Australian Government
Australian Transport Safety Bureau

Loss of control and collision with water involving Grumman American Aviation Corp G-73, VH-CQA

10 km west south west of Perth Airport, Western Australia | 26 January 2017

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
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Addendum

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Safety summary

What happened

On 26 January 2017, the pilot of a Grumman American Aviation Corp G-73 amphibian aircraft, registered VH-CQA (CQA), was participating in an air display as part of the City of Perth Australia Day Skyworks event. On board were the pilot and a passenger. The pilot of CQA was flying 'in company' with a Cessna Caravan amphibian and was conducting operations over Perth Water on the Swan River, that included low-level passes of the Langley Park foreshore.

After conducting two passes in company, both aircraft departed the display area. The pilot of CQA subsequently requested and received approval to conduct a third pass, and returned to the display area without the Cessna Caravan. During positioning for the third pass, the aircraft departed controlled flight and collided with the water. The pilot and passenger were fatally injured.

What the ATSB found

The ATSB found that the aircraft aerodynamically stalled during a positioning turn for the third pass, resulting in the collision with shallow water. The manner in which the pilot returned to the display area after the second pass was not in accordance with the display procedures and increased the risk of mishandling the aircraft in an area of relatively close proximity to the public. The pilot's decision to carry a passenger was also contrary to the requirements of the display instrument and increased the severity of the outcome.

Finally, a safety issue was identified with the current regulatory framework for air display approval and oversight.

What's been done as a result

The Civil Aviation Safety Authority had independently published a revised manual of guidance for air displays in September 2017. The document provided further detail on the key roles and their responsibilities and introduced a requirement to conduct a risk assessment as part of the application process. In April 2018, CASA updated the associated *participant* form, which was expanded to assist pilots with their display preparation and included a requirement to identify and provide justification for any additional persons on board display aircraft. The form also included a section to provide additional assurance around completion of the display coordinator's responsibilities.

Finally, the ATSB has issued a safety recommendation to CASA to undertake further work to enhance their tools and guidance for air display approval and oversight, and procedures to ensure the suitability of those responsible for organising, coordinating and participating in air displays.

Safety message

Air displays are activities with inherent and unique risks that pilots, the organisers and the regulators all have responsibilities in addressing. It is important that holders of these key positions have a thorough understanding of their role and responsibilities, to ensure adequate completion of safety critical tasks. Having well-defined, transparent and consistent processes for planning and approval of air displays will assist in identifying risks and implementing effective mitigation strategies.

In addition to complying with regulations, pilots can limit their risk exposure by only participating in displays that are within their own and their aircraft's capabilities and limitations, and not undertake any impromptu manoeuvres that have not been planned or practiced.

These steps combined will provide greater safety assurance for participants, spectators and the general public.

VH-CQA

Source: Flightaware.com

Contents

The occurrence

On 26 January 2017, the pilot of a Grumman American Aviation Corp G-73 amphibian aircraft, registered VH-CQA (CQA), was preparing to participate in an air display as part of the City of Perth Australia Day Skyworks (Skyworks) event.

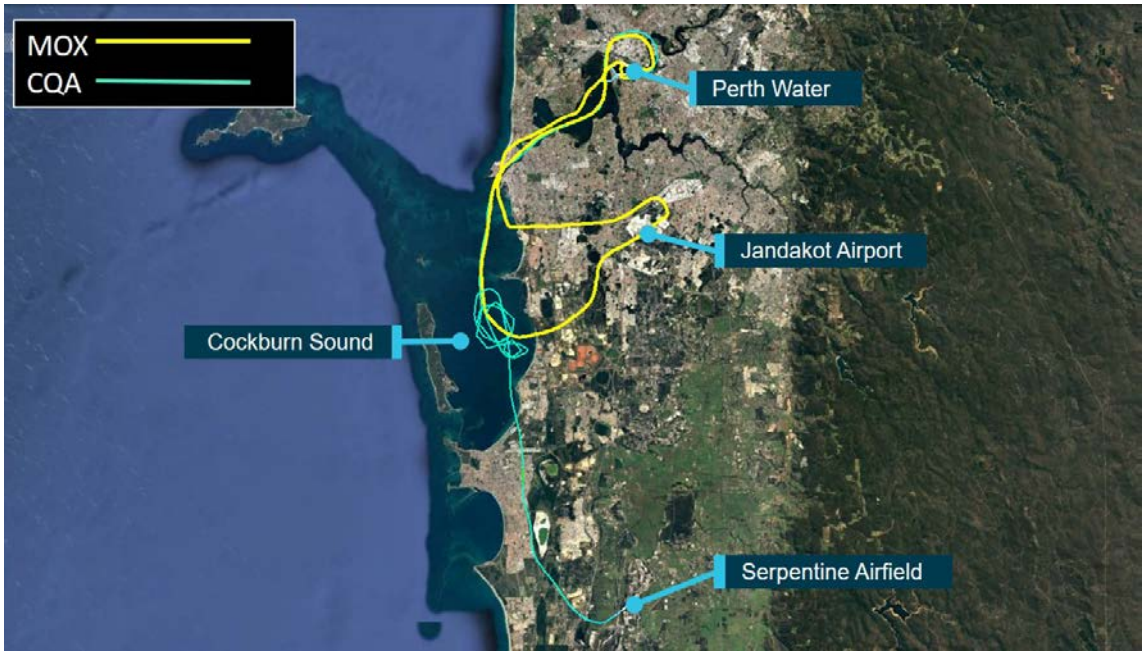
The pilot of CQA and a passenger arrived at Serpentine Airfield, 48 km south of Perth (Figure 1), at about 1500 Western Standard Time,[1] to prepare the aircraft for flight. The pilot was reported to have used his mobile phone to discuss aircraft performance with another individual and subsequently unloaded some equipment to reduce the aircraft's weight. At about 1625, once the pilot had confirmed via phone the take-off calculations for the runway length and local temperature of about 42˚C, he and his passenger, who did not have any pilot qualifications, boarded CQA.

The pilot was in the left seat and the passenger in the right seat. CQA departed from runway 23 and tracked out towards the coast. The pilot of another aircraft returning to Serpentine Airfield observed CQA's departure and described it as a 'long and slow climb', which they surmised was due to a combination of the high ambient temperature and the aircraft's inherent performance.

The pilot of CQA planned on flying 'in company' (see the section titled *Procedure for fly-bys*) with a Cessna Aircraft Company C208 'Caravan' amphibian, registered VH-MOX (MOX) during the air display. The pilot of MOX received a text message from CQA's pilot, advising that he would not be landing at Jandakot Airport as previously discussed and requested that they meet up overhead the agreed alternative location of Cockburn Sound (Figure 1). MOX departed from Jandakot at about 1645 and met up with CQA over Cockburn Sound.

Upon meeting up, the pilot of CQA assessed that MOX's speed was too high for the two aircraft to travel together and requested that the Caravan pilot slow his aircraft down. The pilot of MOX agreed to slow down with a request that CQA 'didn't get too close'. Both aircraft then flew the prescribed route to Perth Water, the location of the air display. The weather was fine with a recorded wind of about 20 km/h from the south-west and a temperature of about 39°C.

Figure 1: CQA and MOX flight path



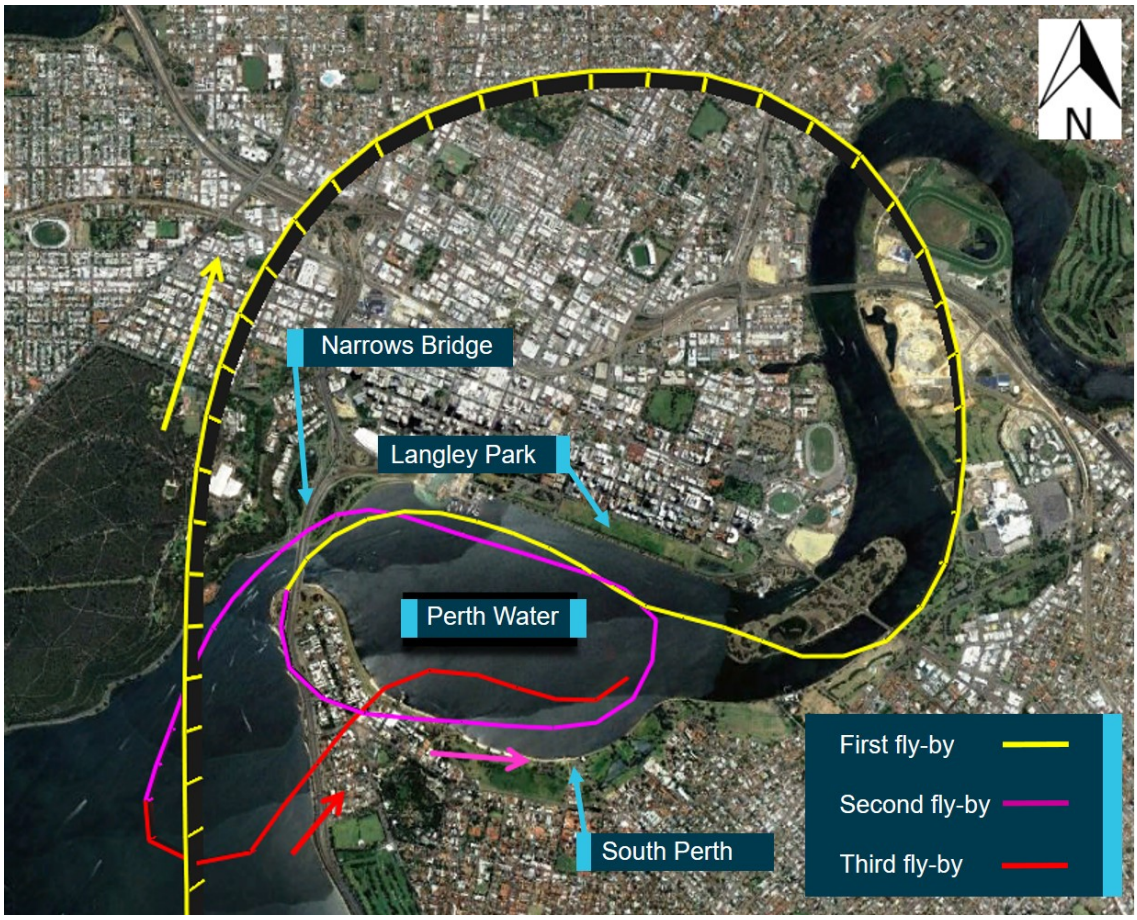
Source: Google Earth, modified by ATSB

[1] Western Standard Time (WST): Universal Coordinated Time (UTC) + 8 hours.

Once approved to enter the display area, CQA followed MOX via the prescribed inbound route to the north of Perth city in order to conduct a fly-by parallel to the Langley Park foreshore in a westerly direction (Figure 2). MOX conducted a splash-and-go[2] in front of Langley Park while CQA followed at about 200 ft above the water. The delay associated with MOX's splash-and-go resulted in the separation between MOX and CQA reducing. MOX lifted from the water surface, entered a climbing turn and conducted a left orbit[3] within the confines of Perth Water to reposition for a second pass of Langley Park.

Flight data and video footage showed that CQA took longer to initiate the left orbit and subsequently flew at about 500 ft over the built-up area of the South Perth peninsula that connects to the Narrows Bridge, at the western end of Perth Water. CQA then descended to about 200 ft over the south of Perth Water while repositioning for a second pass.

Figure 2: CQA air display flight track, showing the first pass in yellow, the second in magenta and the third in red



Source: Google Earth, modified by the ATSB

When MOX conducted its second splash-and-go in front of Langley Park, CQA was about half an orbit behind, flying in an easterly direction along South Perth foreshore. Following completion of the splash-and-go, the pilot of MOX climbed over the Narrows Bridge to about 1,000 ft for the return flight to Jandakot. CQA's second fly-by of Langley Park was lower than the first, descending to just above the water surface, before a climb was also initiated to clear the Narrows Bridge.

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2 A splash-and-go is a manoeuvre whereby the aircraft descends until the floats/hull briefly contacts the water surface, before climbing away.

3 An orbit is generally recognised as a 360˚ turn at a constant altitude, however this was the terminology used for the air display with respect to the manoeuvres within Perth Water and has been used in this report for consistency.

