did not provide any additional information to the cabin crew about the exits to be used during the evacuation. That is, the captain had not used their powers under Civil Aviation Regulation 145 to adjust the procedure for the specific situation (as detailed in some of the operator's training as a suitable alternative in some cases), nor were they required to or needed to. Accordingly, it would be expected that all available exits would be utilised and passengers would be evacuated as quickly as possible as per the documented emergency procedure. The operator's evacuation at the terminal procedure identified additional considerations when an evacuation occurred at a terminal, which included the use of stairs and aerobridges; however, this did not indicate that these options should be used instead of other available exits.

When the captain issued the evacuation command, the aerobridge was being connected to door L1, which provided an easy means of escape for passengers near that door. Of the other exits, 2 doors with slides were opened promptly at the rear of the aircraft (L4 and R4), with R3 also being available soon after (see below). L2 was connected to an aerobridge about 1 minute after the evacuation command, and R1 and R2 were not opened.

Although L2 eventually had an aerobridge connected, there was no reason that the R2 exit could not have been opened as the cabin crew member had assessed that the exit was clear on 2 occasions. They based the decision not to open the exit on an assumption but no visual evidence of an external fire, and possibly the fact that there was an aerobridge already connected at L1 and there was a flow of passengers towards that exit.

The R1 exit remained closed due to a vehicle being seen outside initially; however this exit was not reassessed for availability. The L2 exit was also not checked for availability to ensure that an aerobridge was being connected and to facilitate it being available as soon as possible.

Ultimately, most of the passengers in the front of the aircraft were directed to the L1 exit to evacuate for the first 50 seconds of the evacuation. Although using the aerobridge reduced the risk of physical injuries on this occasion, not opening available exits in an evacuation as soon as practicable can have catastrophic consequences depending on the situation.

Operation of the doors during the evacuation

Two of the 4 cabin crew who opened a door with the intention to activate an escape slide did not rearm the door before opening it (L3 and R3). One of the cabin crew members then promptly closed the door, rearmed the door and opened it again to activate the slide (R3).

The cabin crew members were all trained and assessed against the operator's published and approved procedures, and they were all qualified to operate the flight. However, the training for an evacuation at the terminal was limited. Cabin crew had practiced the procedure for an evacuation at a terminal during initial training, which identifies additional considerations such as ensuring that the doors are rearmed. Nevertheless, the cabin crew had not practiced the procedure in recurrent training for a number of years, and most of the cabin crew had not practiced the procedure since their initial training.

The operator's procedure to open the doors in an emergency stated that they should open the door 'ARMED', and this implied that the cabin crew should first check the door was armed. Reports from cabin crew advised that in their annual training and assessment, the door was always in the armed position in an evacuation scenario, and therefore it was not habitual for them to check that the door was armed prior to opening.

In comparison, the manufacturer's procedure explicitly stated that the person should check that the door was armed before opening. It would therefore be beneficial to ensure that the procedure for opening the door in an emergency includes a step that ensures that the cabin crew check the status of the door prior to opening, and that cabin crew are trained to check that the door is armed, regardless of where an evacuation occurs.

Review of procedures after landing

Just after the cabin crew at the rear of the aircraft (L4 and R4) were alerted to the haze/smoke in the cabin, they completed a verbal review of evacuation procedures together, which included discussion about the need to rearm their doors if an evacuation was required. As a result, they were prepared for the evacuation, rearmed their doors when the evacuation command was given, and successfully deployed both escape slides.

Both the rear cabin crew members recalled utilising the silent review concept with each other just prior to the evacuation being called. The silent review is a well-known tool utilised by cabin crew during the take-off and landing stages of flight and will usually be undertaken when the no-contact phase is in place. The use of this same premise, coupled with communicating what actions were required, is a great example of the use of non-technical skills by these cabin crew members. Cabin crew should be encouraged to mentally rehearse their procedures anytime they have been alerted to an abnormal situation, as well as during take-off and landing, and it would be advisable that crew members are reminded to remain alert to any abnormalities until everyone has safely disembarked the aircraft.

Cabin baggage and use of escape slides

Passenger safety briefing

Information about what to do with cabin baggage in an emergency and the use of escape slides was provided to passengers in a safety video (with audio and subtitles), and was supplemented by the information in the safety briefing card. However, the content provided to passengers was both limited and inconsistent in the following ways:

- The procedure to descend the escape slide safely included instructions about jumping past the girt bar, keeping legs straight with toes pointed upwards; this information was not included in the safety video. Although the briefing card had a pictorial that could be interpreted as having a requirement to jump and slide with toes pointed upwards, it could not be determined to what extent passengers had this interpretation.
- The safety video showed a passenger sitting and then sliding, which is not the recommended means of using an escape slide. As research has shown, this method (rather than jumping first) can cause delays in an evacuation.
- The safety video showed a passenger leaning back with their hands on their knees, rather than leaning forward, which is the safest means of use.

- The briefing card showed a person jumping and crossing their arms to descend the slide. Although this would be an acceptable position when sliding, it was not consistent with the operator's procedure or the safety video.
- The safety video depicted a passenger putting their cabin baggage next to the slide as they sat down to descend the slide. However, it is obviously preferable that passengers do not bring cabin baggage to the exits at all.
- The briefing card showed a small pictorial of a bag with a circle and a line through it to indicate to passengers that cabin baggage should not be taken when exiting; this was the only reference to the requirement to leave bags behind on the briefing card.
- The in-flight announcements (just prior to landing) did not include a reminder to leave cabin baggage behind in an emergency.
- There was no information provided about how to descend the escape slide safely with infants and children, either in the information provided to passengers or in the operator's procedures for cabin crew.

