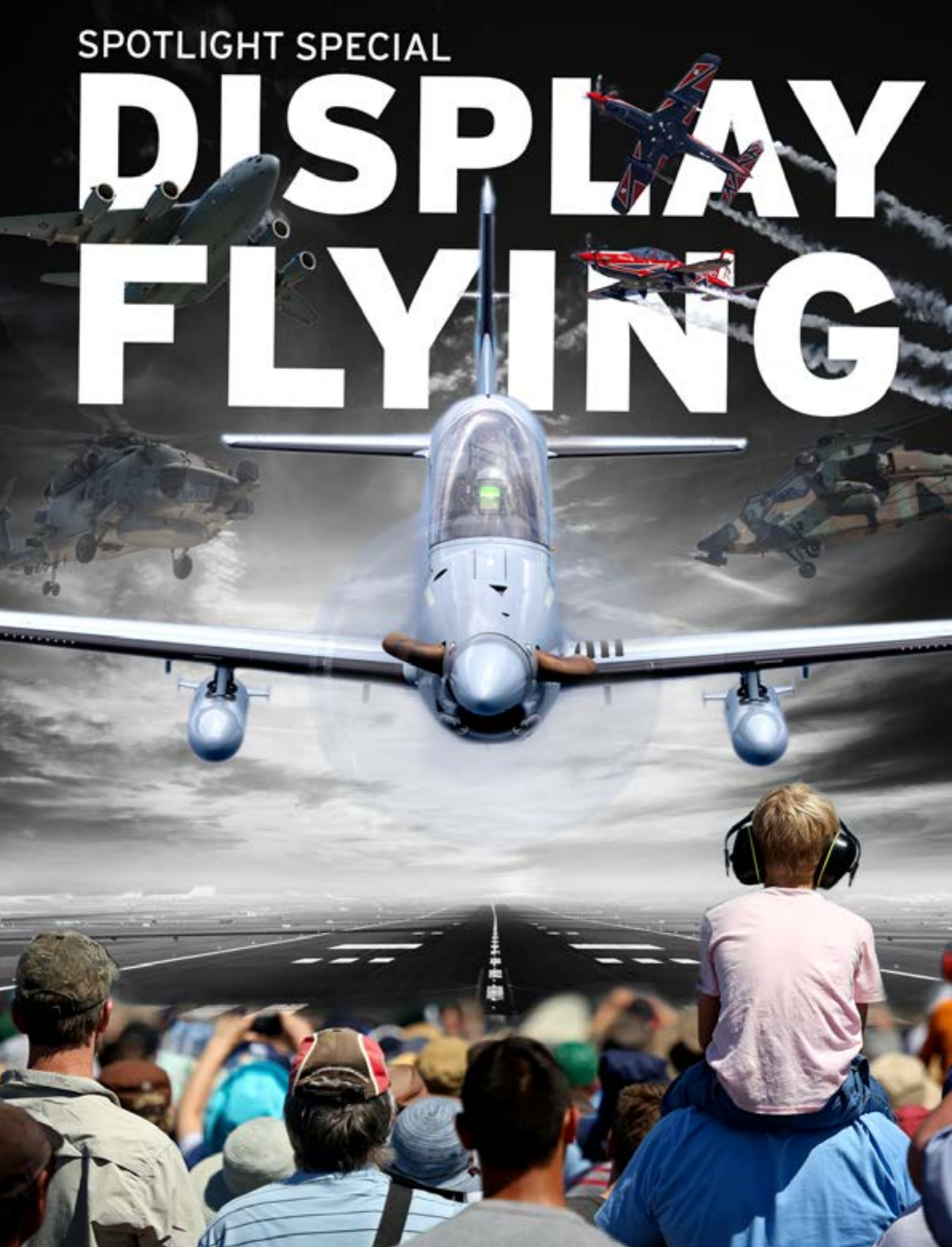
SPOTLIGHT SPECIAL

DISPLAY FLYING



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FOREWORD

WELCOME TO THE 2021 edition of the *Display Flying* Spotlight Special. This publication was last printed in 2007 so it was time for an update, particularly because 2021 is the centenary of the Royal Australian Air Force and there's likely to be more flypast and display activity than we'd usually see during the year. However, this publication isn't just about the displays we might see in the RAAF's centenary year and we have included articles covering all types of aircraft within our ADF inventory — fast jets, formations, big-wing multi-engined aircraft, rotary wing and drones — expanding the intended readership. I'm also very pleased to include perspectives from our experienced Air Traffic Controllers and Airshow 'ringmasters' who have sage advice regarding the planning and execution of large events. There are many ingredients that go into making display flying safe and enjoyable for both the participants, whether they be on-show or behind the scenes, and spectators.

Even though the ADF aviation inventory is modern and contemporary, many of the themes and principles of safe display flying haven't changed over time and therefore a number of case studies within this publication have been 'recycled'. Rest assured, there are many new articles too. The very first article in the publication is about the RAAF's first accident during a flypast in 1927. It's clear that some things have changed but there are still many key lessons that remain relevant to this day from that dreadful accident. You'll be able to apply similar thinking to all the articles you read here that cover many decades of thrilling flying displays but also terrible tragedy. I am of the firm belief that display flying, although with its risks, CAN be done in a way that is both impressive and SAFE, so let's take a little time to read and reflect on the errors of the past.

Within this edition there are also some wise words from experienced aviators who have recorded their own personal connections to the various accidents and incidents covered. I sincerely thank all those who took the time to share their advice, reflections and wisdom when it comes to display flying. I found the enthusiasm and buy-in to this important publication of all involved in its production to be truly humbling. Thank you for your collective passion for aviation safety.

I sincerely hope you learn a lot from this Spotlight Special.

GPCAPT Dennis Tan
Director Defence Flight Safety Bureau

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The RAAF's first mid-air collision

Commemorative Spotlight article by AIRCDRE Mark Lax

THE FOLLOWING ARTICLE is an intriguing study of the RAAF's first mid-air collision. It was featured in the *Flying Safety Spotlight 'Special Commemorative Issue'* of 1996.

"The committee finds that a collision took place between two DH-9 machines belonging to a formation of seven DH-9 machines which formed part of the RAAF aerial escort to Their Royal Highnesses, the Duke and Duchess of York, on their arrival in Melbourne on the 21st April, 1927..."

So begins the Air Accidents Investigation Committee final report into the RAAF's first mid-air collision.

In 1927, this rather tragic accident occurred over Melbourne, the RAAF's ninth fatal since the Service had formed in 1921. The two aircraft, in a seven-ship formation flypast to salute the visiting Duke of York collided, causing the deaths of four airmen and eventually, an independent inquiry into the whole of the RAAF. The accident, 69 years past [now 94 years], still offers many lessons for today.

The aircraft

The RAAF in 1927 was a very small force, both in terms of manpower and aircraft, operating several obsolete types that had been part of an Imperial Gift to the Dominions for service in the Great War. A collection of 128 SE-5As, DH-9s and DH-9As were originally provided to Australia but, because of lack of funds, squadrons did not form until mid-1925[1]. By 1927, many of the original aircraft were unserviceable and squadrons were reduced to making do. The RAAF was not in good shape.

This particular flypast formation consisted of seven DH-9 aircraft. The DH-9 first flew in 1917 as a replacement for the Royal Flying Corps' most successful DH-4 general purpose bomber aircraft.

The DH-9s were essentially two-seat bomber and general-purpose aircraft. Powered by a 230 hp Siddeley Puma engine, they had a top speed of about 112 mph at 10,000 ft, a rated ceiling of about 15,500 ft and an endurance of about 4.5 hrs.

At 30.5 ft long and a wingspan of 42.5 ft, they were relatively small by today's aircraft standards, indeed shorter than a PC-9. They were also primitive.

Problems with serviceability and safety of the WWI-vintage aircraft meant that little in the way of effective training or operations could be achieved. According to PLTOFF Wilfred Brookes[2], squadron pilot at the time:

"The performance of these DH-9s and DH-9As on long-distance flights of some 200 to 300 or more miles would end when a couple of them would have to make forced landings for one reason or another."

Reliability, particularly of engines, was not good. Other squadron members reported wood rot in some spars and fabric decay due to the wet and damp Melbourne weather. Nevertheless, they were all that was available and all were reported serviceable for the flypast.

The parade

The formation in question was one of several tasked to welcome the Royal couple. In all, 30 aircraft would take to the skies and just about every pilot in the RAAF would be needed. As such, some who flew that day were holding down ground jobs, but the accident did not involve any of these gentlemen.