On departure from Perth Water, the pilot of MOX transmitted on the display frequency that he was exiting the display area and returning to Jandakot Airport. CQA flew over the Narrows Bridge and initially followed MOX toward Jandakot, during which time the pilot requested approval to conduct a third pass. This request was authorised via radio by the 'Ringmaster',[4] but as the pilot of CQA did not hear the authorisation, MOX re-transmitted the approval to CQA, while continuing with their own departure. CQA then conducted a left turn and returned directly to Perth Water, at about 300-400 ft over the built-up area and moored spectator boats.

CQA flew in an easterly direction, parallel with the South Perth foreshore, before commencing a left turn towards Langley Park to position for the third pass. The aircraft was at a similar altitude to the first orbit at the commencement of the turn, but was slower and positioned further towards the middle of Perth Water (Figure 3). Video and still imagery recorded that the wing flaps were in the retracted position. The left turn was tighter than that of the first orbit and during that turn, CQA rolled left and pitched nose-down, consistent with an aerodynamic stall[5] (Figure 4). The aircraft collided with the water and was destroyed. The pilot and passenger were fatally injured.

Immediately after the accident, the remainder of the air display was cancelled, followed shortly after by cancellation of the entire Skyworks event.

Figure 3: CQA's pass along South Perth, just prior to the final left turn

Source: David Roses

[4] See the section titled *Air display roles and responsibilities.*

[5] Aerodynamic stall: occurs when the airflow separates from the wing's upper surface and becomes turbulent. A stall occurs at high angles of attack, typically greater than 16˚ to 18˚, and results in reduced aerodynamic lift.

Figure 4: CQA just prior to the collision with water (looking north)

Source: Mike Graham

Context

Pilot information

The pilot held a Private Pilot (Aeroplane) Licence issued in July 1994, and a current Class 2 Aviation Medical Certificate. His endorsements included floating hull, manual propeller pitch control and retractable undercarriage, and he held single- and multi-engine ratings. The pilot completed his floating hull endorsement in October 2011 on a LA-4-200 Lake Buccaneer Amphibian. In 2012, he completed about 18 hours of flight training[6] in the Grumman American Aviation Corp G-73 Mallard (Mallard) in the United States, under his Federal Aviation Administration (FAA) licence.

The pilot accrued about 21 hours on VH-CQA (CQA) between 6 and 13 January 2017. Prior to that, he had not flown any aircraft since 29 August 2016. The pilot conducted no further flights until 26 January 2017. At the time of the occurrence, the pilot's logbook indicated that he had 625 hours flying experience, with about 180 hours in the Mallard.

The pilot had accrued 136 water landings, of which 84 were completed over the two days of his floating hull endorsement. The pilot's Mallard water landing experience consisted of 37 landings during dual training and 11 while solo. The pilot's most recent water landing (which was in CQA) was conducted on 28 February 2016.

Post-mortem examination and toxicological analysis of the pilot and passenger did not identify anything that may have contributed to the accident.

Mallard rating and flight reviews

The pilot's Mallard training in the United States, was completed on 25 May 2012 and was conducted on the same aircraft that was later registered as VH-CQA (see the section titled *Aircraft information*). The pilot's log book was endorsed as 'training completed' and 'unrestricted land and sea use of the G73' and he commenced flying the Mallard solo, in Australia on 30 July 2012.

Due to an administrative error during conversion of the pilot's United States flight crew licence, his Civil Aviation Safety Regulations (CASR) Part 61 licence was not issued with a G-73 rating. This was identified by the Civil Aviation Safety Authority (CASA) during the air display application process. The pilot applied for the G-73 rating on 19 January 2017 and his licence was reissued with the type rating on 24 January 2017.

CASA Instrument 186/14 published on 25 August 2014, introduced prescribed aircraft, ratings and variants for the CASR Part 61 licencing system. On 23 December 2014, CASA published *Prescription of aircraft and ratings – CASR Part 61,* identifying those aircraft considered sufficiently complex or having performance or handling techniques that warranted initial specific training and per-type flight reviews. Schedule 6 of this document identified the Grumman G-73 Mallard as a type-rated aircraft.

The pilot's most recent biennial flight review was conducted in April 2016 in a Piper PA-30 Twin Comanche. The flight review prior to that (April 2014) was also conducted in the PA-30. An exemption to CASR Part 61, EX97/16, allowed for a multi-engine aeroplane class rating flight review to satisfy the flight review requirement for a type-rated multi-engine operation. The pilot therefore satisfied the flight review requirement to fly the Mallard, but had not had a review in the aircraft type since his endorsement.

Despite the exemption, all pilots were subject to the CASR 61.385 'general competency rule', which indicated that a pilot is only authorised to fly an aircraft if they are competent to the

[6] The training was conducted over two trips to the United States, each consisting of three days, in March and May 2012.

standards mentioned in the CASR Part 61 Manual of Standards. Outside of the requirement for flight reviews, the pilot was responsible for ensuring his competence to fly the aircraft.

The instructor who provided the pilot's floating hull endorsement training flew with him again in April 2015, this time in the Mallard. He recalled the pilot as being 'generally pretty good', but that he 'wasn't quite up to speed with the aeroplane' and suggested that this may have been due to the pilot's irregular flying.

Air display experience

The pilot participated in several air displays whilst flying CQA, including the:

- Great Eastern Fly-In (GEFI) events at Evans Head Aerodrome in New South Wales in 2015, 2016 and 2017.
- Brisbane Valley Air Show (BVAS) at Watts Bridge Memorial Airfield, Queensland in 2016.

The programs for these events indicated that the pilot demonstrated a 'handling display'. Review of video footage showed that the displays included one or more straight and level fly-bys with repositioning turns for return passes.

The pilot's application to take part in the Perth air display described the proposed display as 'same display as used previously at GEFI and BVAS, minimum height 300 ft, no aerobatic manoeuvres, multiple passes, no 'dirty pass',[7] all within normal operating manual'.

Familiarity with the Perth Water air display area

On 13 January 2017, during CQA's repositioning from New South Wales to Western Australia, the pilot undertook a flight from Esperance to the north of the Perth metropolitan area and then tracked south along the coast before turning inland, toward Perth city. During this time, the aircraft flew in an easterly direction along the Langley Park foreshore at about 1,000 ft, before turning right prior to the Causeway Bridge (Figure 6). CQA was then flown in a westerly direction toward the south Perth peninsula, where the aircraft tracked toward Fremantle, then down the coast toward Serpentine Airfield. The pilot did not fly CQA again until the air display on 26 January 2017.

Aircraft information

The Grumman American Aviation Corp G-73 Mallard is a high-wing, medium-sized amphibious aircraft[8] with under-wing floats, retractable landing gear and two-step hull (Figure 5). It was powered by twin Pratt & Whitney R-1340 Wasp radial engines. The Mallard was designed for regional airline operations with two pilots and ten passengers. Fifty-nine aircraft were built between 1946 and 1951.

Mallard serial number J-35 was built in 1948 in the United States and was first registered in Indonesia that same year. In 1976, the aircraft was relocated to the United States and operated there before the occurrence pilot purchased it and transferred it to Australia in July 2012. The aircraft was then based at Evans Head Airfield, New South Wales.

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7 A dirty pass involves the aircraft being configured for landing with flaps and landing gear extended.

8 A seaplane is a fixed wing aircraft that can operate from the water and is identified by two categories: floatplanes, having pontoons or floats as landing gear, and flying boats, where the main source of buoyancy is the fuselage. Amphibian aircraft are capable of routinely operating from land or water. All three terms are often interchanged.

Figure 5: VH-CQA

Source: David Roses

The aircraft flew in Australia under its United States registration until it was re-registered as VH-CQA (CQA) in July 2013. In August 2013, CQA was issued with a Special Certificate of Airworthiness in the *Experimental – Exhibition* category with defined operating requirements. This included that any passengers were to be made aware that the design, manufacture and airworthiness of the aircraft was not required to meet any standard recognised by CASA and that flight in the aircraft was at their own risk. In addition, warning placards detailing this information were to be placed in full view of all passengers.

Flight characteristics and performance considerations

The ATSB sought the input of two experienced Mallard pilots and a CASA-authorised flight analyst in order to gain appreciation of the flight characteristics of the Mallard and its performance considerations. It was commented that the Mallard could easily be operated by one pilot. However, it was also mentioned that because it has a constant-angle, high performance wing[9] it 'requires more care than with a wing that provides more lift at a slower speed', particularly as a stall can result in the aircraft going 'straight onto its back'.

Maintenance history

CQA was maintained in accordance with a CASA-authorised System of Maintenance (SOM). This SOM was effective as at May 2013 and the aircraft was required to undergo a conditional 'periodic' inspection every 12 months or 100 hours, whichever came first. CQA was maintained by a CASA-authorised maintenance provider, who conducted a periodic inspection and issued the current maintenance release, on 6 January 2017. At the time of the accident, the aircraft had accumulated about 22 hours since that periodic inspection and had a total time in service of 7,336 hours.

As CQA was reportedly being relocated to Western Australia, the maintainer released the maintenance log books to the pilot. However, they could not be located following the accident and the maintenance history could therefore not be reviewed by the ATSB. Information from CASA and other sources did not identify evidence of any previous accidents involving the aircraft.

An installed autopilot was removed from CQA as part of Supplemental Type Certificate SA635SO, prior to its delivery to Australia. Removal of that equipment reduced the maximum certificated

[9] The Mallard has a constant angle of incidence (or zero-washout) wing with an identical profile from inboard to outboard. The term washout refers to where a wing is designed with a reducing angle of incidence towards the wing tip, which usually results in a stall progressing from the wing root to the tip, providing increased aileron control during a stall onset and some resistance to spinning. It also provides a softer stall onset and increasing aileron authority during the early stages of a stall.

take-off weight to 5,700 kg. The aircraft flight manual authorised the G-73 for single-pilot operation[10] and CQA's instrument panel was set up for left-seat, single-pilot operations.

CQA was not fitted with a stall warning device[11] and there was no requirement for one.

VH-MOX and flight crew information

VH-MOX (MOX) was a Cessna Aircraft Company 208 'Caravan' that was manufactured in 1993 and first registered in Australia in 1994. The Caravan is an all-metal, high-wing aircraft that is powered by a single Pratt & Whitney PT6A turboprop. MOX was fitted with floats with retractable landing gear to allow for land and sea operations. The Caravan had a maximum take-off weight of about 3,600 kg.

The flight crew of MOX consisted of the pilot in command (PIC), in the left seat, and an observer, in the right seat. The PIC held a current instrument and Grade 1 instructor rating and had extensive float experience operating Caravans. The PIC also had commercial Caravan operations experience within Perth Water and had operated the aircraft there in the week prior to the air display. In addition, the PIC had previous experience participating in the Perth Air Display.

The observer was a pilot with significant experience in float planes and floating hull aircraft, at Perth Water and other locations. He held a Grade 1 instructor rating and had over 27,000 hours flying experience. In addition, he had previous air display experience in light aircraft. Both pilots had low-level endorsements, with recent experience, and had flown with each other previously.

Meteorological information and water conditions

The Bureau of Meteorology reported the weather conditions for 26 January 2017 were 'fine, very hot and sunny' with temperatures reaching 42˚C in the Perth area[12] during the day. Perth Airport records for 1500 indicated the temperature was 41.5˚C with a relative humidity of 9 per cent. Wind speed and direction recordings from nearby Melville Water indicated a wind speed of about 11 knots from 226˚ (20 km/h from the south-west). Pilots in the air display described the water condition as 'ideal', not glassy, with small ripples to assist with depth perception and wind direction identification.

The sun was low in the sky to the west and was unlikely to have affected the pilot's visibility immediately prior to the collision, when the aircraft was flying east and then turning north.

Recorded data

Analysis of available track data (as depicted in Figure 2) found that the Mallard's speed on entry to the accident turn was approximately 10 kt slower than at the equivalent point in the previous orbit and within around 10 kt of the aircraft's stall speed for a coordinated turn at an estimated 30° angle of bank at the commencement of the turn.

Site and wreckage information

CQA collided with water on the Swan River, in a shallow section, approximately mid-way between the Langley Park and South Perth foreshores and about 700 m west from The Causeway. A navigable channel had been dredged parallel with the Langley Park foreshore, the remainder of

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10 CASA identify some G-73 variants as requiring multi-crew (two pilots) for operations.