Although there is no guarantee that passengers will attend to safety information provided to them in pre-flight safety briefings, there have been a number of developments in the utilisation of audio/visual presentations (video) by operators, using entertainment in an attempt to gain passenger attention. However, there has been no research that has proven that this approach leads to safer outcomes in emergencies.

Regulatory requirements dictate what information must be provided to passengers orally and in a written format, and in this case those minimum requirements were met. However, the operator's safety video provided the information in differing contexts outside of the aircraft environment. For example, it utilised a slide at an amusement park rather than an actual aircraft emergency evacuation slide. In this part of the safety video, the audio and subtitles provided information about the use of the escape slides and the requirement to leave cabin baggage behind, but the visual content did not match the audio information.

The majority of airlines who fly domestically in Australia do not use a safety video and are not required to do so; rather, information about cabin baggage and slide use is provided orally (using a pre-recorded announcement or a public announcement by the cabin crew) and via the safety briefing card. Utilising a video can certainly be useful in providing passengers a visual representation of actions they may be required to take. However, to be most effective, the information in the video about cabin baggage and the use of the slides should be consistent with the information given in both the safety card and the audio, and clearly outline the required actions.

Research conducted by the NTSB (2000) and the ATSB (2004) found that passengers tend not to look at the safety briefing card, and even if passengers do look at the card not all of them will understand the instructions provided. The NTSB also found that passengers believed that the safety briefing should include information on how to operate the exits and escape slides. As it cannot be guaranteed that a passenger will attend to and understand the information provided on a safety briefing card, it should only be used as a supplement to the oral briefing and not the primary source of safety information provided.

The management of passengers in an emergency situation is the last line of defence in avoiding injury and fatalities. Therefore it is important that passengers are well informed through the provision of sufficient and accurate communication about what they may be required to do. It is widely known that more knowledgeable passengers will be better equipped to react appropriately in an emergency, and that briefing passengers does in fact increase passenger survivability (Meng-Yuan, 2014). In this occurrence, the passengers were provided with information that was limited and inconsistent, and this meant that there was more reliance on cabin crew providing instructions to passengers on what to do during the evacuation.

Commands used during the evacuation

Qantas's cabin crew primary evacuation commands to passengers did not include phrases such as 'leave everything behind' and 'jump and slide'; instead, these phrases were optional. Consequently, passengers would generally not receive specific guidance about required actions until they reached an exit, which would likely slow down an evacuation.

Interviews with all 8 cabin crew indicated that the commands they used to instruct passengers were consistent with the core commands documented in the operator's *Aircrew Emergency Procedures Manual* (AEPM), which were those they had practiced in training. However, some of the cabin crew reported that they had not utilised the 'other recommended commands'.

It is very likely that passengers may attempt to evacuate with cabin baggage in an emergency, particularly when disembarking at a terminal, and there have been examples where confrontation with cabin crew at the exits has caused an interruption to the evacuation flow. Accordingly, it is important that cabin crew advise passengers at the beginning of the evacuation to leave everything behind. This may not stop all passengers bringing cabin baggage to the exit but may prevent some passengers from attempting retrieval, and can limit the potential number of bags brought to the exits.

In terms of escape slide use, almost all passengers will have never had the opportunity to utilise an aircraft escape slide and therefore will rely on the cabin crew to provide instruction on its use. The passenger safety briefing and briefing card in this occurrence provided conflicting and limited information, and this made the reliance on cabin crew instructions even greater. The cabin crew reported only providing additional instruction to passengers when they reached the slide, some of which were not consistent with guidance provided by the manufacturer and others for safe and efficient slide use in an emergency, for example 'sit and slide', 'get out'.

Research has shown that the trained evacuation commands used in an evacuation should be aligned with those used during certification. This is because when the aircraft is certified, the testing that is undertaken provides assurance that not only the aircraft design is effective, but also the procedural aspects such as cabin crew commands are too. Without additional testing or research, a significant change to those commands becomes an unknown in terms of their effectiveness. For example, the operator no longer requires the passengers to form 2 lines for dual lane slides and does not always use the command to jump (onto the slide).

Passenger behaviour during the evacuation

Passenger behaviour in emergencies will always be unpredictable, particularly given that many emergencies will have unique aspects. However, in several previous evacuations passengers have taken cabin baggage, even when instructed explicitly not to.

In this case it was reported that passengers were reasonably compliant when given instruction directly. Given the timing of the evacuation, where some passengers were already standing getting ready to disembark, it is also understandable that they would have already retrieved some cabin baggage. However, it was still very evident that a significant number of passengers retrieved baggage after the evacuation command, and some evacuated with cabin baggage using the escape slides. This resulted in a slower evacuation pace. In this case, the risk of harm from the fumes was less once the doors were opened and the cabin was ventilated. Therefore, there was a lower risk of incapacitation or significant effects from exposure to the atomised hydraulic fluid.

Video footage and reports from the cabin crew showed that many passengers were unaware of what to do when they used the evacuation slides. Some passengers reportedly sat and slid, and others went down the slide on their knees or were lying down. Six passengers were injured as a result of using the escape slides, with a variety of injuries reported, including friction burns to the hands. Friction burns to the hands are a result of placing hands on the slide when sliding down. This is partly why the recommended safe slide position includes placing the arms across the chest or on the knees, the other reason is to provide stability and maintain a slower speed.

The passenger who was seriously injured could not recall any instructions prior to or during the evacuation about how to descend the escape slide. It could not be determined whether other passengers who received injuries paid attention to the information provided in the safety video, or whether they could recall the information.

Post evacuation

The operator's procedures required that both the flight and cabin crew assist passengers on the tarmac after they have evacuated, until relieved by emergency services. On this occasion, emergency services were present when the evacuation occurred. Nevertheless, none of the cabin crew provided assistance to the passengers who had evacuated using the slides. The cabin crew, who have first aid training, may have been able to assist in attending to passengers on the tarmac, particularly those with injuries.