The flypast was to consist of seven aircraft flying in 'V' formation. At the appointed time and place, the lead aircraft would enter a steep dive from 1000 ft in salute to their Royal Highnesses, then pull up on reaching 500 ft AGL to continue normal flight and return to Point Cook.

The formation had practised twice before the appointed time and date for the flypast. Perhaps surprisingly, some pilots who flew in the final salute had not been involved in the practice days, and others had flown in different positions to those in which they practised. After a short briefing, it was usual for the aircraft to take-off in position; so essentially, the formation remained in position throughout the entire flight.

On the day of the incident the formation was numbered and crewed as illustrated in Figure 1.

Each aircraft had a passenger in the rear seat, no doubt a treat for such an important occasion. The passenger of the sixth aircraft, Sergeant Hay, was a photographer who had been put on the flight at the last moment to capture the spectacle on film. The photographs he took, if any, were never developed.

The accident

The aircraft had been flying for about 2.5 hrs before the salute, a long time to hold formation even at about 90 kts. The Royal procession moved up St Kilda Road from Station Pier at 2.15 pm, past the Melbourne Town Hall at 3.20 pm and then back towards Government House to be there by 4.00 pm.

At the appointed time, the flypast turned down St Kilda Road towards Government House. All went well up to this point, but witnesses stated that one aircraft (No. 6), was lagging. Unawares, FLTLT Jones, the formation leader, started his dive followed shortly afterwards by the rest of the formation. At the bottom of the dive, as each aircraft put on power to climb away, No. 6 came up underneath No. 4, collided, and both aircraft subsequently plummeted to the ground.

Witnesses to the mid-air stated that No. 6's propeller severed the other DH-9's port wing causing that aircraft to immediately fall earthward. It impacted in Dodds Street and both crew were killed instantly. The other DH-9; however, appeared to stall, then entered a flat spin, burst into flames and fell through the roof of the Postmaster-General's garage. Both crew also died and the aircraft and garage were destroyed. Fortunately, no one on the ground was injured.

As could be imagined, a huge crowd quickly gathered at the crash scene and police had to use reinforcements and mounted patrols to keep eager onlookers away. A RAAF crash and salvage party arrived some time afterwards and GPCAPT Williams, the Chief of Air Staff (CAS), announced an immediate investigation. Condolences were received from Their Highnesses, the Governor Lord Stonehaven, State and Federal politicians, and many others.

The casualties

The five surviving aircraft and their crews did not play much part in the accident. Some were later called as witnesses. Those involved in the collision; however, deserve further examination. The casualties were flying in No. 4 slot (FLTLT Rob Dines), and No. 6 (FLGOFF Vince Thornton).

Dines had logged 346 flying hours and had served in the RFC and RAF as a pilot in the last year of WWI. A skilled pilot, on joining No. 1 Squadron in November 1924 he was appointed the 'A' Flight Commander within 14 months. Sadly, his promotion to Flight Lieutenant came through one week after the crash.

Thornton, on the other hand, had logged just 68 hrs in the Citizen's Air Force, although he also had war experience. Initially a light horseman then air mechanic, he graduated from pilot's course in August 1918, just as the war was finishing. His active service was with No. 4 Squadron AFC in France. He joined the CAF in June 1925 and became a 'weekend warrior' for his subsequent RAAF service. Perhaps prophetically, he had earlier in his flying career collided his DH-9 with another machine on landing at Essendon, although on that occasion, injuries were only slight.

The passengers were both airmen from No. 1 Squadron; Sergeant Bert Hay (Photographer) and CPL James Ramsden (Carpenter Rigger). Both had joined the Squadron the day it re-formed in July 1925 and both had war experience. Hay had also been a member of the Australian Air Corps, the RAAF's immediate predecessor. Ramsden was the only single man of the four.

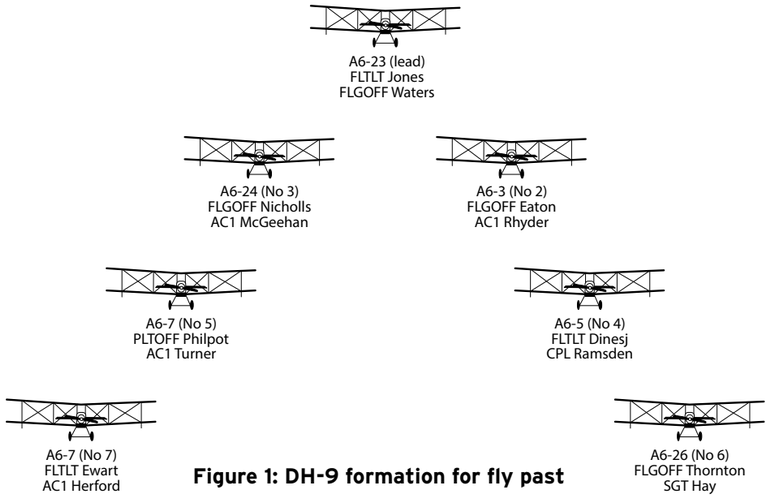


Figure 1: DH-9 formation for fly past

Growing concern over crashes

By the time he left Australia, the Duke must have thought he had been cursed as other crashes followed. Two weeks after the Melbourne accident he witnessed another fatal crash this time at the opening of the Parliament building in Canberra. FLGOFF Francis Ewen's SE-5A inexplicably peeled-off formation, stalled and crashed 600 metres from the House and the assembled crowd. Ewen was pulled from the wreckage, but died several hours later without recounting what happened.

The photographs taken at the opening of Parliament were to be flown to Melbourne in another SE-5A piloted by SGT Orme Denny. The plan was to present an album to the Duke before his departure. However, Denny's engine seized over Mount Buffalo and he crashed and wrote-off the aircraft, but fortunately not himself. For safekeeping, he hid the photographs in a tree stump near the wreckage, but although several searches were conducted around the site and the aircraft recovered, the whereabouts of the photographs remain a mystery.

In both political and defence circles, there had been a growing concern about the number of RAAF fatal crashes. The year prior, 1926, was particularly bad with five fatal accidents causing the deaths of seven airmen – 1927 was not much better. (The accident statistics of 1921-1927 are listed at Figure 2.)

Year	Fatal Accident	Fatalities	Injured
1921	1	1	1
1922	–	–	–
1923	–	–	–
1924	–	–	–
1925	1	1	1
1926	5	7	–
1927	4	7	–

Figure 2: RAAF fatal accidents 1921-1927

To make matters worse, aircraft crashes made sensational newspaper headlines, with journalists often arriving at the crash scene before investigators and police. Such events were clearly in the public eye and sold newspapers, so it was only a matter of time before the whole matter was raised in Federal Parliament.

The Inquiries

As to be expected, a coronial inquest, RAAF Accident Investigation Board and an Air Accidents Investigation Committee (AAIC) inquiry were all convened, the findings of the latter two being preserved at the Australian Archives in Melbourne.

Not surprisingly, these very public incidents were raised in Parliament with the Minister for Defence, the Hon. Sir William Glasgow, calling for a departmental inquiry into "every aspect of the Royal Australian Air Force". A week later, at the behest of the Prime Minister, the Hon. Stanley Bruce, the AAIC was established to inquire into all such mishaps[3]. The RAAF Accident Investigation Board consisted of a President - FLTLT Ivor McIntyre of No. 1FTS, and two members, FLTLT Arthur 'Spud' Murphy of No. 1AD and FLGOFF Leon Lachal, a junior pilot with No. 1 Squadron. They called seven witnesses and presented their findings to the Air Board shortly afterwards. The report; however, was not well received. It was poorly constructed, poorly researched and the findings were totally inconclusive. As CAS, GPCAPT Williams sent it back for further work but the need for re-examination soon became nugatory with the convening of the AAIC.

The AAIC investigation was to be a totally fresh and separate review. It was much more thorough and retained some measure of independence from the RAAF. The AAIC consisted of a Chairman, Professor Henry Payne, and five members; Mr Marcus Bell, LTCOL H. Gipps, SQNLDR Eric Harrison, CAPT Ernest Jones and FLTLT Bill Palstra (who also acted as Secretary).[4] They met nine times between early June and early July, and interviewed 20 witnesses before presenting their findings to the Minister in mid July.