11 A stall warning device can give the pilot a warning of an impending stall, which can include aural (horn) or visual (light or angle of attack indicator) signals.

12 The Bureau of Meteorology records weather observations from Perth Airport (10 km from Perth Water), Melville Water (4 km away) and Mt Lawley (4 km away). Data from these locations was analysed to provide conditions most likely experienced within Perth Water.

Perth Water was relatively shallow, with a layer of silt. The mostly-submerged wreckage was recovered and transported by barge to a nearby secure facility for technical examination.

Damage to the aircraft was consistent with the observed collision with water in a steep nose-down attitude and subsequent contact with terrain, about 1.5 m below the surface. Examination of the wreckage did not identify any evidence of in-flight break-up, component failure or other anomalies that may have contributed to the collision with terrain, or that would have prevented the engines and propellers from operating normally. This was consistent with witness reports, images and video of the aircraft during the display.

Conduct of the air display

Overview

The City of Perth (CoP) managed the Australia Day Skyworks (Skyworks), which consisted of a series of events on 26 January each year, culminating in a fireworks display from barges moored in the centre of Perth Water (Figure 6). Perth Water is located on the Swan River between Langley Park and the South Perth shoreline, the Narrows Bridge in the west and Causeway in the east. Events included various activities on the Langley Park foreshore and the South Perth foreshore, which was coordinated by the City of South Perth. Water-based events and the air display were managed on behalf of CoP by a contracted events management company. Up to 300,000 people attended each year.

The air display had been a part of the Australia Day activities since 1993. The event was originally organised by an individual, then through the Royal Aero Club of Western Australia, before being incorporated into the CoP's overall management of the event.

The air display was scheduled to run from 1530 until 2000, before the commencement of the fireworks display. The programme consisted of fly-bys (small vintage aircraft, like Tiger Moths, through to a medium-sized Fokker 100 jet), individual and group aerobatics, banner/flag-towing, aerial displays from water-bombing aircraft and float plane 'splash-and-go's'. The participating pilots were mostly volunteers, many of whom had been associated with the event for many years. Several of the pilots also participated in multiple displays on the day.

Figure 6: Perth Water

Source: Google Earth, modified by ATSB

Airspace

Perth Water is located about 10 km west-south-west of Perth Airport, in class C airspace. A temporary danger area (TDA)[13] 'Area ALPHA' (Figure 7) was established by Airservices Australia for the duration of the air display, from surface up to 1,500 ft AMSL.[14] This allowed air display aircraft to operate in Perth Water without the need for specific air traffic control (ATC) clearance. A central point of contact - the Ringmaster - was required to maintain two-way communication with Perth ATC and coordinate aircraft access into Area ALPHA on a specified frequency. Standard airspace procedures were required for operations outside of Area ALPHA.

Figure 7: Google Earth image showing approximate location of Perth Water within Area ALPHA.

Source: Google Earth, modified by ATSB

Air display program and procedures

The CASA-approved air display program documented all participating aircraft, flight crew and routines for the display. Where a routine involved multiple aircraft, one aircraft was designated the 'lead' aircraft and would conduct all radio communications on behalf of the group. Each display was scheduled in 10-15 minute time slots. The display program was often similar to the year before, depending on availability of aircraft. All pilots taking part in the air display were provided with briefing notes, which included a copy of the CASA approval, airspace procedures, air display program and standard display procedures.

Inbound, holding and outbound tracking

The procedures for approach and departure from the display area were detailed in 'display procedure B2' (Figure 8). Once aircraft had entered Area ALPHA they were to track toward the holding area XRAY at an altitude of 1,500 ft (D1 INBOUND OUTBOUND HOLDING). If holding

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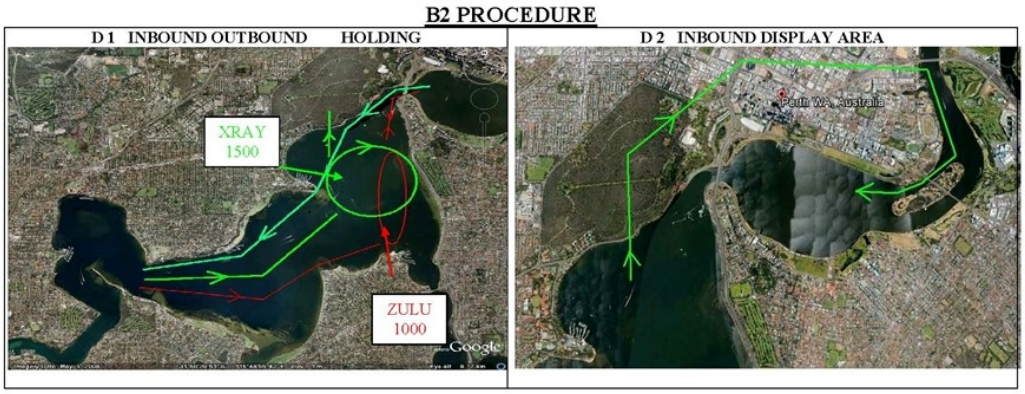
13 A Temporary Danger Area is an airspace established for a specified period and of defined dimensions within or over which activities of potential danger to aircraft flying over that area may exist.

14 Operations above 1,500 ft AMSL in Area ALPHA, such as aerobatic displays, required ATC clearance to operate in class C airspace.

was required, aircraft would perform right orbits until they were given clearance by the Ringmaster to track inbound to Perth Water. Unique displays, including aerobatics, entered Perth Water in accordance with their documented routine.

For all non-aerobatic aircraft, the standard inbound route to the display area (Perth Water) was to fly over Kings Park then Northbridge (to the north of Perth City) and via the Graham Farmer freeway toward the East Perth power station (D2 INBOUND DISPLAY AREA). Aircraft descended to 1,000 ft while flying over the Swan River toward the Causeway and Perth Water. Departure from the display area was via the Swan River at 1,000 ft toward Fremantle, until clear of Area ALPHA.

Figure 8: Extract of the CASA-authorised B2 display procedure supplied to all participants

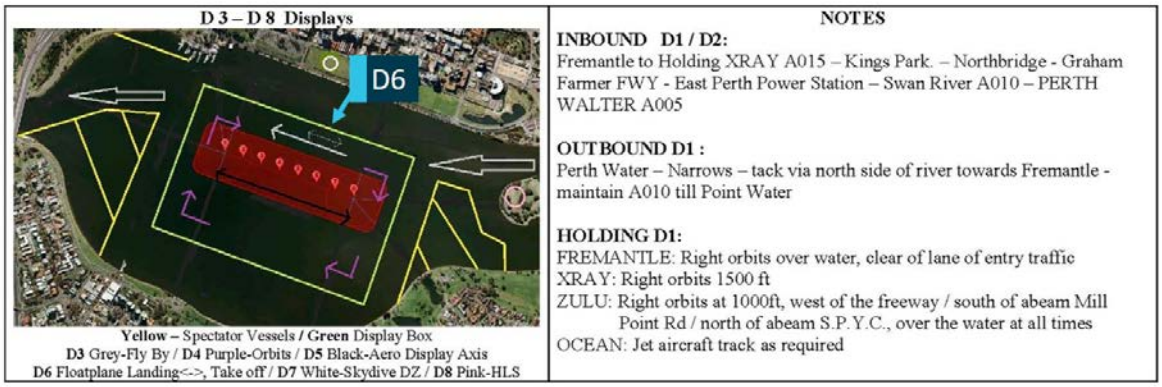


Source: CASA

Procedure for fly-bys

Fly-bys (procedure D3, Figure 9) were to be performed by groups of aircraft flying 'in formation' or 'in company'. The program noted that 'formation rated and current pilots [are to] only [fly] in formation groups up to maximum of 6. Other aircraft [including those operating in company] were to maintain 600 metre separation between each other'.

Figure 9: Extract from the 'display procedures – B2' diagrams, showing the arrow that indicates the direction and location of the float plane landing area



Source: CASA

Following the standard approach and departure procedure, aircraft conducting fly-bys were to descend from 1,000 ft to not below 500 ft over the channel of water between the pyrotechnic barges (red rectangle, Figure 9) and Langley Park foreshore. The aircraft were to depart over the Narrows Bridge (Figure 6) and track over the Swan River at 1,000 ft, back toward Jandakot Airport.

If additional fly-bys were approved by the Ringmaster, there were two options to re-enter the D2 'inbound display area' procedure:

- aircraft could turn right before Kings Park and fly along the freeway on climb to 1,500 ft and re-join the D2 procedure at the western end of Northbridge, or;
- from the Narrows Bridge they could track along the Swan River and fly over Kings Park on climb to 1,500 ft, before re-joining the D2 procedure at Northbridge.

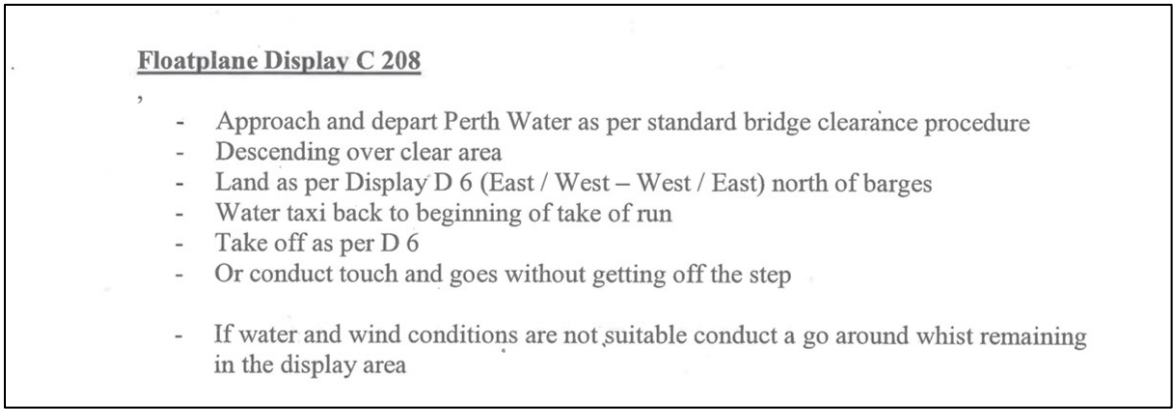
The standard D3 procedure was to be followed for the remainder of any additional fly-bys. Between one and three fly-bys, per display, had been the standard in preceding years. Fly-bys and multiple passes were not specifically detailed with respect to the float plane procedure.

Procedure for float planes

Float planes had been part of the air display in the past, but not every year. Previous float plane displays had included the Cessna C208 Caravan, a Cessna 206 and a Lake Aircraft LA-4-200 Buccaneer.[15] The display coordinator (DC)[16] advised that float planes were added to the air display about 10 years prior to this accident. A representative from CASA observed him demonstrate the intended display in a Cessna 206, before they were approved for inclusion in the display program. The C208 Caravan was the most frequently used aircraft type for this display.

Within Perth Water, the float planes were permitted to descend to the water surface. On some occasions they had landed and back-tracked before turning around and taking off. However, it was reported that when conditions were suitable, float planes were expected to conduct a splash-and-go, remaining on the step.[17] The C208 Caravan float plane procedure submitted to CASA for 2015 and 2017 was essentially the same and is shown in Figure 10.[18]

Figure 10: Float plane procedure approved by CASA in 2015 and 2017



Source: CASA

A procedure for the Mallard was added to the float plane procedure for the 2017 air display and included 'touching the water the same as above [the C 208] but without getting off the step'.

Both the floatplane and flying boat procedures contained a contingency to conduct a missed approach while remaining in the display area if water and wind conditions were not suitable. Both procedures also made reference to 'approach…per standard bridge clearance procedure'. There

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15 The Cessna 206 is a six-seat aircraft with a maximum take-off weight of about 1,600 kg and the Buccaneer is a four-seat, light amphibious aircraft with a maximum take-off weight of about 1,220 kg. The Cessna 208 aircraft is described in the section titled *VH-MOX and flight crew information.*

16 Refer to the section titled *Air display roles and responsibilities*

17 *On the step* is when the attitude of the aircraft on the water is nearly level and the weight of the seaplane is supported mostly by hydrodynamic lift (the upward force produced by the motion of the floats through the water). The rear section of the float, aft of the step, is clear of the water, which greatly reduces drag during take-off. This is also known as *fast taxi.*

18 There was no float plane involvement in 2016.

was no reference to what this procedure was, but it was assumed by the ATSB to be the standard approach and departure (B2) procedure.