Cabin crew did ask the captain if they should exit via the slides, however the captain gave the cabin crew the choice of evacuating via the aerobridges. Both the cabin crew and the flight crew exited via the aerobridges, with the flight crew proceeding to the tarmac to report to the fire commander and provide assistance, before returning to the terminal.

The operator's procedures, and the procedures of the aviation rescue fire fighting service (ARFFS), stipulated that the fire commander was required to conduct a risk assessment of the aircraft before flight crew, cabin crew and ground personnel, were cleared to re-enter. However, following the evacuation, cabin crew continued to re-enter the aircraft cabin to collect cabin baggage and other items for both passengers and other crew members. Other personnel also entered the aircraft cabin. They did so without being given a clearance that it was safe to do so. These personnel were not equipped to re-enter the cabin, nor were they in a position to conduct an informed assessment of the risk.

Rapid disembarkation

The objective of an evacuation is to optimise the use of all available exits. The captain on this occasion commanded an evacuation believing that it was necessary to get out of the aircraft as quickly as possible. The captain was aware of haze, mist or smoke in the flight deck and cabin, was not sure of the source of the problem, and was aware that the problem was getting worse. Given this context, the captain's decision to evacuation was appropriate.

However, to reduce the number of potential injuries related to escape slide use, a rapid disembarkation (if available) may be a suitable alternative in other situations where there may be a need to get out of the aircraft quickly, but not with the same level of urgency. This includes situations such as a fuel spill, fumes event or bomb threat where the rapid disembarkation can be upgraded to an evacuation if required.

In this case, at least some of the cabin crew were inadvertently actioning a form of rapid disembarkation/rapid deplaning procedure, as opposed to an evacuation that required all available exits to be used and the aircraft to be 'evacuated' as quickly as possible. Although the captain had commanded an evacuation, some of the cabin crew had assessed that there was no immediate danger in the cabin, and had decided that it was in the best interests of passengers to only use certain exits and at a slower pace.

For example, the cabin crew in the forward section of the aircraft who did not have an aerobridge connected, upon establishing a flow of passengers, did not continue to check outside their exits to determine if they were usable and instead decided to redirect passengers to the exits connected to the aerobridges. In addition, the cabin crew member at R3 changed their commands for passengers reaching the exit to sit down and slide.

This assessment by the cabin crew of less urgency did not result in any adverse outcomes on this occasion. However, without any further consultation with the flight crew, the cabin crew may not have had all the information to effectively downgrade the emergency response.

As evidenced in the operator's training material, a captain could initiate an evacuation and nominate the use of some exits only. However, adding specific instructions to an evacuation procedure can add complexity to the situation, and the use of selected exits would be more compatible with a rapid disembarkation procedure, if available. A rapid disembarkation procedure can be upgraded to an evacuation at any time. However, it is more difficult to go the opposite way and downgrade an evacuation after it has been initiated, which also has the potential to lead to an increased number of injuries to passengers.

Having a rapid disembarkation procedure ensures that there is a broader framework for crews to use to respond to abnormal or emergency events. It also ensures that flight crew and cabin crew will be routinely trained and assessed in the use of the procedure for responding to particular types of events.

As highlighted by a number of investigation reports, accidents around the world continue to show that there is a significant risk of injury to passengers when escape slides are used. This risk is acceptable in a life-threatening situation where the alternative may be catastrophic; however in cases such as a fumes event, fuel spill or other similar situation where passengers can be disembarked in a quick but controlled manner, particularly if an aerobridge is already attached, a procedure that allows passengers to disembark quickly in a controlled manner may be preferable to prevent unnecessary injury.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

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

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

From the evidence available, the following findings are made with respect to the hydraulic system malfunction, return and evacuation, involving Airbus A330, VH-EBC on 15 December 2019.

Contributing factors

- The rudder servo hydraulic system pressure hose ruptured in flight, depleting the green hydraulic system of fluid, which necessitated a return to Sydney.
- After the auxiliary power unit (APU) was started and bleed selected on, and the aircraft was towed back to the terminal, the leaking hydraulic fluid was ingested into the APU air intake. The atomised hydraulic fluid, which appeared as haze, mist or smoke, was then distributed into the cabin and flight deck through the air conditioning system, resulting in the captain deciding to evacuate the aircraft.
- A number of passengers evacuated using the escape slides in a manner that increased the risk of injury (for example, on their knees, lying down or sitting before sliding, or with hands on the slides). Of the 93 passengers that used the escape slides to exit the aircraft, one was seriously injured and 5 received minor injuries.

Other factors that increased risk

- Although some cabin crew members had detected unusual smells both before and after the aircraft had been towed back to the terminal, they did not pass this information on to the flight crew prior to the captain's decision to initiate an evacuation.
- Although some of Qantas's A330 aircraft were fitted with an emergency evacuation signal, the emergency evacuation checklist located in the flight deck for these aircraft did not include the use of the evacuation signal. In addition, there was no documented procedure that detailed when the evacuation signal should be used by cabin crew.
- A cabin crew member did not open an available exit even though they had observed that there were no signs of smoke, fire or obstruction outside the aircraft. Rather, they assumed that there was fire outside due to haze/smoke being visible inside the cabin.
- During the evacuation, one cabin crew member did not assess outside conditions properly and 2 cabin crew members did not continue to check exit availability, instead directing passengers to the available aerobridge(s).
- The aircraft evacuation occurred at a time when cabin crew members had completed their shut-down duties and the doors had all been disarmed, with an aerobridge already connected to the aircraft. As a result, 2 exit doors were opened in the disarmed mode. Although one of these exits was then armed and reopened and the slide deployed, the other exit remained open without the slide deployed and was declared blocked.