As witnesses were called to give their evidence, a mixed impression of what actually happened emerged. WGCDR Cole, the CO of No. 1FTS who was inside Government House and watching at the time, stated that: "[Thornton] was not paying sufficient attention in keeping station...immediately on impact occurring splinters flew clear of the machines, and the machines themselves became locked together and were more or less stationary as far as height was concerned for an appreciable moment.

"Then the machines fell away almost vertically and disappeared out of sight below the trees of Government House grounds. The other machine descended comparatively slowly in what is known as a flat spin, until it also disappeared below the trees."

While most of the pilots and crew were either keeping station or watching the crowd, AC1 McGeehan (passenger in No. 3 aircraft) saw the collision. He recalled: "I saw the machine piloted by FLGOFF Thornton (No. 6) rise and strike the tail of No. 4. Next I saw them both flying towards the ground."

McGeehan looked away as he did not want to see the impact. Other airmen gave similar accounts. But witnesses on the ground, generally members of the public, provided other twists. Mrs Rogers who described herself to the AAIC as 'a married woman from Armadale' stated:

"... the one that came up under the other one seemed to be late. He came down over my head and as he got close to the first he rose and hit that first and it went up in smoke – smoke or flames. I turned my back as I was too moved, and did not look any more."

Some witnesses stated No. 4 hit No. 6 and yet others, that No. 6 just came in at high speed from the rear. The dilemma for the committee was to decide what actually happened. Although the rules stated that it was No. 6 who should avoid No. 4 and the minimum separation permitted was about 60 ft, possible causes were:

- No. 6 was lagging, put on power and just ran into No 4;
- No. 6 was lagging, put on power and did not observe the formation dive in salute, thus No. 4 flew down and hit No. 6 who was travelling faster;
- No. 6 was moving position to allow his photographer better angles to photograph the parade. In trying to regain position, he did not see the formation dive nor adjust his speed and thus hit No. 4; or
- there was some other (unaccounted) contributing factor.

The outcome

The findings of the initial investigation that is, the RAAF Board of Inquiry, were inconclusive, for example: "The collision was due to the rear machine getting out of station by getting below and overtaking the machine ahead of it and then climbing."

The report went on to state: "... as there are many circumstances beyond his control which might contribute to the temporary

distraction of a pilot's attention while flying in formation. The Court is of the opinion that there is no evidence of negligence."

The suggestion (although not stated) was that Thornton had been distracted by his photographer wanting to get into a better position to take photographs. GPCAPT Williams was shrewd enough to realise that such a finding would not placate grieving widows, the press or Parliament, so he returned it for further review. Meanwhile, the AAIC had been appointed and effectively subsumed the BOI's duties. Brought into being on 26 May 1927 under the *Air Navigation Act*, the AAIC immediately set about its task and brought down its findings on 13 July 1927. The summarised findings were:

- that machines A6-5 and A6-26 were thoroughly airworthy prior to flight;
- there was no evidence of any subsequent defect developing during flight;
- there was no evidence that the crew were anything but medically fit;
- the collision was due to an error of judgment on the part of the pilot of machine A6-26 (No. 6) with regard to his position relative to that of machine A6-5 (No. 4); regulations governing saluting by aircraft had not been specifically laid down; and
- in view of the difficult nature of the salute, the formation had not practised together sufficiently.

More specifically, Thornton had worn the blame but many other issues were also raised. Parachutes, which incidentally were available but disliked by aircrew as uncomfortable, became mandatory in RAAF aircraft from this time onwards and no doubt many lives were saved as a result. Standard operating procedures were reviewed as were formation and practise procedures and, within a year, the RAAF had on order three new aircraft types to replace the obsolete Imperial Gift aircraft.

Nevertheless, the final outcome of the RAAF's poor safety record was the Government's appointment of an RAF officer, Air Chief Marshal Sir John Salmond to inspect, review and audit the RAAF in 1928. Salmond's subsequent report led to changes in the Air Force's command, structure and disposition – but that is another story.

Today, of course, much more stringent safety and flying procedures are in-place for the conduct of formation flypasts. Rules governing practice sessions, proximity of aircraft, altitude over built-up areas and recovery action are all in place. All members involved in these activities are required to be familiar with and strictly adhere to them.

Postscript

Subsequent to the various inquiries, it surfaced in RAAF circles that several of the pilots who flew in the aerial salute on 21 April had been drinking in the Mess the lunchtime prior to take-off. According to PLTOFF Brookes[5]: "Dines was a teetotaller, but Thornton in my opinion had had a good deal to drink. I had a few glasses myself, but not as many as Thornton. It was, of course, Thornton who flew into Dines."[6]

The extent of the drinking and the subsequent effect of alcohol on the pilots' reactions cannot be quantified. Why such information was not presented to any of the three inquiries will never be known, but at least today blood samples are always taken as part of any accident investigation.

References

1. Although No. 1FTS had been formed in 1921, the RAAF's two operational squadrons were not formed as flying units until July 1925.

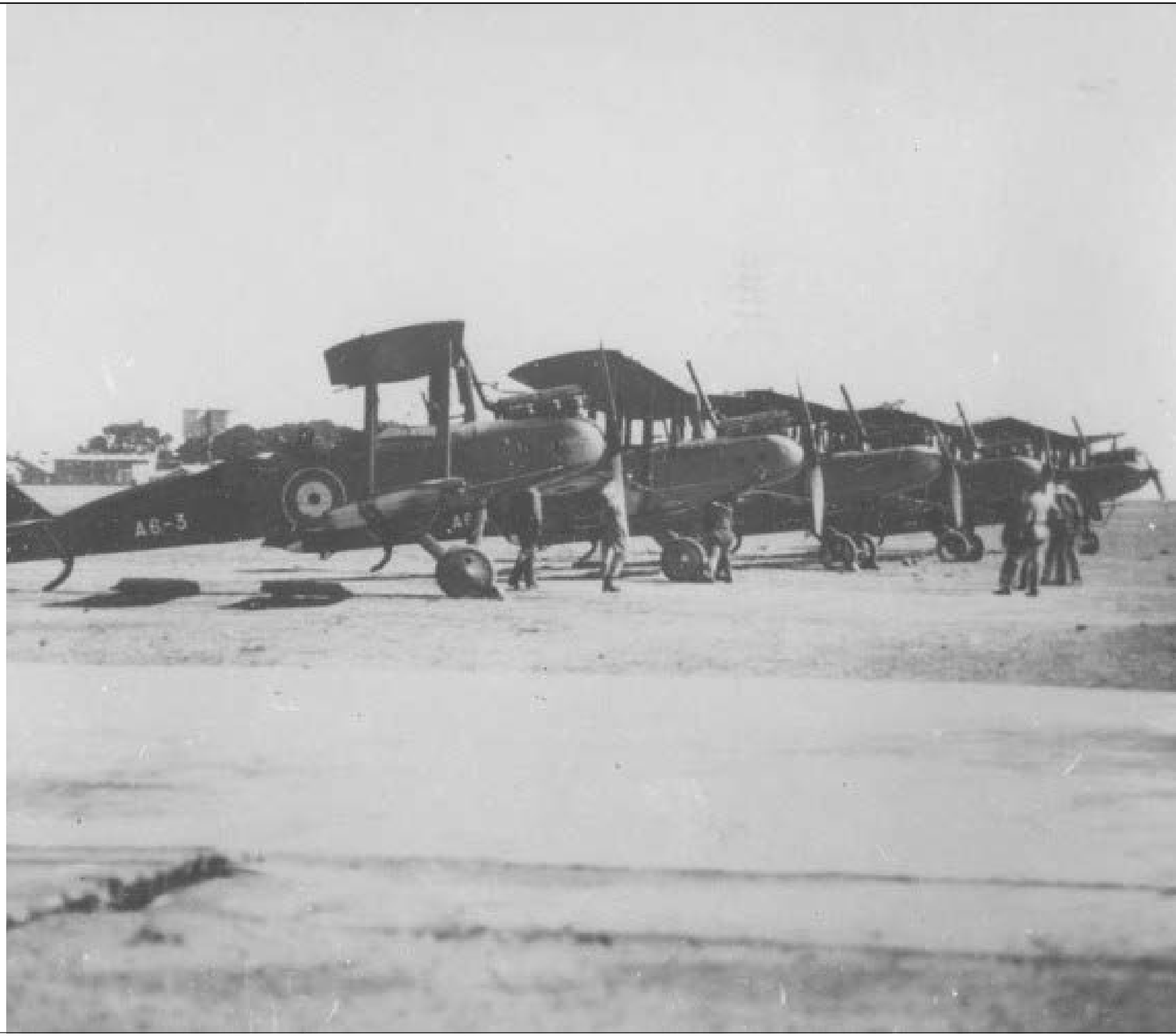
2. Sir Wilfred Brookes – personal correspondence and interview with author.