The B2 display procedure included the 'D6 Floatplane Landing' (Figure 9) location at the northern edge of the display box.

Actual conduct of the float plane display

When the float plane display was first introduced, the aircraft would usually land, back-track and then take off. While not documented, the sequence was subsequently altered to a splash-and-go, followed by the left orbit. That variation had reportedly been in place for a number of years.

The float plane procedure in practice was therefore to approach from behind the city to enter Perth Water, conduct a low pass (or splash-and-go) at the northern edge of the display box, followed by a left orbit within the confines of Perth Water, before conducting a second pass along the Langley Park foreshore. The float planes would then depart as per the standard procedure or conduct a second left orbit if they were going to do a third pass/splash-and-go.

This sequence was consistent with the display briefing given the night before the activity, where the float plane display was described by the DC as follows:

> The float planes… will be doing their touch and go…but they won't be landing fully. If anything they [are] just kissing the water and then do an orbit and then another one and then [depart].

Further, video footage of the briefing showed the DC indicating left orbits on the projected map at this time.

CASA's understanding of the float plane display sequences

CASA personnel who approved the display advised that they were not aware left orbits within the confines of Perth Water were being conducted during the float plane display. They reported having an understanding that:

- the float planes would conduct the standard approach from behind the city
- perform one low pass, or splash-and-go
- depart via the standard procedure.

They further stated that had they known left orbits were being conducted, they would not have approved a 'turn into that area in a Caravan, let alone a much larger aircraft'.

The DC advised he had not mentioned the left orbits to CASA as they had never specifically enquired about the float plane sequence. However, CASA staff were present for the briefing conducted the night before the activity, in which the conduct of orbits was described.

Operation within Perth Water

The ATSB spoke with Caravan and Buccaneer float plane pilots who had experience operating within Perth Water and were therefore familiar with the display area. They noted that their aircraft did not have a lot of room to manoeuvre and described Perth Water as a 'confined', 'constricted' and 'very tight operating area'.

Air display conditions for conducting the display in Perth Water were captured in the display instrument, and included that:

> Non-aerobatic display aircraft are not to be operated below 1.3 times the stall speed for the aircraft's configuration.
>
> …display aircraft will pass no closer than 200 metres horizontally from spectators. Aircraft below 1500 feet AGL shall not track or manoeuvre directly towards spectators within a horizontal distance of 500 metres.
>
> For aircraft operated by pilots holding a low-flying approval, the demonstration may be conducted with the following manoeuvring limitations:
>
> a) Between 50-200 feet AGL – wings level only

b) Between 200-300 feet AGL – up to 30 degrees angle of bank

c) Between 300-500 feet AGL – up to 60 degrees angle of bank

Despite the differences in understanding of the intended display between CASA and the display participants, and the stated effect on the display approval, the ATSB determined that it was possible to conduct orbits in the Mallard, while adhering to the display conditions, however there was little room for error. A similar conclusion was reached by CASA in their post-occurrence regulatory safety review.

However, following review of the draft investigation report, CASA advised that the conduct of orbits within Perth Water could not be conducted in compliance with Civil Aviation Regulation (CAR) 157. Despite this, the ATSB noted that CASA did approve the conduct of essentially identical manoeuvres in the form of a '…go around whilst remaining in the display area', per the display procedure.

Approval of VH-CQA in the air display

The DC met the pilot of CQA in late 2016. In early 2017, when he became aware the aircraft was coming to Western Australia, he invited the pilot to participate in the air display. In January 2017, leading up to the air display, the following key interactions to facilitate participation of the aircraft and pilot occurred:

- In an email to CASA on 4 January that included documents for the air display application, the DC mentioned the possibility of CQA being involved in the display. The display procedures submitted in this email included one for 'flying boat'. He also provided details for several display pilots, including the pilot of CQA.
- On 11 January, the DC advised CASA via email that another float plane had been added to the program to fly with CQA. However, a revised procedure detailing this new aircraft was not included in this email.[19]
- On 12 January, CASA asked the DC if the pilot of CQA was going to get an opportunity to practice prior to the event. He replied that it would be the same as 'all other displays where pilots will prepare appropriately', and that he would meet with the pilot of CQA when he arrived in Perth. CASA then requested the pilot of CQA provide a statement in relation to the water depth in the proposed landing area, for the appropriate date and time of the event. The DC replied there would likely be a water depth of about 1 m.
- On 16 January, the DC sent an email to the pilot of CQA where he offered to be 'co-pilot' during the display, to 'help with the radio and procedure'.
- In an email to CASA on 17 January, the DC indicated that he had spoken with the pilot of CQA and agreed that he would only do a splash-and-go and that the aircraft would not get off the step.
- During a phone call on 19 January, the DC was advised by CASA that the pilot of CQA would not be able to participate in the air display without the required G-73 type rating being endorsed on his licence. The DC advised the pilot of CQA of the issue with the type rating via email and that CASA had agreed to wait until midday 23 January when, if no evidence of this type rating was provided, CQA would be withdrawn from the program.
- About a week before the air display, the DC arranged with CASA for MOX to be included in the display and submitted details for the pilot and advised that he was still waiting for confirmation that CQA could participate. The email advised that the pilot of MOX had been in the display three years previous and had 'done this very sequence', described as being 'fly by + touch and go on water'.

[19] The other float plane was later withdrawn from the display due to unavailability.

- On the evening of 23 January, the DC submitted a revised float plane display sequence showing details solely for the Caravan. The Instrument (the approval - the term *Instrument* is discussed in the section *CASA approval and oversight of air displays*) was sent to the DC at 1940 that evening.
- On the afternoon of 24 January, the DC emailed CASA with documents showing that CQA's pilot now held the required G-73 type rating and an 'authority to fly letter' from CASA. He also requested that CQA now be included in the display. He also submitted the float plane display sequence including the Mallard and the Caravan and a revised program, which now showed CQA and MOX. In his email to CASA, the DC also stated that as a member of the CASA team had reportedly had a concern about the 'first time [participation of a new pilot and aircraft type]', he would 'go along to be of support [to the pilot] for the procedure which should mitigate against that concern'. Revision 2 of the Instrument was issued by CASA that evening.

Risk mitigation

CASA personnel reported that they approved the inclusion of CQA on the basis of having the DC on board, to mitigate against the risk associated with having a new pilot and aircraft type involved in the display. CASA's documented reason for allowing CQA to participate in the display referred to the email received from the DC on 24 January (detailed above), indicating that he would be on board.

The DC reported that he originally offered to be on board to assist the pilot with any procedural aspects associated with his first time in the display. However, he indicated that having CQA follow MOX for the display effectively mitigated that concern. He also indicated that his offer to be on board CQA was not acknowledged by CASA and there was no indication that this was their expectation. Therefore, he believed his presence on board was not a requirement. Additionally, the pilot elected to depart from Serpentine Airfield, rather than the original Jandakot Airport departure point. As the DC was a participant in five displays that day, he would not have had the time to travel to Serpentine in order to be on board.

As part of their post-occurrence regulatory safety review (see the section titled *CASA approval and oversight of air displays* section) of the lead-up and conduct of the air display, CASA identified that despite their expectation that the DC would be on board CQA, they had not specifically advised the DC of this, nor was this requirement included in the Instrument of approval. CASA also did not advise the pilot of CQA that the DC being on board was a requirement for his inclusion.

Pre-display briefing and flight planning

The CASA air display guidance manual (see the section titled *CASA approval process for air displays*) detailed that a written brief of the flying program should be circulated in advance of the air display, to pilots and those in other critical roles. In addition, 'a formal verbal briefing should be given on the day of the display and at any rehearsal, and all participants, where possible, must attend'. Those not able to attend were to be verbally briefed separately. The manual listed the minimum items that were to be covered in the briefing.

The Skyworks pre-display briefing was held at Jandakot Airport the night before the event. All air display participants were required to sign Form 695 *Participant signature sheet*, acknowledging that they have read the CASA approval for the air display and would operate their aircraft in accordance with the terms of the approval. The briefing was conducted by the DC in a large cafeteria-style room, with participants seated at various small tables. The Ringmaster and CASA also addressed the participants. The event was video recorded by the City of Perth and the

footage[20] was reviewed by the ATSB. Participants were seen reviewing copies of the written brief, which had been provided to them at the commencement of the briefing.

The briefing included a discussion of the display area, air space, radio communications and standard approach, holding and departure procedures. As detailed previously, the extent of the float plane-specific brief was, 'the float planes… will be doing their touch and go…but they won't be landing fully. If anything they [are] just kissing the water and then do an orbit and then another one and then [depart]'. The DC also discussed the importance of aircraft serviceability, the anticipated weather conditions, considerations about personal fatigue and to 'have your own risk management'. He also emphasised that they were the lead-up to the main event and there was 'no pressure to do anything special', 'just do everything as you normally do, don't do anything different' and to 'have your own limitations'. The DC reported that separate 'formation' briefs were conducted for participating pilots on the morning of the air display, prior to departure from Jandakot Airport.

The pilot of CQA attended the briefing, where he first met the pilot and observer of MOX. The pilot of MOX reported that:

- he and the pilot of CQA discussed airspeeds, who would lead and who would be on board CQA
- it was arranged that the two aircraft would meet at Jandakot Airport (where CQA could refuel and/or collect the DC) or overhead Cockburn Sound (if CQA flew directly from Serpentine Airfield)
- MOX would be the lead aircraft, handle the radio calls and general procedures, so that CQA could follow.

The pilot of MOX reported that he did not have any expectations of CQA's pilot, other than CQA would follow MOX. He recalled that the pilot of CQA had suggested he would not touch the water, but conduct a low overshoot. On the day of the display, the pilot of MOX received a text message from the pilot of CQA at about 1515, advising he would meet MOX overhead Cockburn Sound.

Carriage of passengers during the air display

Civil Aviation Regulation (CAR) 2 *Interpretation* defines a 'crew member' as a person assigned by an operator for duty on an aircraft during flight time and 'operating crew' as any person who:

- is on board an aircraft with the consent of the operator of the aircraft; and
- has duties in relation to the flying or safety of the aircraft.

CASR Dictionary – *Part 1 – Definitions* describe the following roles:

> Flight crew member means a crew member who is a pilot or flight engineer assigned to carry out duties essential to the operation of an aircraft during flight time.
>
> Passenger, in relation to an aircraft, means a person:
>
> (a) who:
>
> (i) intends to travel on a particular flight on the aircraft; or
>
> (ii) is on board the aircraft for a flight; or
>
> (iii) has disembarked from the aircraft following a flight; and
>
> (b) who is not a member of the crew of the aircraft for the flight.

Under Civil Aviation Order 29.4 *Air Displays*, one of the conditions of approval to conduct an air display is that 'passengers shall not be carried for hire or reward during any part of the air display except where specifically approved as part of the program'. While this did not exclude the carriage

[20] The footage was taken from several angles and contained some gaps in the briefing. It did, however, provide an overall appreciation of the conduct and content of the briefing.

of passengers for no compensation, the CASA instrument of approval for the 2017 Skyworks air display was more explicit, stating that 'passengers shall not be carried in display aircraft and only aircrew essential to the operation of the aircraft are to be carried'. Similarly, the following statements were included in the *Flight Crew* section of the air display manual:

> No persons other than **operating crew** may be on board a civil aircraft during the air display unless the prior written permission from CASA has been obtained.
>
> The responsibility for ensuring that an aircraft is operated in accordance with its Certificate of Airworthiness, Permit to Fly and Air Display Approval rests with the pilot in command. This does not absolve the Display Organiser from the responsibility to take such action as is necessary should a display aircraft deviate from the bounds of any approval or operate in an unsafe manner.

In addition to the regulatory considerations above, as part of the pre-display briefing the DC reinforced that 'you're not allowed to carry passengers but you are allowed to carry operational crews'.

During discussions following the pre-display briefing conducted on 25 January 2017, the DC was made aware that the pilot of CQA intended to have an additional person on board, in the right front seat. The pilot had mentioned to several people that it was necessary for this person to be on board CQA to assist in the case of needing to manually deploy the main landing gear. The Mallard's flight manual did not include this method for releasing the main gear and other Mallard pilots reported being unaware of it.