- **Qantas's cabin crew recurrent training did not include any situation whereby a disarmed door would have to be rearmed in an emergency. This increased the likelihood that a door would be opened without the escape slide deployed, reducing the number of available exits.** (Safety issue)
- **Qantas's method of briefing passengers provided limited and inconsistent information about how to use the escape slides safely and what to do with cabin baggage in an emergency.** (Safety issue)
- **Qantas's cabin crew primary evacuation commands did not include phrases such as 'leave everything behind' and 'jump and slide'; instead, these phrases were optional. Consequently, passengers would generally not receive specific guidance until they reached an exit, which would likely slow down the evacuation.** (Safety issue)
- Some passengers evacuated utilising the slides and aerobridges carrying their cabin baggage. As a result, the evacuation was delayed and the risk of injury to themselves and others was increased.
- Following the evacuation, the cabin crew did not assist the passengers who had evacuated using the slides on the tarmac (as required by Qantas's procedures).
- Following the evacuation, the passengers were cleared from the cabin but the cabin crew and other staff members re-entered the cabin prior to the aircraft being deemed safe by emergency services (as required by Qantas's procedures).
- **Qantas did not have a procedure for a rapid disembarkation, or other similar procedure that would effectively enable rapid deplaning at a slower and more controlled pace than an emergency evacuation. Therefore, the only option for rapid deplaning was an emergency evacuation utilising slides, which unnecessarily increased the risk of injuries in some situations.** (Safety issue)

Other findings

- Just after the cabin crew at the rear of the aircraft were alerted to the haze/smoke in the cabin, they completed a verbal review of evacuation procedures together, which included discussion about the need to rearm their doors if an evacuation was required. As a result, they were prepared for the evacuation, rearmed their doors when the evacuation command was given, and successfully deployed both escape slides.

Safety issues and actions

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues. The ATSB expects relevant organisations will address all safety issues an investigation identifies.

Depending on the level of risk of a safety issue, the extent of corrective action taken by the relevant organisation(s), or the desirability of directing a broad safety message to the aviation industry, the ATSB may issue a formal safety recommendation or safety advisory notice as part of the final report.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

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

Passenger safety information

Safety issue description

Qantas's method of briefing passengers provided limited and inconsistent information about how to use the escape slides safely and what to do with cabin baggage in an emergency.

Issue number:	AO-2019-073-SI-03
Issue owner:	Qantas Airways Limited
Transport function:	Aviation: Air transport
Current issue status:	Closed – Adequately addressed
Issue status justification:	The ATSB is satisfied that the safety action undertaken by the operator has reduced the risk of this safety issue.

Proactive safety action taken by Qantas Airways Limited

Action number:	AO-2019-073-PSA-01
Action organisation:	Qantas Airways Limited
Action status:	Closed

The operator has revised its safety briefing video, which shows passengers how to descend the escape slide through an animation. The animation depicts the position that the passengers need to adopt and occurs on an aircraft slide as opposed to being in another context. Although still not consistent with the safety briefing card, it shows the safe way to descend the slide more clearly.

Proactive safety action taken by the Civil Aviation Safety Authority

Action number:	AO-2019-073-PSA-02
Action organisation:	Civil Aviation Safety Authority
Action status:	Closed

In August 2021, the Civil Aviation Safety Authority (CASA) released a multi-part Advisory Circular (AC), AC 91-19, AC 121-04-07, AC133-10, AC135-12 and 138-10 v1.0 (Passenger safety information), which provided additional guidance about the requirement for consistent information across formats:

> 3.3.1 Differences in style and technical content between two forms of information can be confusing and unintentionally provide conflicting information.

3.3.2 To minimise confusion for passengers, it is important that the information provided on the safety cards accurately reflects the aircraft being operated and is consistent with other safety information available.

3.3.3 The following considerations are relevant in this regard: − where there are differences between aircraft of the same type / model / series, e.g. the equipment carried on board or the equipment type is different, the safety cards used are specific to the aircraft − information contained in the card is consistent with information given in the safety briefings, the operator's procedures, and other information displayed in the aircraft, e.g. emergency exit markings and operating instructions that must be displayed.

The AC also covered briefing material related to cabin baggage and emergency escape slide use, stating that passengers should be advised to leave cabin baggage behind in an emergency in the pre-flight briefing and also in the pre-landing announcements. It was also recommended that the following information be covered in the safety briefing card in relation to the use of emergency exits:

3.4.12 Emergency exits and the means for assisting evacuation

− use of the means for assisting evacuation (e.g. escape ropes, evacuation slides), including with infants and children

− leaving carry-on baggage behind…

Evacuation commands

Safety issue description

Qantas's cabin crew primary evacuation commands did not include phrases such as 'leave everything behind' and 'jump and slide'; instead, these phrases were optional. Consequently, passengers would generally not receive specific guidance until they reached an exit, which would likely slow down the evacuation.

Issue number:	AO-2019-073-SI-01
Issue owner:	Qantas Airways Limited
Transport function:	Aviation: Air transport
Current issue status:	Open – Safety action pending
Issue status justification:	To be advised

Proactive safety action taken by Qantas Airways Limited

Action number:	AO-2019-073-PSA-43
Action organisation:	Qantas Airways Limited
Action status:	Monitor

Qantas advised in April 2022 that it was conducting a risk assessment for the inclusion of ‘leave everything behind’ in its primary evacuation commands.