3. According to Glasgow, "The primary functions [of the AAIC are to investigate each accident with a view to determining its cause and, at the same time, to recommend what action it considers should be taken to prevent recurrence". CPD (Senate), Vol 117, 6 Dec 27, pp 2602-3.

4. Professor Payne was from Melbourne University, Mr Bell was superintendent of the Defence Laboratories, LTCOL Gipps was the Chief Inspector of the Munitions Supply Board and Captain Jones was from the Civil Aviation Branch. Harrison was the RAAF's Assistant Director of Technical Services and Palstra represented the interests of the Air Board.

5. Sir Wilfred Brookes – personal correspondence and interview with author.

6. *The Third Brother*, p 322.



Behind the magic of AIR SHOWS

Air Show Team carefully manages flying displays to ensure safety

By Rebecca Codey

FOR THE AVIATION enthusiast, there is nothing quite like the buzz of an air show. The sights, the sounds and the smells combining to create a palpable excitement shared by air show-goers of all ages; many who know little about the aircraft, but are awed regardless.

While eyes are trained on the spectacular choreography overhead, or attention focused on the static displays on the ground, the men and women of Air Force's Air Show Team (AST) – the driving force behind the air show – are quietly proud.

Team effort

The AST oversees every aspect of staging an air show, from the air display itself, to the logistics of event management and importantly, the finance, governance and compliance that underpins it all, according to AST Head of Air Shows, AIRCDRE Noddy Sawade.

The team has been planning and delivering air shows since the early 2000s and was officially established as part of AFHQ Chief of Staff Branch in 2015. It boasts a comprehensive list of air shows and air displays on its resume, having contributed to Defence's input into the Avalon Airshow flying display and run the Exercise Pitch Black Open Day over alternating years.

Major Air Force air shows at Point Cook (2014), Townsville (2016) and Edinburgh (2019) have also impressed onlookers, along with many smaller-scale air shows and air displays at Defence and community events around the country. The team has been working hard to prepare for the RAAF's 100th birthday celebrations this year.

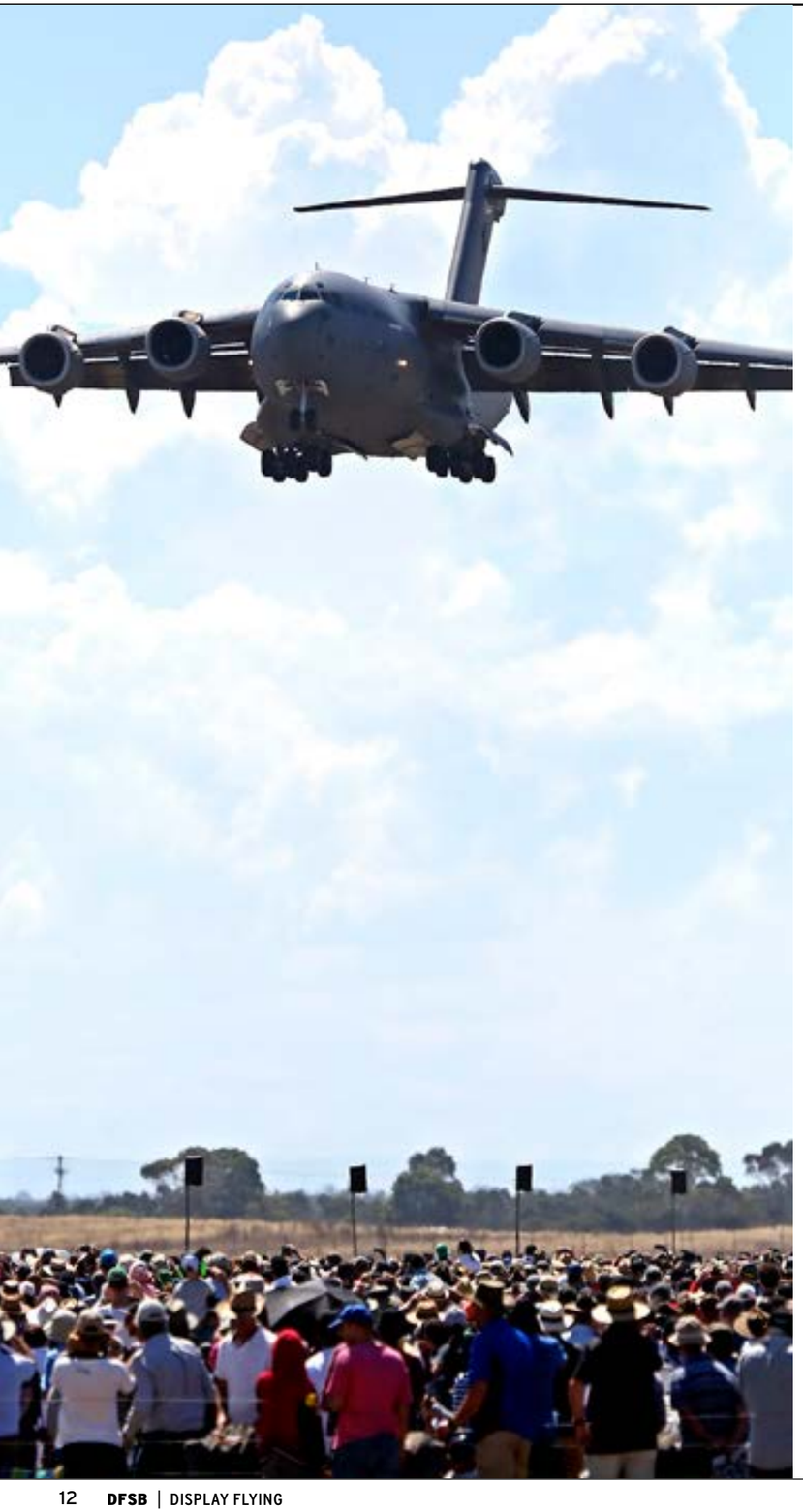
AIRCDRE Sawade says having a dedicated team to manage air shows and major air displays centralises Air Force's contribution, which is not only better in terms of safety and consistency of messaging, but takes the pressure off units and bases.

"The AST is a trusted brand – we've made a big effort over more than six years to be visibly compliant and inclusive and certainly from the perspective of the bases where we hold the shows, there is no mystery about what we do. It is also important when staging the big shows that we minimise disruption to the bases and communities."

AST Director Air Operations, GPCAPT Tim Sloane, says the team plays an integral role in Air Force's engagement strategy with the Australian public. "It is a team made up of experienced personnel who have specialist skills that cover all aspects of planning and running a large activity that entertains significant numbers of the public," he says. "The activities are designed to cater for all enthusiasts by demonstrating the capabilities of the Air Force in a family-friendly atmosphere."

Prioritising safety

"Safety is paramount – risk management is applied to all aspects to ensure that the activities (both ground and flying) are low risk, safe and compliant while still providing interesting and enjoyable



displays and other family-orientated activities," GPCAPT Sloane explains.

"We carry out thorough debriefs after each activity where lessons learnt are recorded and actions taken to implement improvements or remove any identified risks. Every member of the team acts as a safety monitor and is empowered to act if there is any doubt about safety, confident that they will be supported in their actions."

"The display needs to be designed for the audience, not for the benefit of the other participants. The majority of spectators don't know how close an aircraft may be operating closely to its limits, so there is no need to fly to them. The spectacle of an aircraft flying low and fast is as interesting to them as some complex, difficult and risky aerobatic manoeuvres. Plan your display carefully, rehearse it, fly it and don't change it at the last minute. Have fun but stay well within the limits."

Nothing too big or small

The AST consists of 15 reservists posted into established positions. This number doubles in the lead up to and during events and all members are reservists with a vast array of skills and experience. As mentioned earlier, AST members manage every imaginable aspect of an air show from the big, overarching aspects of planning and contracts to traffic management and toilet facilities. "It's a big job," AIRCDRE Sawade says. "We have embedded processes but a huge show will still take a couple of years to put together."

He says the AST does not tell the operators what they have to do. "We leave that to the Air Command system – the normal authorisation approval, training, work-up system is a unit responsibility through the chain of command. What we do is take all of those individual components from the various operators and piece them together, creating a time-on-target display that allows fairly continuous overhead of aircraft."