This reasoning was also raised by the pilot when questioned by CASA officers after they witnessed two people disembark the aircraft during CQA's participation at the Great Eastern Fly-In events at Evans Head Aerodrome, New South Wales on 7-8 January 2017. The outcome of that conversation was that the CASA officers informed the pilot that his passenger did not meet the definition of essential crew.

The CASA officers that participated in the discussion at Evans Head were from the sport aviation office and were not aware of the pilot's application to participate in the Perth Air Display. The Perth office was similarly unaware of the discussion that had taken place at the Evans Head event when they assessed the pilot's application for the Perth display.

The pilot's log book indicated that his passenger had flown on CQA several times, between 6-13 January 2017 and had a total time on board CQA of about 19 hours. While it was reported that the passenger was interested in flying training, information received from CASA and the National Transportation Safety Committee (NTSC), Indonesia found that she had not registered with either organisation and did not hold a flight crew licence.

It was also reported that the pilot had invited another person to be on board during the Skyworks display. However, the pilot's decision to minimise the weight of the aircraft due to the temperature on the day, prior to departure from Serpentine Airfield, resulted in that person not being on the accident flight.

Following a recommendation from their regulatory safety review conducted after this accident, CASA published a revised Form 697 *Pilot or essential crew details* in April 2018. This expanded form added a checklist of considerations for display pilots in relation to their intended display. Sections were also included to allow for identification and reasons for the requirement of additional crew and a DC checklist to ensure consistency in the application. In addition, this form was now required to be signed by the pilot, crew (if applicable) and the DC.

Air display roles and responsibilities

Documented roles and responsibilities

CASA's *Air Display: Safety and Administrative Arrangements* manual (air display manual) provided guidance on the minimum safety and administrative procedures necessary to run an air

display. The manual included a list of key personnel and their responsibilities, most notably, that of the Display Organiser, Display Coordinator and flight crew (Table 1).

Table 1: CASA *Air Display Administration and Procedure Manual* [21] **terminology of air display roles**

Display Organiser (DO) The air display 'organising body must appoint one person as the DO to assume overall responsibility'. This person is also expected to be 'personally familiar with each pilots' display routine and ensure that it complies with the safety criteria'. They are responsible for the planning and display management, including: • appointment of DC, flying display committee, officials and flight crew • site assessment • marking of the display axis • pre-display briefing • document checks • pilots' display programs (both normal and weather-restricted programs). Where the DO does not have 'considerable aviation experience', they are to appoint a 'suitably qualified person, preferably with display experience, as the DC.
Display Coordinator (DC) The DC is 'sometimes referred to as the Ringmaster because he/she controls the actual flying program'. The DC's responsibilities included: • flying discipline in general • compilation, approval and modification of individual flying routines • the overall flying program • cancellation or modification of the flying program in the event of unsuitable weather or other such conditions. 'It is strongly recommended that, before being appointed as a DC, the DC should have had the experience of being an Assistant DC or being in a similar subordinate role in at least one Air Display of similar complexity.'
Flight Crew The pilot in command's responsibilities included: • ensuring the aircraft is operated in accordance with its certificate of airworthiness and the air display approval • planning their flying sequence to maintain minimum separation distance from the crowd line. During the pre-display briefing, the pilots were to be reminded 'that flying over the crowd, car park or any public enclosure is prohibited and any turns towards these areas must be completed without infringing the safety buffer between the display axis and the crowd line'.

The CASA-issued instrument granting approval for the 2017 air display assigned the City of Perth to the role of 'Display Operator' and separate individuals to the roles of DC and Ringmaster. The instrument did not assign a DO.

[21] CASA procedures and manuals detailed in the section *CASA approval and oversight of air displays*

The role of Display Operator was not defined in the air display manual, however they, along with the DC, had a responsibility via the instrument to ensure that the display was conducted in accordance with the relevant legislation.

Recognising the discrepancy between the roles defined in the air display manual and the instrument, the role titles identified in the CASA-issued Perth air display instrument are used throughout this report for consistency.

Display Coordinator

During the 2017 display organisation and approval, the DC carried out some of the responsibilities of that role, as well as that of the DO, per the air display manual. When interviewed by the ATSB, members of the CASA team referred to the same individual as both the DO and DC. It was noted that this was possible in accordance with the manual.

The DC held an Air Transport Pilot (Aeroplane) Licence and a Commercial Pilot (Helicopter) Licence, for single- and multi-engine aeroplanes and single-engine helicopters. He held multiple design feature endorsements including floating hull and float plane. The DC was endorsed for aerobatic flight activities and held low-level ratings for both aeroplanes and helicopters.

The DC had been involved as a pilot in the Perth Air Display since its inception and over time voluntarily took on various roles with respect to planning, procedures and approvals. He was directly involved in developing the display program and conducting the pre-flight brief, typically the night before the event. He advised that on the day of 26 January each year, 'I'm just a display pilot… just like all the other pilots participating in the displays'. The DC advised that responsibility for ensuring the display instrument was being followed on the day of the event was with the Ringmaster.

The DC self-identified as the 'air display liaison' which was also reflected on the Airservices Australia letter of agreement (airspace arrangement) and the City of Perth Skyworks emergency contact list. Despite this, the DC had entered his name as DO on the 2015, 2016 and 2017 application forms.

With regard to the approval process, the DC reported that different CASA officers had different application requirements. He indicated his role was to provide information to CASA, to allow them to assess and approve the display. The DC said that CASA had requested to observe a certain routine in the past, before issuing the display approval. It was therefore the DC's opinion that it was ultimately CASA's decision as to whether or not to approve a pilot and their display.

In contrast, several CASA officers reported it was the DO/DC's responsibility to ensure that a pilot and/or display was suitable, before including them in the application. However, CASA officers also stated that it was ultimately the individual pilot's responsibility to satisfy themselves that they were capable of conducting the intended display.

The DC reported that he did not necessarily have the opportunity to know each pilot and their display, however he would not invite a pilot that he felt was not suitable to be part of the display. The DC noted that some years certain pilots and/or aircraft were not available but on the whole the applications were similar each year, with just an occasional display name change. Other than inviting the participation of the Mallard, the DC could not recall the last time a new display was introduced.

Ringmaster

The Ringmaster carried out a portion of the DC's responsibilities as they related to controlling the flying program on the day.

The Ringmaster held a Commercial Pilot (Aeroplane) Licence and was a flight instructor. She reported having been involved in the event for about nine years, first as an observer with the DC in a Caravan, then assisting the previous Ringmaster during one display, before taking on that role. The Ringmaster described her role as coordination of the display aircraft and monitoring

them for good separation. She advised she would sometimes offer or approve a request for additional fly-bys where time permitted. The Ringmaster also coordinated the various banner/flag aircraft between displays.

For the 2017 display, the Ringmaster was located in a room on the twelfth floor of a hotel, situated on the northern side of Langley Park that provided a full view of the display area (Figure 11). An assistant located with the Ringmaster provided support in visually monitoring aircraft movements when the Ringmaster was conducting radio communications. The assistant advised he was a flight instructor and had been in that role for the last four or five years.

When the approval for CQA's third pass was granted by the Ringmaster, the assistant reported that their vantage point and the position of the sun made it difficult to identify exactly what the aircraft was doing over Melville Water (Figure 11) prior to returning to the display area. Although the Ringmaster did not specify the manner in which the Mallard was to return for the third pass, the assistant expected the approach to be via the standard procedure, behind the city, and was surprised when he realised CQA was re-entering Perth Water directly. He reported that CQA may have flown over boats[22] lower than the authorised height, but as the moment had passed, there was no gain in immediately contacting the pilot about it. The Ringmaster advised that she did not observe CQA until just prior to the accident as she was communicating with a banner-towing helicopter via radio.

Figure 11: The view of Langley Park from the Ringmaster's vantage point

Source: City of Perth

The Ringmaster had a copy of the Instrument, emergency contact list and display schedule with her on the day. The display schedule contained basic detail of the actual display routines, however it was reported they were generally similar each year. Further, she did not necessarily know who was on board each aircraft, other than the schedule-listed pilot. The Ringmaster generally didn't communicate with pilots during their display, so as not to distract them, but would make a call if there was something unsafe.

Suitability assessment for key roles

The CASA air display manual in effect at the time of the occurrence made limited reference to the suitability or experience required for individuals to hold key roles. The guidance was that the DO should have considerable aviation experience if also assuming the function of the DC, or otherwise appoint a suitably qualified person, preferably with display experience. There was no mechanism detailed for assessing the suitability of individuals for the roles and no additional training or accreditation.

By contrast, the Civil Aviation Authority United Kingdom (CAA UK) published Civil Aviation Publication (CAP) 403 *Flying Display and Special Events: A Guide to Safety and Administrative Arrangements*. CAP 403 provided detailed information about the roles and responsibilities of event

[22] Flight over moored vessels at this location would also involve flight over the built-up area of the South Perth peninsula.

organisers and participants. From 1 May 2017, the UK CAA implemented Flying Display Director (FDD)[23] accreditation. The accreditation scheme required the applicant to 'demonstrate their knowledge, experience and capability against a number of FDD competencies' including:

- regulatory compliance
- maintaining flying discipline
- risk management
- 'understanding of human factor influence on the safety of flying displays'.

The applicant was also required to undergo behavioural and attitudinal fitness assessments.

If successful, the FDD would be authorised to an appropriate tier level, based on degree of display complexity, for a period of three years and must maintain currency for re-accreditation. The United States and New Zealand had similar programs to ensure the knowledge and suitability of the person primarily responsible for coordinating the event.

The CAA UK also required formal evaluation of potential display pilots and their intended routine. This involved having an authorised Display Authorisation Evaluator (DAE) evaluate and mentor a pilot, at which point the pilot can apply for a Display Approval (DA), which was required to participate in a CAA UK authorised event.

Similar to the FDD, to be granted a DA a pilot was required to undergo behavioural and attitudinal assessment to determine their suitability for a flying display role. The pilot's DA was aircraft type and routine-specific. These accreditation requirements were established in the mid-1980s, with additional restrictions and formalised training introduced after the 2015 Shoreham Air Show accident (see the section titled *Related occurrences*). As with the FDD role, currency and re-evaluation was required for re-validation of the DA. At the time of writing, the United States had a similar pilot evaluation program for aerobatic pilots.

Additional guidance was provided by the CAA UK publication, CAP 1047 *Civil Air Displays – A guide for pilots*. This publication was 'intended to provide advice to display pilots to help them avoid the pitfalls which have been experienced in the past'. Topics included personal fitness, planning and practicing for displays, and what to do on display day.

CASA approval and oversight of air displays

Regulations and guidance material

Australia's Civil Aviation Act 1988, through the Civil Aviation Regulations (CARs) and Civil Aviation Orders (CAOs), provides CASA with the authority to regulate exhibitions of flying, commonly referred to as air displays, flying displays or airshows involving civil aircraft.

CAR 156 and CAO 29.4 cover the regulatory requirements as they relate to air displays. CAR 156 relates to flying over public gatherings. CAO 29.4 outlines the application process and specifies the conditions of approval, planning and control requirements. The order states that an air display shall not be conducted without the written approval of CASA and that the organiser shall be responsible for ensuring that the applicable regulations are met.

CASA also developed the *Air Display: Safety and Administrative Arrangements* (air display manual) as guidance material to be read in conjunction with the regulations.

Air Display Manual

The air display manual provided guidance on the minimum safety and administrative procedures necessary to run an air display. It outlined the responsibilities of key personnel involved in an air display, including that of the DO, DC and display pilot (flight crew) (see the section titled *Air*

[23] The Flying Display Director's responsibilities most closely aligned with those of the Display Coordinator in CASA's *Air Display: Safety and Administrative Arrangements* manual

display roles and responsibilities). The guidance in effect at the time of the display approval process was version 1.3 (November 2010). While the air display manual contained detail with respect to responsibilities of the DOs, it was limited in guidance with respect to assessing an application to an expected standard.

In comparison with other jurisdictions, the United States FAA order 8900.1 Volume 3, Chapter 6, Section 1 contained detailed guidance around processing and assessing applications for aviation events (including air displays) to determine whether to issue a certificate of waiver or authorisation to an applicant.