Proactive safety action taken by the Civil Aviation Safety Authority

Action number:	AO-2019-073-PSA-03
Action organisation:	Civil Aviation Safety Authority
Action status:	Closed

In November 2021, the Civil Aviation Safety Authority released *Cabin safety bulletin 26 – Brace and evacuation commands* which provided guidance on commands that can be used during an evacuation. The bulletin highlights that there needs to be emphasis on cabin crew being ready to manage passengers that bring cabin baggage to exits during an evacuation. The bulletin also

suggests that once the evacuation command is given that passengers be instructed to ‘leave everything behind’ and that this command should be repeated throughout the evacuation.

Recommended commands when an exit is opened for an aircraft with dual laned slides were also included in the bulletin and included ‘form two lines’ and ‘come this way’ followed by ‘jump and slide’ or ‘sit and slide’ for upper deck slides.

Cabin crew training

Safety issue description

Qantas's cabin crew recurrent training did not include any situation whereby a disarmed door would have to be rearmed in an emergency. This increased the likelihood that a door would be opened without the escape slide deployed, reducing the number of available exits.

Issue number:	AO-2019-073-SI-02
Issue owner:	Qantas Airways Limited
Transport function:	Aviation: Air transport
Current issue status:	Closed – Adequately addressed
Issue status justification:	The ATSB is satisfied that the safety action undertaken by the operator has addressed this safety issue.

Proactive safety action taken by Qantas Airways Limited

Action number:	AO-2019-073-PSA-04
Action organisation:	Qantas Airways Limited
Action status:	Closed

The operator incorporated a practical exercise into their 2020/2021 cabin crew evidence-based recurrent program, which covers an evacuation at the terminal and utilises the QF575 event as an example. The program included a focus on the other considerations when evacuating at the terminal and the post evacuation duties of the cabin crew. The operator has also included the procedure for evacuating at a terminal in its 3-year training matrix.

Proactive safety action taken by the Civil Aviation Safety Authority

Action number:	AO-2019-073-PSA-42
Action organisation:	Civil Aviation Safety Authority
Action status:	Closed

In December 2021, the Civil Aviation Safety Authority (CASA) released guidance in their Acceptable Means of Compliance and Guidance Material (AMC/GM) Australian Air Transport – Larger Aeroplanes, CASR Part 121 v2.2 which covers the practical training and checking requirements of cabin crew. The guidance reiterates the annual and 3-yearly requirements contained in the CASR Part 121 Manual of Standards (MOS) and highlights that operators must develop a means to verify that cabin crew are competent in those functions required to be performed that may not be specifically mentioned in the regulations.

Procedure for a rapid disembarkation

Safety issue description

Qantas did not have a procedure for a rapid disembarkation, or other similar procedure that would effectively enable rapid deplaning at a slower and more controlled pace than an emergency

evacuation. Therefore, the only option for rapid deplaning was an emergency evacuation utilising slides, which unnecessarily increased the risk of injuries in some situations.

Issue number:	AO-2019-073-SI-05
Issue owner:	Qantas Airways Limited
Transport function:	Aviation: Air transport
Current issue status:	Open – Safety action pending
Issue status justification:	To be advised

Proactive safety action taken by Qantas Airways Limited

Action number:	AO-2019-073-PSA- 44
Action organisation:	Qantas Airways Limited
Action status:	Monitor

In May 2022, Qantas advised that it was undertaking a review of its current non-routine disembarkation procedure and, in consultation with other airlines within the Qantas group, looking to incorporate a procedural framework that provided for the rapid disembarkation of passengers in certain circumstances.

Proactive safety action taken by the Civil Aviation Safety Authority

Action number:	AO-2019-073-PSA-05
Action organisation:	Civil Aviation Safety Authority
Action status:	Closed

In December 2021, the Civil Aviation Safety Regulation (CASR) Part 121 Manual of Standards (MOS) came into effect and included requirements for flight and cabin crew to be trained in rapid disembarkation procedures when converting to a new aircraft type and for cabin crew to be trained annually. Guidance material that included the definition of a rapid disembarkation was also released in *Acceptable Means of Compliance and Guidance Material (AMC/GM) Australian Air Transport – Larger Aeroplanes, CASR Part 121 v2.2*.

In addition, the Civil Aviation Safety Authority produced guidance material in *Cabin safety bulletin – 25 Emergency evacuation and occupant survivability* in October 2021 that explained the difference between an evacuation and a rapid disembarkation and described the types of situations where this procedure may be appropriate to prevent unnecessary injury and avoid possible external hazards that may be present if needing to get out quickly at a terminal.

Safety action not associated with an identified safety issue

Additional safety action by Qantas Airways Limited

Replacement of hydraulic hoses in 4 of the oldest A330's

Even though the manufacturer did not recommend proactive replacement of the hoses, the operator advised that it had replaced the hoses for the green system on its 4 oldest A330 aircraft as a precautionary measure.

Periodical replacement program for all 3 hydraulic systems

Qantas implemented a periodical replacement program (discard limit) for the pressure supply line to the rudder hydraulic servo on all 3 hydraulic systems on its A330 fleet. This was to be repeated at 8 years or 12,000 flight cycles, whichever came first, on both mechanical controlled rudder aircraft (hose part number AE2464379H0316) and fly-by-wire rudder (different hose part numbers).

Procedure for the management of smoke/fumes on the ground

Following the occurrence, in April 2021 the operator made changes to its procedures in its *Flight Administration Manual* (FAM) to include further considerations when a smoke/fumes event occurs on the ground:

> **FAM Section 22.10.X Management of Smoke / Fumes Events On The Ground (A330 Only)**
> Smoke/Fumes Abnormal Procedures should be utilised to manage both on ground and inflight events. On the ground and after an associated system failure e.g. hydraulic system leak, the APU BLEED valve should remain closed until Engineering personnel (where available) perform an external visual inspection to confirm that there is no risk of fluid ingestion into the APU inlet.