Civil and military side-by-side

Another component of the AST's responsibilities is to manage air shows and larger air displays in conjunction with civil operators. "That is trickier," AIRCDRE Sawade admits. "The military is a known entity – we know that aircraft are going to be sound and the operators qualified, authorised and trained."

"When we are dealing with civil operators, that is not necessarily the case. We are dealing with a significant warbird component. We have our own military aviation regulations under the Air Command system. But for civil operators we have to have knowledge of the CASA regulations and this is a large part of the job for our director of air operations."

Ringmaster leads the way

One of the most important roles in an air show is that of the ringmaster, whose job it is "to deconflict and ensure that the people within the display understand where and how they fit into that display", AIRCDRE Sawade says. "They come with an act, we fit it into a larger show. We put them together so they make sense to the public."

The creation of a Ringmaster/Flying Display Coordinator (FDC) or Supervisor role was among the outcomes of investigations into the tragic Shoreham Air Show crash of 22 August 2015. [See sidebar at right.]

As a result of the fatal accident, UK civil and military aviation airworthiness authorities made significant changes to the way flying displays are managed – and a new flying display director/ringmaster competency program was developed. "CASA watched that very closely of course, and came out with a new manual on flying displays in Australia," AIRCDRE Sawade says. "CASA was not regulating that people had to meet these competencies, but it was heading that way."

"The AST leadership recognised that it had to be proactive. We met with CAF and advised him that we planned to run an air show FDC/ringmaster course based on the UK outcomes and competencies and enlist one of the main practitioners of the UK training, professional air show delivery consultant Dave Walton of TSA Consulting, to deliver it."

The AST supplies Flying Display Supervisors to those events where there's two or more FEGs involved in putting on a flying display, for example Avalon and Wings Over Illawarra. Where only one FEG is involved in a flypast the team doesn't necessarily get involved. Events registered with Air Force Headquarters' public events of significance program, such as Bathurst and Australia Day often involve requests for flypasts.

AIRCDRE Sawade adds: "The Roulettes and RAAF Balloon do what they do. When normal operational aircraft are tasked to do flypasts, we aren't involved if it is only one aircraft. But if it is more involved than that, we provide input through HQAC. We'll take a look and for example, if it's a flypast of two Hawks we generally still won't get involved. But if it's a Hawk, a C-17 and a Navy helicopter all turning up to do a show in the same event we will usually be part of the process and provide a trained ringmaster or flying display coordinator for the event."

If units are tasked to do a flying display or flypast of some sort, AIRCDRE Sawade strongly encourages members to thoroughly understand the job, checking off questions such as: what's being asked, are other units involved, do they need to talk to anyone, who is the tasking authority? He says AST tasking is co-ordinated through AFHQ; however, members can contact the team for advice at any time.

"There is always the chance flying displays can go awry – so it is important to ensure planning and approval processes are such that any risk of something going wrong can be minimised," AIRCDRE Sawade says. "That's our outlook – not on telling pilot what to do, but ensuring that if something does go wrong we have given that operator enough room to minimise any outcomes. Both from a civil and military perspective."

The AST can be contacted via the DPN to: AST Chief of Staff, GPCAPT John Ibbotson – john.ibbotson@defence.gov.au

SHOREHAM AIR SHOW CRASH TRIGGERS REVIEW

Eleven people died when a 1950s Hawker Hunter exploded into a ball of fire upon crashing into traffic on the A27 in West Sussex on 22 August 2015.

The aircraft was taking part in a flying display at Shoreham Airport during which the pilot, Andrew Hill, conducted a manoeuvre with both a vertical and rolling component, at the apex of which it was inverted. Following the subsequent descent, the aircraft did not achieve level flight before it struck the westbound carriageway of the A27.[1]

Mr Hill, a former British Airways pilot and RAF flying instructor, was thrown into a ditch when the aircraft broke up. He suffered spinal and head injuries and was released from hospital a month later.[2]

The 11 men who lost their lives were either travelling along the road at the time or watching the display from the perimeter of the airport.[2]

The crash at Shoreham caused the deaths of people who were not participants in the show, and so had not made any sort of informed decision as to the risks involved. Media at the time commented that most in the aviation industry recognised that should never happen, and because of that there would be at least two separate investigations.[3]

The comprehensive investigations were carried out by the Air Accidents Investigation Branch (AAIB) and the Civil Aviation Authority.[3]

In 2019 following a civil trial, Mr Hill was found not guilty of manslaughter by gross negligence. It was argued he suffered cognitive impairment brought on by hypoxia possibly due to the effects of G-force.[2]

References

1. Air Accidents Investigation Branch AIB AAIB Special Bulletin: S1/2016 G-BXFI EW/C2015/08/04 2; 2016

2. Shoreham Airshow crash pilot acquitted over deaths; *BBC News online*; 8 March 2019; https://www.bbc.com/new/uk-england-47495885

3. Shoreham crash will bring safety changes, but airshows are here to stay; *theconversation.com*; By Guy Gratton; 25 August 2015; https://theconversation.com/shoreham-crash-will-bring-safety-changes-but-airshows-are-here-to-stay-46545

AUSTRALIA DAY NEAR CFIT

By SQNLDR Clare Fry

ON THE AFTERNOON of 26 January 2019, a C-130J was preparing to conduct a flying display over Sydney Harbour. The display was to consist of two elements – a handling display in the early evening, followed by a flare dispense after sundown. In between, the crew had two flypasts in the vicinity of the Hawkesbury River.

The weather had been sunny and clear for most of the day but began to deteriorate in the late afternoon. By the time the crew departed, weather reports indicated a visibility of 8 km and a cloud base of 600 ft. The flying display was planned to commence overhead Sydney Harbour Bridge, but the low cloud precluded this. Instead, the crew requested a localiser approach to Sydney in order to descend safely below the cloud base. This was unsuccessful, so the crew conducted the missed approach and held to the east of the Harbour. The crew was still in contact with personnel in the Harbour regarding weather conditions, and when they identified a gap in the cloud, they elected to descend to 500 ft, becoming visual.

The crew entered the Harbour and commenced the display. The majority of the display was conducted with only minor amendments to the planned vertical manoeuvres. Following a ramp-down pass overhead Circular Quay; the crew reconfigured the aircraft for the final manoeuvre – a zero-G bunt.

The manoeuvre was planned to commence at 1500 ft, push to zero-G 30 degrees pitch nose down, and recover not below 250 ft minimum safe distance (MSD). Due to the low cloud; however, the AC decided to modify the manoeuvre by pitching only 15 degrees nose down, and recovering immediately and not below 250 ft MSD. Instead, the AC inadvertently pitched 28 degrees nose down, identified the entry error almost immediately and commenced a recovery manoeuvre, intending to balance the available airspeed above the stall with G and with the available height above the water.

The aircraft descended to 38 ft above Sydney Harbour.

Once above 250 ft MSD, the crew confirmed that there was no overstress or overspeed of the aircraft and, after discussion with the authorising officer, decided to continue with the remainder of the sortie.

As part of the investigation, the Aircraft Research and Development Unit (ARDU) was asked to analyse the data from the Flight Data Recorder and the Data Transfer and Diagnostic System to determine the flight profile and safety margins of the aircraft recovery. ARDU identified that the maximum G pulled was 2.41 G, the minimum stall margin was 6 kts above the stick shaker speed (incipient stall) and 18 kts above the stick pusher speed (fully developed stall).

The analysis determined that had the AC pulled to 2.5 G, the stick shaker would have activated. As 0.1 G is barely perceptible to the pilot, the recovery flown was considered approximate to an optimal recovery. The ASIT considers; however, that as the performance of the aircraft was 0.09 G below stick shaker activation, with a surface clearance of 38 ft, the margin between a successful recovery and controlled flight into terrain is minimal (Figure 1, page 16).