At the time of the occurrence, a revised air display manual had been drafted. Subsequently, version 2.0, significantly revised and renamed the *Air Display Administration and Procedure Manual,* was published in September 2017, with version 3.0 published in April 2018.

Receipt and processing of air display applications

Applications to conduct air displays were generally submitted to the local regional CASA office, using Form 696 *Application for approval to conduct an air display*, along with supporting documentation. After assessment of the application, the officers provided advice in the form of a 'reason for decision' to the authorised CASA delegate. If approved, the delegate then issued an Instrument under CAO 29.4, identifying the person, or organisation, authorised to conduct the air display. This Instrument formed the approval and permission to conduct the air display, including any CASA-imposed conditions.

As part of this investigation, the ATSB reviewed Skyworks display approvals conducted by the Western Region (Perth) office, as well as those for the Great Eastern Fly-In conducted by the sport aviation office between 2015-2017.

Staff in both the Perth and sport aviation offices developed forms or checklists to assist the display approval process. The Perth office developed an 'Air Display Energy Management' form, which was used in the 2015-2017 air display documentation to provide detail for some aerobatic and specialised displays. The form was titled 'CASA Western Region – Air Display Form' and had provision for 'participant' and 'DC' signatures. However, none of the 'Energy Management' forms reviewed had been endorsed by the DC.

The sport aviation office developed a spreadsheet to monitor air display pilots' medicals, licence and endorsements, and aircraft registrations and airworthiness categories. This office also developed a risk assessment document for DOs to complete and submit with their application, and a checklist to monitor the progress and requirements of the approval process. It was reported these additional measures were implemented to ensure consistency and standardisation of the sport aviation office approval process.

The region-specific documents were not referenced in the air display manual nor disseminated more widely. Additionally, the Perth and sport aviation offices were also unaware of the documentation each other had developed.

Air display surveillance

The CASA Western region office increased their involvement in the 2017 air display in response to a drone sighting in Perth Water and a near-collision involving display aircraft, just outside Area Alpha, during the 2016 event.

The office initiated a surveillance activity, which included ramp checks [24] at Jandakot Airport before the air display, and observations of the City of Perth and Police coordination centre and Ringmaster locations. CASA advised the DC of these planned activities in early January 2017 and

[24] CASA advise that ramp checks are conducted to make sure flight operations are being carried out safely and in accordance with regulations. A typical ramp check involves the inspection of documentation, flight preparation (including the aircraft).

subsequently met to discuss the purpose of the activities and to address concerns of the DC that the surveillance activity may distract the involved pilots.

After CASA staff escalated the DC's concern internally, the decision was made to continue with the planned surveillance activities as there had not been any formal surveillance of the event for a significant time period, and the staff understood that the upcoming version of the air display manual would require such activity in the future.[25]

CASA officers attended Jandakot Airport on 26 January 2017, from 1330 until about 1630. The surveillance included a series of ramp checks, observation of formation briefs and general liaison with participants. Due to the proximity of the ramp checks to the display, there was reported concern among the DC, Ringmaster and some of the air display pilots that the checks may have caused stress or distracted pilots immediately prior to flying.

It was reported to the ATSB that the pilot of CQA elected to depart from Serpentine Airfield (instead of Jandakot Airport) to avoid the surveillance activity. While that could not be verified, departure from Serpentine meant there was no opportunity for either CASA, the DC or the pilot of MOX to observe or engage with the pilot prior to the display.

While the Perth office reported they generally attended the pre-display briefings, they did not have a policy to observe, and did not routinely attend the air display. By contrast, the CASA sport aviation office regularly attended the air displays they approved. They reported that this allowed them to observe that the requirements of the display authorisation were being upheld and provided assurance that the documented Instrument was relevant. In addition, the sport aviation office reported that regular attendance of air displays fostered good cooperation with organisers and participants.

Air display risk management and governing framework

Defining risk management

International Standard ISO 31000:2018 *Risk management – Guidelines* defines risk as the 'effect of uncertainty on objectives'. That is, deviation from the expected. Risk management is defined as 'coordinated activities to direct and control and organization with regard to risk'. Some of the key risk management principles include that it:

- be integrated into organisational (or in this case, event-based) activities
- provide a structured and comprehensive approach, allowing consistent and comparable results
- be dynamic, as risks can emerge or change as the context changes
- use the best available information, so that both historical and current information from all stakeholders can inform the risks.

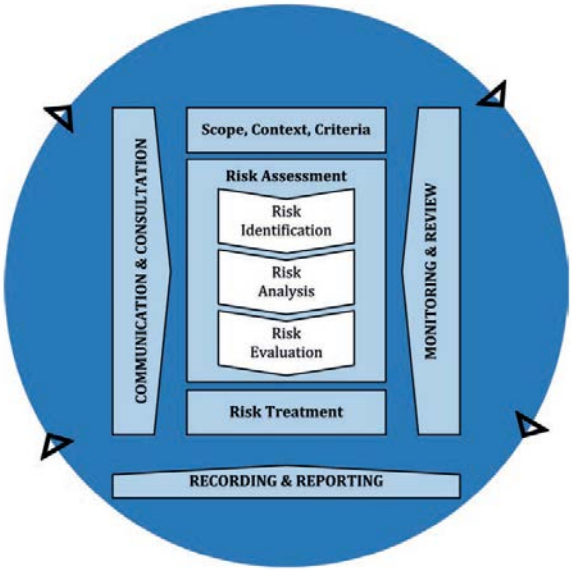
The risk management process in ISO 31000:2018 is outlined in Figure 12, and defined as involving:

> …the systematic application of policies, procedures and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing and reporting risk.

This process is designed to be an 'integral part of management and decision making' and can be applied at any level including operational matters.

[25] The *Air Display Administration and Procedure Manual published* September 2017 included the following statement: The scale of CASA attendance at the event, if any, will depend on the nature of the event, scale and location of the display.

Figure 12: The risk management process



Source: International Standard ISO 31000:2018 Risk Management - Guidelines

The elements of this risk management process relevant to air display preparation, included:

- Communication and consultation: where relevant expertise is brought together to ensure the right information is considered when identifying, assessing and controlling risk. In this case, the input of stakeholders such as the City of Perth, DC, Ringmaster, CASA and the display pilots.
- Scope: In the context of an air display, the scope should include all activities that may affect the safety of the flying operations.
- Risk identification: the purpose of risk identification is to 'find, recognise and describe risks that might help or prevent' the desired outcome. In this context, it is important that regulators and DOs consider potential threats, indicators of emerging risks (for example, late inclusion of a new display), limitations of knowledge and time-related factors.
- Risk treatment: the purpose is to 'select and implement options for addressing risk', including whether a certain risk is to be avoided, changed, shared or retained. Relying on individual pilots to manage their own risks when taking part in an air display is a limited treatment strategy, but combined with more systematic approaches and the collective knowledge of others allows for improved identification of defences.

There is further guidance about the risk management process in ISO 31000:2018 and the September 2017 CASA air display manual.

The concept of a risk framework

As outlined in ISO 31000:2018, a framework for managing risk is designed to 'assist [organisations] in integrating risk management into significant activities and functions' for good governance. 'Framework development encompasses integrating, designing, implementing, evaluating and improving risk management' across an organisation or group of people.

The United Kingdom (UK) Department for Transport commissioned a study in response to a recommendation from the UK Air Accident Investigation Branch investigation of the 2015 Shoreham accident (see the section titled *Related occurrences*). The resulting report, *A Review of UK civil flying display and special event governance,* discussed the concept of governance and how it can range from structured to informal in nature. A governance framework was described as providing 'an organisation or a group of individuals with common objectives, and reflects the interrelated relationships, factors and other influences on them'. The report stated that good governance should:

- provide a set of processes and procedures to deliver clear direction and oversight to industry

- distil down specific roles, accountabilities and communications, and
- provide a feedback loop that can identify trends and respond to changing circumstances, challenges and regulatory needs.

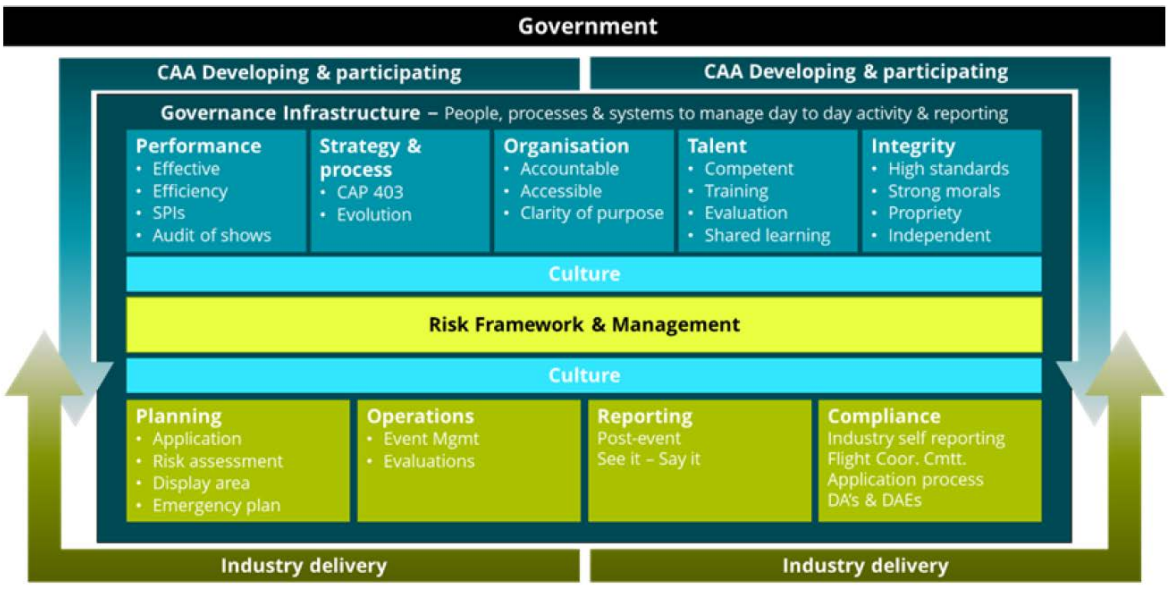
A visual representation of such a framework, based on good governance principles, was developed to review the UK civil aviation flying display activities, existing around the time of the Shoreham accident. It depicted interactions between the government, the CAA UK and industry (Figure 13). It defined the governance infrastructure as the 'people, processes and systems to manage day to day activity and reporting'. The top half of the diagram shows those activities that the CAA UK have primary responsibility for defining, developing and participating in, including:

- performance – including monitoring of safety performance indicators, and conducting audits
- strategy – including reviewing and updating legislation
- organisation – including defining the roles of those organising the air display, accrediting the display organisers and briefing display pilots
- talent – including developing CAA UK staff skills, mentoring display pilots and shadowing display organisers

The bottom half outlined the areas to be delivered by industry, where the CAA's responsibilities were more related to understanding, oversight and monitoring (rather than active involvement). This included the planning of the display, the operations themselves, and compliance with regulations.

Throughout this, the CAA UK is also responsible for establishing a risk management framework, including the application of a risk assessment process, auditing flying displays, and setting a risk matrix applicable for flying displays.

Figure 13: United Kingdom civil flying display governance framework



Source: Helios, 2018

Risk management for air displays

In April 2016, CASA convened a working group to update the air display manual. That group identified that the risk assessment process was likely an appropriate and effective tool for the assessment of air display approvals. Despite that, the air display manual in effect for the 2017 air display did not include a requirement to complete a risk assessment as part of the planning or approval processes. However, the September 2017 version of the Manual included a requirement for the DO to 'compile and conduct [a] risk assessment', and provided comprehensive guidance in an appendix.

As previously mentioned, the CASA sport aviation office advised that they expected DOs to include a risk assessment as part of their application. An example reviewed by the ATSB for the Great Eastern Fly-In included risks associated with a range of operational activities, including flight and group operations, maintenance, display pilot matters and airspace.

In reviewing other States' requirements for their air displays, the ATSB noted that the Civil Aviation Authority of New Zealand (CAA NZ) included in their Advisory Circular AC-91-1 *Aviation Events* that the organiser was expected to risk assess the activity. They add that:

> The responsibility of implementing and monitoring risk removal and risk mitigation steps falls to the organiser, flying display director and flying display committee. They should therefore all be involved in the risk assessment of the aviation event.