In addition, the following caution was added to the *Flight Crew Operating Manual* (FCOM) in the section that instructed flight crew on what to do if there was a nose-wheel steering fault:

> If the NWS is inoperative due to hydraulic fluid loss, APU bleed air should not be used to supply the air-conditioning packs during towing due to the risk of hydraulic fluid ingestion into the APU inlet and resulting smoke and/or fumes in the cabin. If cabin temperatures become excessive, APU bleed may be used to supply the air-conditioning packs only after an engineer performs an external visual inspection to confirm there is no risk of fluid ingestion into the APU inlet.

General details

Occurrence details

Date and time:	15 December 2019 – 0851 EST	
Occurrence category:	Accident[24]	
Primary occurrence type:	Hydraulic, Emergency evacuation, Diversion / Return	
Location:	94 km west-north-west of Sydney Airport, NSW	
	Latitude: 33° 42.720 S	Longitude: 150° 17.928 E

Aircraft details

Manufacturer and model:	Airbus A330-202	
Registration:	VH-EBC	
Operator:	Qantas Airways Limited	
Serial number:	506	
Type of operation:	Air Transport High Capacity-Passenger - (Air Transport High Capacity)	
Activity:	Commercial air transport-Scheduled-Domestic	
Departure:	Sydney Airport	
Destination:	Perth Airport	
Persons on board:	Crew – 10	Passengers – 222
Injuries:	Crew – 0	Passengers – (1 serious, 5 minor)
Aircraft damage:	Nil	

[24] Because this occurrence resulted in one serious injury, it met the definition of an accident.

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the flight crew and cabin crew on VH-EBC
- Qantas Airways Limited
- the Civil Aviation Safety Authority
- Airbus
- Airservices Australia
- the Sydney Airport Corporation Limited.

References

Australian Transport Safety Bureau (2004) Public attitudes, perceptions and behaviours towards cabin safety communications', ATSB Research and Analysis Report.

Corbett C L (2005) *Caring for precious cargo, Part II: Behavioural techniques for emergency aircraft evacuations with infants through type III overwing exits*. Federal Aviation Administration.

Meng-Yuan L (2014) An evaluation of an airline safety education program for elementary school children. *Evaluation and Program Planning.*

National Transportation Safety Board 2000, '*Safety Study: Emergency Evacuation of Commercial Airplanes*', NTSB/SS-00/01 PB2000-917002, Washington DC, USA.

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- Civil Aviation Safety Authority (CASA)
- the flight crew and cabin crew on board VH-EBC
- French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile
- Qantas Airways Limited
- Airbus
- Airservices Australia.

Submissions were received from Qantas Airways Limited, Airbus and CASA. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Glossary

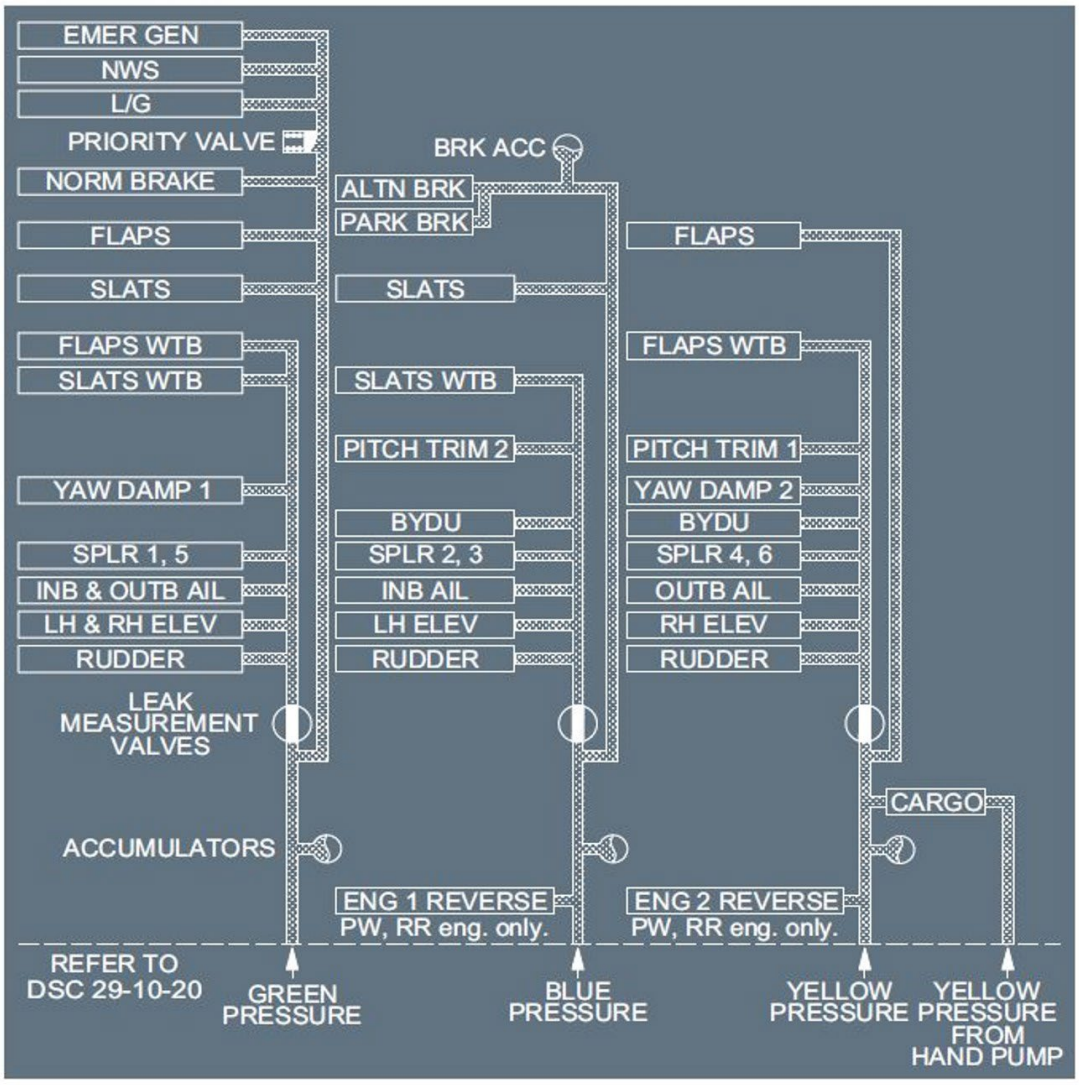
AC	Advisory Circular
AEPM	Aircrew emergency procedures manual
AMC	Acceptable means of compliance
AMM	Aircraft maintenance manual
AOC	Air Operator's Certificate
APU	Auxiliary power unit
ARFFS	Aviation Rescue and Fire Fighting Service
ATSB	Australian Transport Safety Bureau
BEA	French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Order
CAR	Civil Aviation Regulation
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulation
CCOM	Cabin crew operations manual
EASA	European Aviation Safety Agency
EST	Eastern Standard Time
FAA	Federal Aviation Administration
FAM	Flight administration manual
FCOM	Flight crew operating manual
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
MOS	Manual of Standards
NTSB	National Transportation Safety Board
PBE	Protective Breathing Equipment
UTC	Coordinated Universal Time