FLYING DISPLAYS

Flying displays carry inherent risk. By their nature, they are high profile and require careful planning and skilled execution. Even in heavy aircraft such as the C-130J, the combination of sequenced manoeuvres, height and distance restrictions, workload and pressure to perform, create a unique and demanding environment for the crew. The ASIT reviewed past flying display-related accidents and incidents, and reviewed contemporary best practice for flying display planning, preparation and execution. A number of key elements to successful flying displays were identified

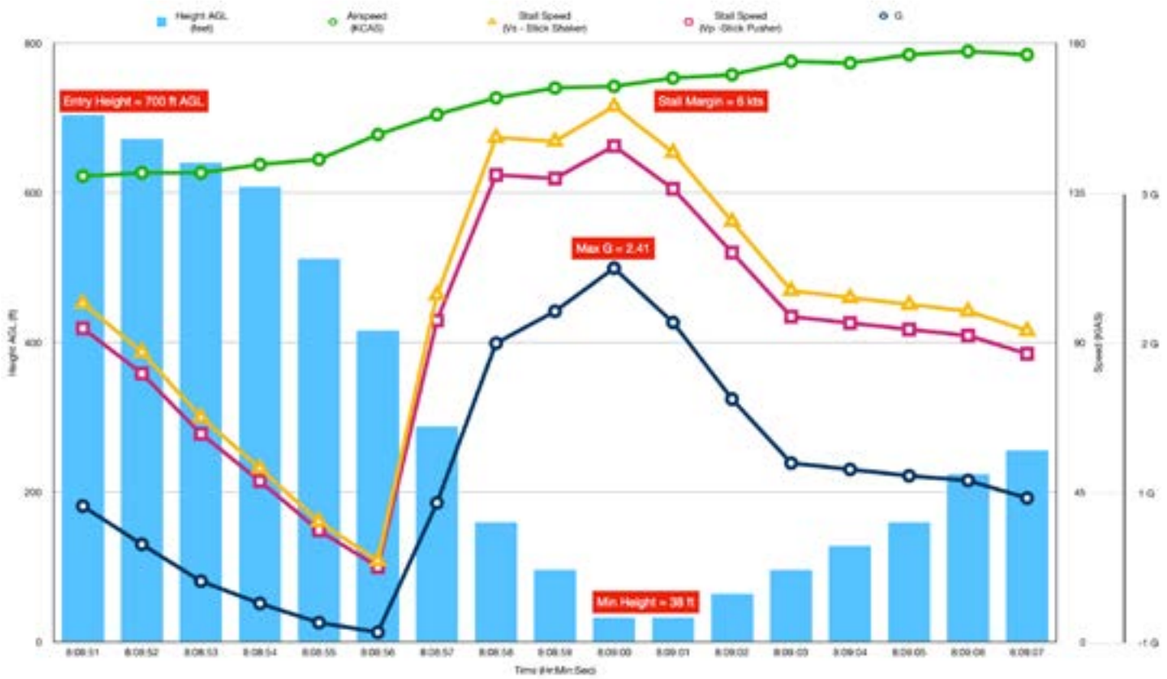


Figure 1: ARDU Analysis

and considered in the context of this event. They included:

- **Crew selection.** Documented selection criteria for display crews ensures appropriate training and proficiency, and supports effective succession planning.
- **Display selection.** Standard display manoeuvres, either in isolation, or as a standard profile, provide a number of advantages, including:
  - The risks associated with each manoeuvre, and the linking of them, are appropriately considered.
  - A consistent approach to training and preparing crews for display flying.
  - Crew members have a common mental model and well-understood procedures to fall back on.
  - Reducing workload through standardised training and crew cohesion.
- **Work up.** The ASIT found that standardised work ups are a key risk control for flying displays. They ensure appropriate resources are assigned, and crews have adequate preparation.
- **Alternative show.** The ASIT found that contemporary best practice for flying displays is to have a low or alternative show, or to cancel a show that can not be done within the practiced parameters.

RISK MANAGEMENT

Flying displays are an opportunity to demonstrate professionalism and capability but it is important to consider who the audience is and what will have the most impact. Fundamentally, the ASIT found no evidence that the squadron or wing had appropriately considered the risks associated with a non-standard manoeuvre, in a confined area against the benefit of what it added to the display.

FLYING SUPERVISION AND AUTHORISATION

In the six months preceding the display there were a number of executive postings and deployments within the wing and squadron, resulting in key positions being gapped or filled by temporary commanders. Additionally, the ASIT identified that a number of key positions had limited or no flying-display experience.

This resulted in significant workload for squadron and wing executives, and the lack of flying-display experience ultimately reduced opportunities to provide effective oversight and support to the crew to ensure safe and effective preparation and execution of the flying display.

MISSION EXECUTION

The ASIT found that the crew were unprepared for the poor weather conditions, there was no low show or alternative weather plan, and the crew and authorising officer did not discuss or adhere to the minimum weather conditions prescribed by the risk management plan. During the conduct of the display, a number of additional conditions were identified that negatively affected the crew decision-making and performance. They included:

- **Workload.** During the event, the normal high workload expected in a flying display was exacerbated by the weather, the requirement to amend manoeuvres on-the-go, poor communications with Air Traffic Control and display co-ordination communications.
- **Distraction.** Co-ordination for the flying display was via the smart phone app *WhatsApp*. The increased availability of alternative methods of communication has increased flexibility and information exchange, but it also introduces (or re-introduces) new hazards. The ASIT found in this event, that the *WhatsApp* message thread introduced a lack of clarity in communications, additional pressure through the banter and the push to continue the display despite the weather, and unnecessary distraction through the non-essential messages that were part of the thread.
- **Stress.** Stress is defined in the DFSB *Non-Technical Skills Guidebook* as a state of emotional arousal, characterised by an individual's perception of what they are required to achieve against the resources available to support them. The ASIT found a number of indications that the AC was exposed to higher than normal workplace stressors, and identified a number of behavioural and cognitive symptoms that can be symptomatic of increased stress, including; reduced communications, regression to previous behaviour, filtering of information, and sub-optimal decision-making. The ASIT therefore found that the AC's performance was likely adversely affected by stress.
- **Lack of team performance.** The crew had conducted a pre-flight briefing, and had conducted the practice displays together; however, these events were all predicated on fine weather. During the display, the AC determined the modifications as they needed to happen and did not recall briefing the crew at any stage. The CP, and the loadmasters, were not part of any immediate risk management for the amended manoeuvre and were not able to provide back up to the AC prior to, or during, the manoeuvre. The ASIT found that the lack of planned low show, or additional planning and briefing when it was apparent that the weather was below optimum, reduced the ability of the crew to work effectively as a team.
- **Learnt behaviours.** On entry to the manoeuvre, the AC inadvertently pushed through the planned 15 degrees nose down to approximately 28 degrees nose down. The AC had conducted this manoeuvre a number of times in practices for, and during displays, and had deliberately built habit patterns to reduce workload during the display. It is not unusual and often encouraged, for Defence aircrew to form habit patterns – by building instinctive reactions to certain situations, we reduce the likelihood of error, speed up reaction times and free up attention for other tasks. Unfortunately, in this instance, the AC was under significant workload and pressure and that led to a reversion of a previously learnt action.

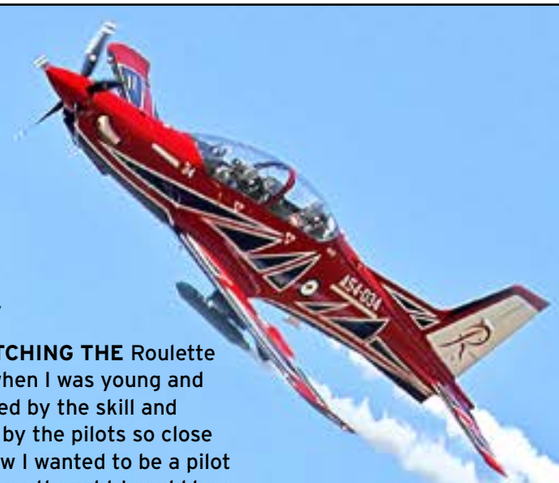
This significant safety event has highlighted the exacting nature of flying displays, and the requirement, even for simple display profiles, for careful planning and preparation. The ASIT identified a number of deficiencies in the lead up to the event, including substandard risk management, high workload and late changes to the profile, the crew and the aircraft configuration. Additionally, the ASIT found that the number of executives within both squadron and wing either absent, newly posted in or in temporary roles, increased individual workloads and reduced the organisation's overall ability to provide appropriate oversight of, and guidance to, the authorisation officer and the display crew.

While the ASIT did not do a full review of safety climate at the squadron (due to a programmed review of safety culture at the wing in November 2019), they did note potential weaknesses. Review of Safety Snapshot reports and Airworthiness Board results indicated that the squadron has a strong performance-orientated culture, but also high job demands, including high work rates, increasing complexity of tasks and breadth of capability. This imbalance can often result in can-do attitudes that set powerful expectations on individuals, and subtle and often sub-conscious trade-offs between maximising capability, and minimising exposure to risk.