Similarly, the CAA UK CAP403 *Flying Display and Special Events: Safety and Administrative Requirements and Guidance* outlined that 'risk assessment is an essential element in the production of any safety plan…Flying Display applicants are required to submit information about any risks that will be actively managed during the event to CAA as part of the display application process'.

Skyworks risk management activities

The City of Perth developed a risk management plan, covering activities associated with the events and coordination around Skyworks, including the air display. It outlined key responsibilities for stakeholders and the tools that were used to identify, assess and control risk. One of these tools was a risk register, which included a number of aviation-related risks such as 'aircraft/skydive incident causing injury or ill health'. The mitigation for that risk included the provision of the air display approval, and proposed surveillance, from CASA, a landing area exclusion zone and an emergency response plan. The DC provided input into this risk management plan or risk register. Risks identified from previous years' events included the effects of falling debris, an 'aircraft incident on Perth Water', particularly among the moored boats, and skydivers landing in unintended areas.

A near-collision occurred during the 2016 air display involving a banner tow aircraft and a group of display aircraft, just outside of Area ALPHA. The occurrence prompted the DC, in late January 2016, to request that CASA assist with a modification to area ALPHA for the 2017 display, to reduce the risk of a repeat occurrence. In conjunction with Airservices Australia, CASA's Office of Airspace Regulation requested that the DC complete a risk assessment, relating to the proposed airspace changes for the 2017 display. The DC questioned the need for the risk assessment when it had not been required previously. In addition, the DC advised CASA he would sign a risk assessment that CASA prepared, when he returned from an overseas trip in November 2016. In response, CASA encouraged him to develop it as a 'living document' rather than rely on his experience in the conduct of the air display and examples of risks were provided to the DC. A completed risk assessment (limited to the scope of airspace changes) was ultimately supplied to CASA and the airspace changes were authorised.

In the lead-up to the air display, the CASA Perth office liaised with the DC on some concerns such as the draught of the Mallard in the water and the single-engine performance. However, apart from the requested risk assessment relating to airspace matters, there was no formal or systematic way that other types of operational risks were identified, assessed and controlled. There was also no requirement to do so under the current regulations.

Related occurrences

Within limitations of the ATSB occurrence database, there were approximately 22 air display-related occurrences in the ATSB database between 1969 and 2017. Thirteen of those occurrences resulted in a fatality, therefore averaging one fatal accident every 3.7 years. The majority of the occurrences were related to aircraft handling, resulting in loss of control and collision with terrain.

The ATSB also reviewed other states' investigations into air display accidents, particularly those involving passengers and/or spectators. The scope of the review was to gain appreciation of risk factors to spectators, and where lessons learned had resulted in improvements to the planning and approval of air displays. A number of occurrences were identified and two of these are discussed below.

United Kingdom

The Air Accidents Investigation Branch, United Kingdom investigated the accident involving *Hawker Hunter T7, registration G-BXFI near Shoreham Airport on 22 August 2015*. The aircraft crashed on to the Shoreham Bypass while performing at the Shoreham Airshow, fatally injuring 11 road users and bystanders. A further 13 people, including the pilot, sustained other injuries.

Beyond examining the actions of the pilot, the investigation found that:

> …the parties involved in the planning, conduct and regulatory oversight of the air display did not have formal safety management systems in place to identify and manage the hazards and risks. There was a lack of clarity about who owned which risk and who was responsible for the safety of the air display, the aircraft, and the public outside the display site who were not under the control of the show organisers.
>
> The regulator believed the organisers of air displays owned the risk. Conversely, the organiser believed that the regulator would not have issued an approval for the display if it had not been satisfied with the safety of the event…and the display organiser believed that it was the responsibility of the operator or the pilot to fly the aircraft's display in a manner appropriate to the constraints of the display site.
>
> No organisation or individual considered all the hazards associated with the aircraft's display, what could go wrong, who might be affected and what could be done to mitigate the risks to a level that was both tolerable and as low as reasonably practicable.
>
> Controls intended to protect the public from the hazards of displaying aircraft were ineffective.

Additional detail in the report included consideration of risk to spectators outside the event, non-participants (general public in the area) and proximity of residential, industrial and recreational areas, including schools and hospitals.

United States

On 16 September 2011, an experimental single-seat North American P-51D collided with terrain while participating the National Championship Air Races in Reno, Nevada. The pilot and 10 people on the ground sustained fatal injuries and at least 64 others were injured. The National Transportation Safety Board (NTSB) investigation identified the aircraft was conducting a turn just prior to the loss of control. The NTSB made several recommendations, including evaluation of the course design and safety areas to minimise manoeuvring near, and potential conflicts with, spectators. The event organiser subsequently relocated the course and primary spectator area to 'create and maintain a greater distance' between the racers and spectators.

Safety analysis

Following two low fly-bys along the Langley Park foreshore as part of the City of Perth Australia Day Skyworks event, the pilot of Mallard VH-CQA (CQA) manoeuvred his aircraft in order to conduct a third pass. During the final positioning turn, CQA rolled left, pitched nose-down and collided with water. The pilot and passenger were fatally injured and the aircraft was destroyed. This analysis will examine the:

- loss of control
- pilot's actions in returning to the display area for a third pass
- carriage of a passenger
- regulatory framework for approval and oversight of air displays.

As part of the analysis, comparisons have been drawn with other country's regulations, guidance and practices as a means of benchmarking other methods for managing air displays. Other countries have also published extensive guidance material and some have dedicated air display organisations to support those organising and participating in air displays.

Loss of control

Analysis of recorded flight and video data, and witness reports identified that the aircraft stalled in the positioning turn for the third pass. Such a loss of control in this aircraft type at the relatively low operating altitude meant the situation was unrecoverable before contact with the shallow water.

Technical examination of the aircraft did not identify anything that contributed to the accident. In the absence of a problem with the aircraft, the stall most likely resulted from a handling error and there were several factors that increased the risk of that occurring.

The pilot had limited recent experience operating the Mallard and had not previously participated in a display involving low-level turns within a confined area. Considering this, and noting the limited opportunity available due to his late inclusion and licencing issue, the pilot had not practiced for the event.

The pilot's lack of familiarity was intended to be mitigated by following another participating aircraft, VH-MOX (MOX), during the display sequence and having a pilot familiar with the display present in CQA. These defences were not effective however, as CQA parted company from MOX prior to returning to the display area in a different manner to that associated with the first two passes and there was no accompanying pilot on board CQA during the flight.

Additionally, although current and recent in accordance with the regulations, the pilot had not undergone any formal training in the Mallard in the five years since his endorsement and had satisfied the intervening biennial flight review requirement in a different aircraft type. This was despite the Mallard being a type-rated aircraft, considered as having performance or handling techniques that warranted specific training and flight reviews. The lack of assessment in the Mallard since endorsement was a missed opportunity to objectively confirm the pilot's competency, or identify and correct any degraded skills specific to operation of that aircraft.

Finally, although not a requirement, the aircraft was not fitted with a stall warning device that may have alerted the pilot to the developing situation in sufficient time to take corrective action.

There was insufficient evidence to establish the extent to which any of these factors influenced the development of the accident. Similarly, the degree to which a focus on participating in the event may have distracted the pilot from operating the aircraft could not be determined.

Returning for the third pass

The pilot of MOX only conducted the two planned passes and was unaware of the intention for a third by CQA until it was requested of the Ringmaster. This impromptu action was contrary to the

briefed plan that the two aircraft would fly in company to mitigate against potential issues with the pilot of CQA's unfamiliarity with the display.

After completing the second display pass, MOX departed the display area bound for a return to Jandakot Airport, followed by CQA. By the time CQA turned to return for the third pass, it was well inside Melville Water. On approving the third pass, the Ringmaster did not offer any direction regarding its conduct and the pilot elected to track directly back to Perth Water. The return to the display area was conducted at low altitude over the built-up area of The Narrows and moored water craft, which was a deviation from the display approval.

Although not observed by the Ringmaster, the assistant assessed that CQA may have passed over boats below the authorised height during the return for a third pass. However, because CQA had then effectively joined the downwind leg of the accepted orbits over Perth Water, no immediate action was considered necessary.

Left orbits in the Mallard within the confines of Perth water were possible while adhering to the display conditions. However, the requirement to remain clear of the spectators, including water craft, meant that the area was relatively confined. As a result, manoeuvring within the display area, as opposed to entering it in the prescribed manner around the city, required turns at higher bank angles and lower altitudes, which reduced the margin for error. Had CQA re-entered the display area using the standard procedure, the manoeuvres required to position for the pass would have been relatively benign and significantly reduced the risk of mishandling the aircraft.

Pilot decision making

Nature of decision-based errors and motivational factors

In considering whether the pilot's actions in returning for the third pass were reasonable to him at the time, it is useful to consider the nature of decision-based human error. One such example, knowledge-based mistakes, are defined as 'errors brought about by a faulty plan or intention'. They arise in novel situations with 'resource limitation (bounded rationality) and incomplete or incorrect knowledge' (Reason, 1990) and likely arise from a lack of appreciation of potential consequences (Harris, 2011). Knowledge-based mistakes can be significantly influenced by certain 'performance shaping factors' (O'Hare, 2006). These can be external factors, such as environmental conditions, equipment design and procedures, or internal factors, such as a pilots' emotional state, physical condition, stress, experience, and task knowledge.

As discussed, the pilot was not well-prepared for the planned display. Additionally, although the pilot attended the pre-display briefing and had access to the display procedures, CQA had likely only ever planned to follow MOX and therefore it is possible that the pilot placed less emphasis on familiarisation with the complete display conditions and procedures. These factors may have contributed to a level of unfamiliarity with the task that resulted in the pilot flying the display with an incomplete or incorrect knowledge and/or appreciation of the potential consequences.

As part of the investigation, the ATSB also considered the motivational effects of being part of event such as an air display. The pilot was reportedly enthusiastic about being involved and was known to enjoy displaying what was a unique and interesting aircraft. While it is difficult to quantify the effect of the pilot's emotional state in this occurrence, these elements have the potential to influence pilot behaviours, which is reflected by the inclusion of display pilot attitudinal assessments in other jurisdictions.

Handling human factors considerations in air displays: other countries

The human factors considerations of air displays is a topic that has gained more traction in recent years. As part of the Civil Aviation Authority United Kingdom (CAA UK) response to the Shoreham accident findings (one of which required them to undertake a study of error paths that lead to flying display accidents), a workshop called Human Factors in Flying Displays was held in 2017, and attended by about 35 DOs and pilots. One of the topics of discussion was the 'personal qualities and characteristics of display pilots' and the DOs. Boundaries between 'confidence and

arrogance' were discussed, and the importance of promoting learnings and good practices among display pilots.

Additionally, the CAA UK-commissioned study authored by Butler and others (2018) raised some considerations for the future, finding that:

> the processes related to the assurance of the competence of air display pilots was a recurring contributory factor highlighted in accident reports. These included training, supervision, practical experience and assessment.

They included a recommendation in their report for display pilots to undertake human factors training, provided by the CAA UK to 'ensure there is an exchange of expertise across the display community'.

Other States have recognised the need to improve air display pilots' overall proficiency. For example, the Federal Aviation Administration (FAA), United States, established the Aerobatic Competency Evaluation (ACE) program where pilots must obtain a Statement of Aerobatic Competency (SAC) card prior to conducting aerobatics, or other defined manoeuvres. The FAA delegated the ACE program to the International Council of Air Shows (ICAS), subject matter experts.[26] ICAS published the *Air Show Performers Safety Manual* to 'help establish an understanding of the risk factors attendant to air show performances'.

Summary

While the precise reasons for the pilot's actions will remain unknown, there were several factors that may have influenced the pilot's decision making, and which reinforce the importance of planning and practicing for displays. A safety message was highlighted in the CAA UK's guide for display pilots, which emphasised:

> Never be tempted to make unrehearsed changes to your display routine and do not undertake any manoeuvres you have not practiced….Stick to your planned routine but always be prepared, particularly at hot and high displays, for reduced aircraft performance…Never press on into a manoeuvre with less than ideal start conditions.

Carriage of a passenger during the display

Participation in an air display is a specialised aviation activity that frequently involves flying the aircraft in a non-standard manner and in unique locations. As such, there is an increased risk associated with this type of flying and for this reason passengers are not permitted to take part.