Appendices

Appendix A – Hydraulic system supply overview

Figure 16 shows the hydraulic system architecture on the Airbus A330 and the system redundancies in design. The diagram shows that the green hydraulics are the primary system with the blue and yellow systems providing redundancy for flight controls and secondary functions such as engine thrust reversers.

Figure 16: A330-200 hydraulic system supply diagram



Source: Qantas

Appendix B – Operator cabin crew land evacuation impact drill

Basic impact drill	Expanded drill
1. As directed by captain commence evacuation commands.	• The decision making process may take several minutes, however after impact has occurred and the aircraft has stopped, the engine shutdown procedure may only require 5-10 seconds. • After shutdown the captain orders the evacuation by as many means as possible. • Upon receipt of the evacuation order or signal, cabin crew move to assigned door/exit, continually repeating evacuation commands. • Repeat these commands until doors/exits are available for use. Continue with motivational and directional commands as applicable.
2. Check door/exit safe to open.	• Check through door/exit windows adjacent to door to ensure no fire or obstruction is present.
3. Open door/exit	• Information regarding actions required to open doors/exits is contained in the evacuation provisions section of the appropriate Aircraft Type Chapter. [See *Operation of aircraft doors in an emergency]*
4. Ensure correct inflation	• Guard the door while the slide/slideraft inflates.
5. Direct passengers	• Grasp assist handle (as fitted) • Stand clear of door. • Establish even passenger flow. • Strike at arm or leg of passengers blocking a door/exit. • If doors/exits are slow to evacuate, redirect passengers where evacuation is moving faster • Make all attempts to ensure passengers do not take cabin baggage when evacuating • Use appropriate commands during this phase
6. Take torch, check your area, assist other areas	• When the flow of passengers to the door ceases, take torch and check the following places for passengers/crew: - seats - aisles - between seats - galleys - lavatories - flight deck - crew rest areas • After capable passengers are evacuated, attempt to move others. These include unconscious, incapacitated, disabled etc. • To prevent duplication of area checks, crew must communicate with each other and nominate when the area they are checking is clear. Teamwork is essential during area checks.
7. Evacuate	• Render assistance until cabin clear or can no longer be occupied • Evacuate through first available exit • Take megaphone (if located at your station)
8. Assist on the ground	• Check activity at slides being used • Assist passengers away from slides • Direct passengers upwind from aircraft • Assemble passengers and treat injured – begin first aid • Ensure strictly NO SMOKING
9. Door unusable – remain, block, redirect and reassess	• Remain at door • Declare blocked exit

	• Redirect passengers to useable exits upon hearing the ‘come this way’ command • Use appropriate commands to redirect passengers to other doors/exits • Unusable doors/exits must be constantly reassessed

Appendix C – Research and previous occurrences related to rapid disembarkations

The National Transportation Safety Board (NTSB) in its *Safety study: Emergency Evacuation of Commercial Airplanes* (2000) discussed the importance of the assessment and utilisation of all available exits in an evacuation, rather than the nomination of certain exits by flight crew or cabin crew. There was however recognition of an alternative procedure (rapid deplanement) that permitted the use of only some exits that had stairs already available and when there was no imminent threat to the passengers.

Qantas utilised this NTSB report, in part, to justify a response to an ATSB recommendation that was issued following the evacuation of VH-OJH in July 2003, during which an over-wing slide was used during the evacuation following a brake fire. The ATSB recommendation text included:

> **Safety Recommendation R20050003**
>
> The Australian Transport Safety Bureau recommends that Qantas Airways Ltd, review the adequacy of their procedures for the deployment of over-wing slides during known brake fire situations. This review should take into consideration the visual cues used and potential risk to passengers of evacuating within close proximity of a fire zone.

The operator's response to this recommendation also identified the precautionary disembarkation procedure as an alternative to an evacuation where exits could be nominated:

> Qantas has a Precautionary Disembarkation procedure that caters for disembarkation in non-normal circumstances when a evacuation is not yet but maybe required. This allows certain doors to be directed for use during disembarkation in an expeditious but planned manner.