At an organisational level, the ASIT identified a lack of OIP to support commanders in the selection of flying display crews, display profiles, and work-up processes. For comparison, the ASIT found comprehensive guidance in some wing- and unit-level organisations that would be invaluable in the development and preparation for all flying displays conducted by Defence aviation.

No single contributory factor was considered primary in this event. Rather, the ASIT identified a number of local conditions, absent or failed risk controls, and organisational deficiencies, that together, reduced the safety buffers normally present, and resulted in an unintentional manoeuvre that led to the descent of a C-130J to 38 ft over Sydney Harbour.

Getting in the zone



By WGCDR Jay Tuffley

I REMEMBER WATCHING THE Roulette aerobatic team when I was young and being truly amazed by the skill and precision displayed by the pilots so close to the ground. I knew I wanted to be a pilot early in life but I never thought I could be a Roulette, let alone lead the team one day.

Flying at speeds of almost 600 kmh at only three metres apart is not for the of faint heart. I still remember my first hand-over flight where at the end I thought "how on earth am I going to do that"! I have since completed some major pilot qualifications that enabled me to successfully perform many Roulette displays around Australia.

FLYING BUBBLE

With a hectic and diverse professional role it was not unusual to be inundated with questions, emails and responsibilities at short notice. The key was separating all this noise in time to be focused on flying. To do this I remember:

- using the phrase "I am in my flying bubble"
- closing my office door to stop injects
- not checking emails approaching briefing time
- not answering phone calls unless it was the Authorising Officer
- cutting away admin, delegating duties and writing a list of things to do later so I could clear my mind.

COMPARTMENTALISE

I separated my home and work life. When I was at work, I was mentally at work. When I was home, I was at home and tried not to think about work issues. I found I could deal with the two elements differently by trying not to deal with major home-life issues at work and likewise I didn't complete major work preparation around the family. If I did need to do some preparation at home, I ensured I was in a different room away from home-life distractions.

REST

Do not underestimate how fatigue can impact decision-making and ultimately flight safety.

So too can your health. Flying medically unfit is not worth the risk, you may get away with it but if something major happens would the second guessing of "what if you had not" be worth it?

PREPARATION

Thorough preparation allowed me to know the display venue well, the other players, frequencies, airspace layout and timings. I had visualised the display's locations and geographic features so well that it all made sense when airborne in the moment. A well laid out knee-pad card with all details readily accessible airborne was a useful guide for ground study. I found an uneventful trip that went to plan was a great trip – surprises are not a good thing in the display world.

ORGANISATION

To take the pressure off the leader, each member of the Roulette team understood not only what they had to do airborne but also what roles and responsibilities they had on the ground. Through delegation and sharing the load, the team could carry out much better public-relation activities and ensure everyone had spare capacity. Roulette 7, the commentary and ground liaison pilot, played an important role in shielding the team against late-notice injects before flight (PR requests, venue liaison, NOTAM point of contact, media requests et cetera).

SAFETY FOCUSED

Safety is a critical element that must be assured in aviation, the "*mission first, safety always*" statement paramount. The pressure – self-induced but pressure all the same – means that it is easy to put the display or flight completion (mission) ahead of safety.

Crowds of people (paid spectators at air shows) have come to see the performance. Representing your country, the ADF and the professionalism of the Roulette brand. In the heat of the moment decision-making can become focused on the task and you accept risks you ordinarily would not – otherwise known as press-on-itis.

Not to say I cancelled at the first element that made a situation unusual. Often immediate risk management was required to try and complete the mission safely.

In an effort to avoid poor decisions and inappropriate safety focus we employed:

- a robust authorisation process that established set red lines providing a left and right of arc as to what was acceptable and establishing clear pre-planned knock-it-off criteria
- processes dealing with emergencies and anything unusual
- an open, just culture where all members were encouraged to speak up
- being prepared to cancel in order to fly another day, and on occasion we did – there was always tomorrow.

VISUALISATION

You can visualise after you have flown the sequence enough to know the timing and what the pictures should look like 'where to look'. To assist, pilots can use videos, HUD footage, procedural trainers or simulators. Once timing and 'where to look' was known, I found it useful to visualise while moving my hands, a model or even walking my way through display sequences. In an aircraft, a lot of information can be picked up through watching another pilot perform as a demo allows cognition without motor skills (unloaded).

PRACTICE

The aim is to be able to transfer from consciously competent to unconsciously competent. This automatic zone is when you can apply brain space to other areas while performing high-end skills.

The Roulette team practiced emergency procedures and had pre-planned degraded displays that we could employ if the weather precluded a full display, or a member of the team was suddenly unavailable.

It was critical everyone knew what to expect and what their roles would be in unusual circumstances as much as practicable. Having this rehearsed enabled recognition-primed decision-making and ensured that all team members remained in the same situational-awareness state. Just to make sure, an airborne display brief was given prior to every display (display type, crowd axis, critical altitudes, altimeter setting, headings, smoke use, wind and step – formation offset).

SITUATIONAL AWARENESS

Situational awareness is paramount in ensuring good decision-making. I found the lens I looked through effected my situational awareness. I remember having a massive fear of failure and being worried about making mistakes when I started pilot training. I now see that that this was an unhelpful mindset that actually decreased my SA and made me rush decisions. A rushed first decision was often not the best one. Learning to sit on my hands was extremely helpful when assessing options.

Being focused on mistakes meant that I couldn't move forward airborne, instead I was distracted by what had just happened. It wasn't until I failed flights that I realised that I could refocus my fear of failure positively into realising mistakes were common and that a better method was to strive for improvement rather than perfection.

Perfection in every facet of flying is pretty much impossible, but learning from mistakes is critical. I found having a focused but relaxed mindset, one in which I certainly cared and tried my best but strived for continuous improvement instead of perfection, really helped. If you want to be perfect don't become a pilot let alone a display pilot.

STRESS

Everyone is different. I find I need a small amount of stress for optimum performance. For example, I would often plan extra time between take-off and a display so I could take-off slightly late. The slightly late take-off increased my stress levels; however, the net result was that I was on time for every time-on-target display we flew. The stress helped me focus on the task at hand without time for distraction.

HABIT PATTERNS

Pilots are generally creatures of habits. We tend to have set routines and habit patterns that are employed to ensure tasks are completed correctly.

This is a learnt trait because of the benefit that a habit pattern provides in avoiding omissions or errors. I had a set routine for how I would set up the cockpit, how I completed the pre-flight inspections, when I would sign for the aircraft and how I would complete my flying checks. The key was recognising when these habits were broken because of distraction, as this could lead to errors.

DOWNTIME – THE UNWIND

With a relatively stressful job I found it super important to be able to clear my mind by getting completely away from work and doing something very different. I achieved this through adventures in the outdoors and archery. Armed bushwalking became a passion in which I could focus on a completely new challenge. Not only did I have the potential to come home with dinner but I always felt reinvigorated by the beauty of the Australian wilderness.

CONFIDENCE

Too much and too little confidence can both be poor pilot traits. Generally experience builds confidence but how can you be confident if you aren't experienced? I found it beneficial to realise that everyone has firsts and that my firsts didn't have to be perfect nor go to plan, but they would be mine... so why not own it, enjoy them and learn from them. Maintaining a positive outlook and confidence certainly helped me perform as well as I could.

Roulette accident 2005

ON 21 JANUARY, 2005, Roulette Five (R5) collided with Roulette Four (R4) during a high-show practice over East Sale. The collision occurred during a Vic-barrel rejoin. R5 ejected successfully from his PC-9A, which was completely destroyed on impacting the ground. He sustained only minor injuries. R4 landed safely but with substantial damage to his port wingtip.

Work up

Following their return from leave, team members had only one week to complete the work up before the first major display of the season.

The Roulette team for the first season of 2005 was selected to begin its work up in mid-November 2004. But work up began a week early in an attempt to negate the effect of a longer-than-normal Christmas break – brought about by a CDF directive to reduce leave.

Five of the six positions had changed from the 2004 team, including the Roulette Leader. The Roulette Leader had returned to CFS following an absence of about 18 months, prior to which he had occupied the positions of R2 and R6. The only position not to change from the 2004 team was that of R2.