This requirement was clearly stated in the conditions of the display. The pilot had also received the display briefing the night before, reinforcing this condition. Additionally, the pilot had previously been informed by staff from the Civil Aviation Safety Authority (CASA) that the person carried was a passenger and was not considered as crew for the purpose of an air display. Despite this, he carried this passenger during the Perth display, which increased the severity of the accident outcome.

Regulatory framework for approval and oversight

According to the International Standards ISO 31000:2018 *Risk management – Guidelines* and a review of the UK CAA's approach towards air displays, good governance in this context comes from activities such as:

- having processes and procedures for the industry and the regulator to work by
- clearly delineating and providing guidance in the roles and responsibilities of organisers and pilots

[26] ICAS information can be accessed via www.airshows.aero

- monitoring safety performance of those involved in the planning and preparation of the air display including ensuring that regulator staff are adequately prepared.

The regulator's responsibilities are met by ensuring there are the right 'people, processes and systems to manage day to day [air display] activities and reporting' (Helios, 2018).

With respect to air displays in Australia, although certain regulatory processes did exist, CASA did not have an effective framework to consistently approve and oversight air displays. This was predominantly due to the following factors, which increased the likelihood that key safety risks associated with the conduct of the air display would not be adequately managed. It could not be determined whether the regulatory framework in place at the time of the accident contributed to it.

Air display approval guidance

The CASA-published manual, *Air Displays: Safety and Administrative* Arrangements (air display manual) to provide 'guidance on the minimum safety and administrative procedures necessary to run such an event'. However, there was no comprehensive guidance for the assessment of an air display application or oversight of the event, including the expected standard for certain criteria.

While those assessing the applications had shared their methodology and local knowledge within their office, this information was not readily accessible to all offices. As regional offices sought to independently ensure completeness and standardisation of their assessment processes, they developed local procedures, forms and checklists. Variability in assessment and approval practices increases the likelihood of applying an inconsistent process or standard to the task, increasing the risk that key safety aspects may be overlooked.

In contrast, both the FAA and CAA UK published documents that provided their staff with specific guidance and processes for assessing and approving an air display, which in turn provides some assurance of standardisation.

Roles and responsibilities

Air displays require careful management and coordination. The scale and complexity may differ, but any lack of clarity around key roles will affect how well they are managed. The roles of the display organiser (DO) and display coordinator (DC) are vital to the planning and safe operation of each air display. For this display, the roles were not clearly or consistently defined and there were differences in the understanding of who held those roles, exactly what their responsibilities were or the standard those responsibilities were expected to be carried out. This meant that key, safety-related elements of the air display planning and oversight were more likely to be overlooked.

These points indicated that CASA's processes were not effective in ensuring that key personnel were fully aware of their responsibilities or that they were suitably equipped to carry them out to the expected standard. By comparison, the CAA UK, FAA and CAA NZ have all established accreditation programs for persons taking on the role of the DO or DC (or equivalent roles). While the accreditation process varies between countries, the concept is similar. In addition to requiring knowledge of the regulations and role responsibilities, the candidates are individually assessed for suitability including behavioural and attitudinal fitness for the role. Essentially, the accreditation program is designed to provide organisers, and in some cases participants, with the knowledge and skills to effectively and safely plan and coordinate and/or participate in an air display. As such, it provides necessary assurance to regulators that the roles will be carried out with consistency and to the expected standard.

Identification and treatment of risk

The risk management process is designed to be an 'integral part of management and decision making' (ISO, 2018) for an event such as an air display. If organisers and regulators take the opportunity to systematically identify, assess and treat risks, it is possible to reduce the impact of hazards on the safety of the event. The application of the risk management process will not, in all

likelihood, capture every possible risk, but the process can trigger identification and validation of those that are foreseeable, and prioritise their treatment. In particular, it increases the chances that changes, such as the late inclusion of an unfamiliar pilot in the air display, can be considered in terms of the potential introduced risk.

The air display manual current at the time of the accident was the main reference for organisers however, it did not include a requirement for any risk management activities to be done. It was therefore less likely that CASA staff (unless requiring a risk assessment as part of their local procedures) involved in the approval and oversight of air displays were in a position to review organisers' perceptions of operational risks, or apply systematic methods of risk management.

In this case, CASA identified a number of safety-related risks, such as the pilot not having the appropriate endorsement on the Mallard and the benefit in having the DC on board CQA to mitigate against the pilot's inexperience. However, these were not identified through any systematic means, and the treatment measures were sometimes not implemented (for example, the DC was not on board CQA for the display), or had other unintended consequences (authorising the pilot's participation two days out from the display significantly limited his available time to prepare and practice). These examples, plus the absence of any documented processes or any requirements for the staff organising air displays to use systematic risk management methods, reduced the chances that identified risks were going to be treated adequately and controls implemented.

It is noted that CASA has revised the air display manual since this accident to include a requirement for a formal risk assessment to be completed by DOs, which reflects the best-practice approach to identifying and controlling display risks (see the section titled *Safety issues and actions*). However, using a risk-based approach for the assessment and approval process itself would probably provide additional safety benefit.

Findings

From the evidence available, the following findings are made regarding the loss of control and collision with water involving the G-73 Mallard aircraft, registered VH-CQA 10 km west-south-west of Perth Airport, Western Australia on 26 January 2017. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

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

Contributing factors

- The pilot returned the aircraft to the display area for a third pass in a manner contrary to the approved inbound procedure and which required the use of increased manoeuvring within a confined area to establish the aircraft on the display path.
- During the final positioning turn for the third pass, the aircraft aerodynamically stalled at an unrecoverable height.
- The pilot's decision to carry a passenger on a flight during the air display was contrary to the Instrument of Approval issued by the Civil Aviation Safety Authority for this air display and increased the severity of the accident consequence.

Other factors that increased risk

- **The Civil Aviation Safety Authority (CASA) did not have an effective framework to approve and oversight air displays, predominantly due to the following factors:**
    - **While the Air Display Manual provided guidance to organisers conducting an air display, it did not inherently provide the processes and tools needed for CASA to approve and oversee one and no other documented guidance existed.**
    - **Unlike the accreditation models adopted by some other countries, CASA did not have a systematic approach for assessing the suitability of those responsible for organising, coordinating and participating in air displays.**
    - **CASA did not have a structured process to ensure that risks were both identified and adequately treated.**

  The combination of these factors significantly increased the likelihood that safety risks associated with the conduct of the air display were not adequately managed. [Safety issue]

Safety issues and actions

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

Depending on the level of risk of the safety issue, the extent of corrective action taken by the relevant organisation, or the desirability of directing a broad safety message to the aviation industry, the ATSB may issue safety recommendations or safety advisory notices 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 information comes to hand.

Air display approval and oversight

Safety issue number:	AO-2017-013-SI-01
Safety issue owner:	Civil Aviation Safety Authority
Operation affected:	Air displays
Who it affects:	Organisers and participants in air displays

Safety issue description

The Civil Aviation Safety Authority (CASA) did not have an effective framework to approve and oversight air displays, predominantly due to the following factors:

- While the Air Display Manual provided guidance to organisers conducting an air display, it did not inherently provide the processes and tools needed for CASA to approve and oversee one and no other documented guidance existed.
- Unlike the accreditation models adopted by some other countries, CASA did not have a systematic approach for assessing the suitability of those responsible for organising, coordinating and participating in air displays.
- CASA did not have a structured process to ensure that risks were both identified and adequately treated.

The combination of these factors significantly increased the likelihood that safety risks associated with the conduct of the air display were not adequately managed.

Proactive safety action

Action taken by:	Civil Aviation Safety Authority
Action date:	September 2017/April 2018
Action type:	Proactive safety action
Action status:	Released

Safety action taken:

At the time of the occurrence, the Civil Aviation Safety Authority (CASA) had a revised air display guidance manual in draft. This was subsequently published in September 2017 as the *Air Display Administration and Procedure Manual*. Version 3.0 of this manual was published in April 2018. Pro-active safety actions arising from the new publication included:

- the requirement to conduct a risk assessment as part of the air display planning
- the requirement for the display organiser and display coordinator to document their relevant qualifications and associated display experience, to allow CASA to assess their suitability for the role
- further clarification of roles and responsibilities, and display organisational expectations
- enhanced forms for display pilots and additional crew, to assist the display coordinator in their assessment of the pilot and display, and to ensure all persons on board are identified and authorised.

ATSB response:

The ATSB acknowledges the improvements to the Civil Aviation Safety Authority's *Air Display Administration and Procedure Manual*, and associated forms. While these changes improve existing guidance and partially address the safety issue, The ATSB considers that further improvements can be made to provide additional assurance of the suitability of key personnel, and to provide enhanced guidance and tools around the approval and oversight of air displays. Accordingly, the ATSB issues the following recommendation.

ATSB safety recommendation to the Civil Aviation Safety Authority

Action number: AO-2017-013-SR-029

Action status: Released

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority undertake further work to enhance their tools and guidance for air display approval and oversight, and procedures to ensure the suitability of those responsible for organising, coordinating and participating in air displays.

Status of the safety issue

Issue status: Safety action pending

General details

Occurrence details

Date and time:	26 January 2017 - 1708 WST	
Occurrence category:	Accident	
Primary occurrence type:	Loss of control	
Location:	10 km west-south-west of Perth Airport, Western Australia	
	Latitude: 31° 58.07' S	Longitude: 115° 51.92' E

Pilot details

Licence details:	Private Pilot (Aeroplane) Licence, issued July 1997
Endorsements:	manual propeller pitch control; retractable undercarriage; floating hull; single- and multi-engine aeroplanes less than 5,700 kg maximum take-off weight
Ratings:	G73 (SP)
Medical certificate:	Class 2, valid to October 2013
Aeronautical experience:	625 hours
Last flight review:	April 2016

Aircraft details

Manufacturer and model:	Grumman American Aviation Corp G-73	
Year of manufacture:	1948	
Registration:	VH-CQA	
Operator:	Private	
Serial number:	J-35	
Total Time In Service	7,336.2 hours	
Type of operation:	Experimental Certificate - Exhibition	
Persons on board:	Crew – 1	Passengers – 1
Injuries:	Crew – Fatal	Passengers – Fatal
Damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Civil Aviation Safety Authority
- Air Accidents Investigation Branch and Civil Aviation Authority, United Kingdom
- National Transport Safety Board and Federal Aviation Administration, United States
- National Transport Safety Committee, Indonesia
- Civil Aviation Authority, New Zealand
- International Council of Airshows
- Perth Air Display organisers, participants and witnesses
- City of Perth
- G-73 and other float plane pilots
- Bureau of Meteorology
- Airservices Australia

References

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Boud and McFarlane, 2018 *Review of UK civil flying display and special event governance*, Hampshire, United Kingdom

Butler and others, 2018, *Human Factors in Air Displays: Transfer of Behaviours and Error Path Study*, Health and Safety Laboratory.

CAA NZ, Advisory Circular (AC) 91-1 *Aviation Events*, Civil Aviation Authority New Zealand

CAA UK, Civil Aviation Publication (CAP) 403 *Flying Display and Special Events: A Guide to Safety and Administrative Arrangements,* Civil Aviation Authority United Kingdom

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Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the ATSB may provide a draft report, on a confidential basis, to any person

whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Civil Aviation Safety Authority, the City of Perth, the display coordinator, the ringmaster, the ringmaster's assistant, the pilot of VH-MOX, the National Transportation Safety Board, the Federal Aviation Administration, the International Council of Airshows, the Civil Aviation Authority United Kingdom and the Air Accidents Investigation Board.

Submissions were received from Civil Aviation Safety Authority, the City of Perth, the display coordinator, the ringmaster, and the pilot of VH-MOX. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

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

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

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

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

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

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

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

Terminology used in this report

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing factor: a factor that, had it not occurred or existed at the time of an occurrence, then either:

(a) the occurrence would probably not have occurred; or

(b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or

(c) another contributing factor would probably not have occurred or existed.

Other factors that increased risk: a safety factor identified during an occurrence investigation, which did not meet the definition of contributing factor but was still considered to be important to communicate in an investigation report in the interest of improved transport safety.

Other findings: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Loss of control and collision with water involving Grumman American Aviation Corp G-73, VH COA, 10 km WSW of Perth Airport, Western Australia on 26 January 2017

AO-2017-013
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