The ATSB has reported on the use of a precautionary disembarkation procedure in a number of previous investigations, including 2 other investigations into occurrences that involved the operator.[25] Following the investigation into an in-flight uncontained engine failure involving an Airbus A380-842 (QF32) in November 2010, the ATSB noted:

> The crew's decision to perform a precautionary disembarkation via the stairs likely provided the safest option, particularly given the low immediate safety threat and the elevated risks associated with an emergency evacuation into a potentially hazardous external environment.

The French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) investigation into an occurrence involving smoke in the cabin during boarding and evacuation of passengers involving a Boeing 777 in July 2013[26] identified a problem with the operator not having a rapid evacuation (rapid deplaning) procedure. The investigation report noted that the captain did not have a procedure for the strategy that they wanted to implement, which was to get passengers and crew off quickly using the aerobridges. In this case the captain used language that was not suited to the situation and, with the absence of a procedure, cabin crew were in doubt about what the evacuation instruction meant. It was noted in this investigation that other airlines had implemented such a procedure. Safety action taken by the French operator included the development of a rapid deplaning procedure as an alternative to an evacuation.

The United Kingdom Air Accidents Investigation Branch (AAIB) investigated a smoke event resulting in an evacuation at London Heathrow airport on 26 June 2016, involving an Airbus A330-323 aircraft.[27] In this instance, just following boarding, while still connected to the aerobridge, smoke filled the aircraft cabin. The cabin crew attempted to contact the captain but were

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[25] ATSB investigation 199904538 Boeing 747-438, VH-OJH Bangkok, Thailand 23 September 1999 and ATSB investigation AO-2010-089 In-flight uncontained engine failure overhead Batam Island, Indonesia 4 November 2010 VH-OQA

[26] BEA investigation into Boeing 777-300, F-GSQA Smoke in cabin during boarding, evacuation of passengers, Paris Charles de Gualle Airport, 28 July 2013

[27] AAIB investigation into Airbus A330-323, N276AY Emergency evacuation at parking stand after APU failure filled cabin with smoke, London Heathrow Airport, 26 June 2016

unsuccessful. As a result, the cabin crew initiated an evacuation, which the captain tried to stop. It was noted in the investigation report that an 'Emergency Deplaning' drill may have been more appropriate but did not exist at the time. Safety action taken by the operator included the development of an emergency deplaning procedure as an alternative to an evacuation.

Research conducted by the Royal Aeronautical Society published in its paper *Emergency Evacuation of Commercial Passenger Aeroplanes* (2020) discussed the relevance and use of a procedure as an alternative to an evacuation, stating:

> Some incidents might require passengers to leave the aeroplane with some degree of urgency, but not necessarily via evacuation slides. Rapid disembarkation might be preferable to an evacuation in circumstances where, for example, there are fumes in the passenger cabin, or there has been a large fuel spillage outside the aeroplane, or the commander has been advised that an explosive device might be on board.

The report also advised that conducting a rapid disembarkation rather than the use of evacuation slides has the potential to avoid external hazards such as ground service equipment and vehicles, as well as ground personnel. In such circumstances, injury to aircraft occupants and ground personnel can be avoided. However, unlike the operator's previous rapid disembarkation procedure that had the option to use slides, the report suggested that the rapid disembarkation could only be achieved when airstairs and/or aerobridges were connected to the aircraft or could be rapidly repositioned at floor level emergency exits.

Appendix D – Airbus response to recommendation SR49/2016

AIRBUS

Safety Recommendation **DATE 12/09/2016**

SAFETY RECOMMENDATION
MODIFICATION OF SMOKE PROCEDURES TO DISTINGUISH GROUND/FLIGHT

Origin: GCAA-UAE	**Recommendation Reference:** SR49/2016
Report Reference: AIFN/0016/2014	

Recommendation

It is recommended that Airbus:
Assess the risk of amending the existing SMOKE/FUMES/AVNCS SMOKE and SMOKE/FUMES REMOVAL checklists to distinguish between inflight and on-ground smoke scenarios, and insert text in the checklists to differentiate between the aircraft be on the ground or inflight.

Airbus Answer:

The SMOKE/FUMES/AVNCS SMOKE procedure is applicable in flight and on ground. The SMOKE/FUMES REMOVAL is only applicable in flight since, on ground, if smoke/fumes become the greatest threat, the Emergency Evacuation procedure prevails.

In this event, the smoke/fumes generation in the cockpit and the cabin would have been stopped by switching the APU BLEED to OFF. This action is requested at the very beginning of the “smoke origin identification and fighting” part of the QRH paper SMOKE/FUMES/AVNCS SMOKE procedure considering that an AIR COND SMOKE is suspected. In this event, an AIR COND SMOKE could be suspected considering the presence of smoke/fumes in the cockpit and the cabin and the triggering of a subsequent LAVATORY SMOKE warning (refer to FCTM AO-026 “Smoke origin identification and fighting”).

Based on the following facts:

- The current SMOKE/FUMES/AVNCS SMOKE procedure is applicable and efficient on ground,
- The smoke/fume event in flight is the most critical scenario (compared to a ground situation),
- Majority of events (reported to Airbus) occurred in flight and
- Emergency Evacuation must remain a crew decision based on its own assessment of the situation,

we have assessed that there is currently no input (known by Airbus) that would request to amend the existing SMOKE/FUMES/AVNCS SMOKE procedure to distinguish between inflight and on-ground smoke scenarios. We consider that it is not suitable to modify a procedure to cope with a specific event by taking the risk that it would render it less efficient or more complex to apply in all the other cases.

Of note is that the SMOKE/FUMES/AVNCS SMOKE procedure has been subject to template/publications at industry safety level and therefore we consider that such a recommendation should be addressed to aviation industry level as it is actually not aircraft type related.

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- 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, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

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

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining 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. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.