During the pre-Christmas phase of the work up, the team experienced several unplanned disruptions to the syllabus, which placed perceived pressure on the Roulette Leader to have the team at an appropriate standard before the break. The fact the team members had only one week on their return from leave to complete the work up before the first major display of the season, scheduled for Australia Day, created additional pressure on the pre-Christmas phase of the work up.

Despite these pressures, the Commanding Officer Central Flying School (CO CFS) directed that, should the team not be at an acceptable standard, a more simplified display would be flown on Australia Day.

To facilitate training within a compressed timeframe, the Roulette Leader made some alterations to the syllabus, enabling the team to concentrate on preparing only for the primary display – the high show. Other display variants, such as the low show were excluded with the intent of completing the training for them later in the display season.

CFS executives were satisfied that, despite the disruptions to the work-up program, the team was making satisfactory progress and, barring any further disruptions, should be ready for events surrounding Australia Day in Melbourne, Canberra and Sydney.

On their return from leave, the team continued with the work up, which was to culminate with two display practices on 21 January. The practice was the final approval flight before the team deployed and was being viewed by an audience including Officer Commanding Air Training Wing (OC ATW) and CO CFS.

The accident occurred about one hour into the first sortie and was the first full display practice.

Cause of accident

...the damage most probably rendered the aircraft non recoverable...

The Aircraft Accident Investigation Team (AAIT) concluded that the most significant contributing factor to the accident was the manoeuvring of R5, the rejoining aircraft, who became disorientated following a mishandled rejoin. R5's disorientation was exacerbated by an encounter with R3's wake vortices.

The proximity of R4 and R5, and their relative flight vectors, led to R5's port wing striking the port wing of R4's aircraft. R5's aircraft sustained substantial damage to the outer portion of the port wing and aileron.

The AAIT concluded that the damage most probably rendered the aircraft non recoverable. R5 ejected from vertically nose down flight at an altitude of approximately 1100 ft (AGL). The AAIT determined that an additional time of approximately one second existed after which survivable ejection was unlikely.

The accident manoeuvre was one of the more difficult flown by the Roulettes and, in particular, R5. This was primarily due to the number of variables affecting its successful completion and the difficulty in establishing repeatable parameters to negate some of these variables.

Additionally, there was a lack of visual cues to assist R5 and as such, the risk of becoming task fixated while completing the rejoin, was commensurately higher than other Roulette manoeuvres.

Notwithstanding the relative difficulty of the manoeuvre, it was considered fundamentally safe due to numerous, easily executed, bug-out options. Successful completion of the manoeuvre was not critical to the continuity of the overall show.

CFS priorities

...the display calendar for the first six months of 2005 contained few events that did not have Public Events of Significance (PES) status...

Within CFS, Roulette activities were considered subordinate to other unit roles including flying instruction and external standardisation.

The Roulettes were aware that if a confliction of priorities occurred, conduct of higher priorities would take precedence over Roulette activities.

However, in spite of these guidelines, PES and other particular high-profile events received Roulettes' support almost always. In fact, the display calendar for the first six months of 2005 contained few events that did not have PES status. This presented a significant management challenge in achieving tasking priorities.

Selection and training of Roulettes

A review of previous accidents and incidents involving the Roulettes identified recommendations that were similarly applicable to the outcomes of the AAIT investigation.

Roulette candidates were drawn from the staff of qualified flying instructors (QFI) at CFS. Manning constraints within CFS often presented limited personnel alternatives and, as such, selection was based on an evolutionary, next-in-line, philosophy.

The process was underpinned by the extant experience requirements of a posting to CFS and measured against broad, minimum-experience guidelines contained in Defence Instructions (DIs). The only subjective selection criteria in the DI was "above average spatial awareness in three-dimensional manoeuvring". This was considered a criteria that was difficult to formally address.

Training of the incoming team member was the sole responsibility of the previous incumbent and therefore subject to the individual nuances incorporated by that individual during their tenure in a particular position.

A view from the hotseat

REFLECTION by
WGCDR Roland Morscheck

MANY YEARS HAVE passed since the Roulette accident occurred and I am forever grateful to the excellent Martin-Baker product (ejection seat) that allowed me to write these words today. I had the pleasure of visiting the Martin-Baker factory in Uxbridge where I was made very welcome and met many of the staff. They are all extremely proud of their product and genuinely relish meeting their customers.

Since this accident I am often asked similar questions. Did you feel the collision? What did it feel like to eject? Were you hurt? These are all pretty easy to answer, but the question less asked is "how did you make the decision to pull the handle?" I mention this because every pilot who straps themselves into an ejection seat briefs themselves prior to getting airborne on their individual ejection-decision parameters. Generally this involves decision points during the take-off phase, especially in single-engined aircraft, and considerations for other scenarios where a landing is not considered achievable or too dangerous. While take-off decisions would be made pretty much instantly, the other scenarios are generally not time critical, and would allow time to prepare and perhaps even ponder. There are many examples where the decision was left too late, resulting in injuries or even fatalities. My accident was time critical, but not at take-off. I can truthfully say when the time came there was no hesitation in pulling the handle.

I did not feel a collision. I thought I had flown through the burble, or wake, of the formation when bugging out, which had somehow flicked me into an incipient spin. This is what it looked like out the front and the controls were unresponsive. I had no idea the ailerons were jammed. The ejection was dark and noisy. I closed my eyes and felt and heard the bang. After a couple of seconds of floating through the air I experienced the violent opening shock of the parachute. This jolt felt worse than the ejection, perhaps because I was not braced for it. The descent was rapid as I drifted downwind from the fireball underneath me. My thoughts were focused on the landing point and preparing to fold and roll on impact. From pulling the handle to my feet hitting the ground was just 15 seconds. I was dragged along the ground by the still inflated chute before I released the harness. I then just laid there and tried to process what on earth had just happened.

The human brain operates differently under extreme stress. My recollections immediately after the accident attested to significant time dilation. The ejection decision considerations and thought processes I recalled making in a deliberate manner actually occurred much faster than I believed they took. I recall considering the commencement height of the manoeuvre, my relative speed to the formation, where I was in the manoeuvre when I began bugging out, the responsiveness or lack of with the flight controls, the nose down attitude of the aircraft, the roll rate of the aircraft et cetera. I even thought I made a radio call prior to adopting the ejection posture and pulling the handle. Thankfully due to my correct posture and being tightly strapped-in I was unharmed by the ejection.

An obvious question is, could a similar accident happen today? Roulette operations are inherently risky – the manoeuvres flown place the aircraft, the pilot, and the team in dynamic situations requiring skill, anticipation and trust to make them both entertaining and safe. In my opinion the key components to success are experience, training and airmanship. The absence of any of these will increase risk and compromise either the effectiveness of the display or safety. I reckon these components are much better considered and mitigated today than they were 15 years ago.

So what went wrong in 2005?

Regardless of my previous flying experience, being new to the positon and also flying a difficult manoeuvre not seen before meant my experience was actually low when the Roulette work up commenced. A subtle change in the way the manoeuvre was flown served to negate experience further. The work-up training process serves to increase exposure and repetition, with the aim to build experience. I was still in this building phase when the accident happened. The accident manoeuvre is no longer flown by the team, but other new manoeuvres, and a change in aircraft type, have been introduced into the Roulette repertoire since. The considerations mentioned at the end of the accident article have since been well applied and documented, significantly reducing the risk.

Airmanship means many things, including preparation, decision-making, and awareness. I was 'pressing' to get the manoeuvre 'sorted' and applied pressure on myself to perform. A breakdown in my situational awareness put me in an unfamiliar positon during the rejoin. Upon recognition of this, too late though, I commenced a bug-out. It was not my intention to try and save the manoeuvre, we could always set up and try again. I rolled and pulled to get clear of the formation. I was then in the completely different situation already mentioned. Survival kicked in.

Supervising displays

I learnt many things from that day, and indeed since.

I have been fortunate to be the commanding officer and flying supervisor of the Roulettes. I have also been intimately involved with low-level aerobatic pilot training and assessment, supervised displays by individual Roulette solo pilots, supervised large-size and mixed-type formations, and supervised balloon operations. From my experiences I offer the following tips to be a successful flying display autho.

Should I authorise? The delegation of authorisation authority does not automatically imply you are competent or suitable to authorise flying displays and rehearsals. If you are not the most suitable or qualified person to perform the authorisation, even though promulgated, use common-sense and seek assistance from a subject matter expert if there is any doubt. When coming in to the role, sit in on auth briefs with others to gain exposure and get a feel for how you will frame your auth process.

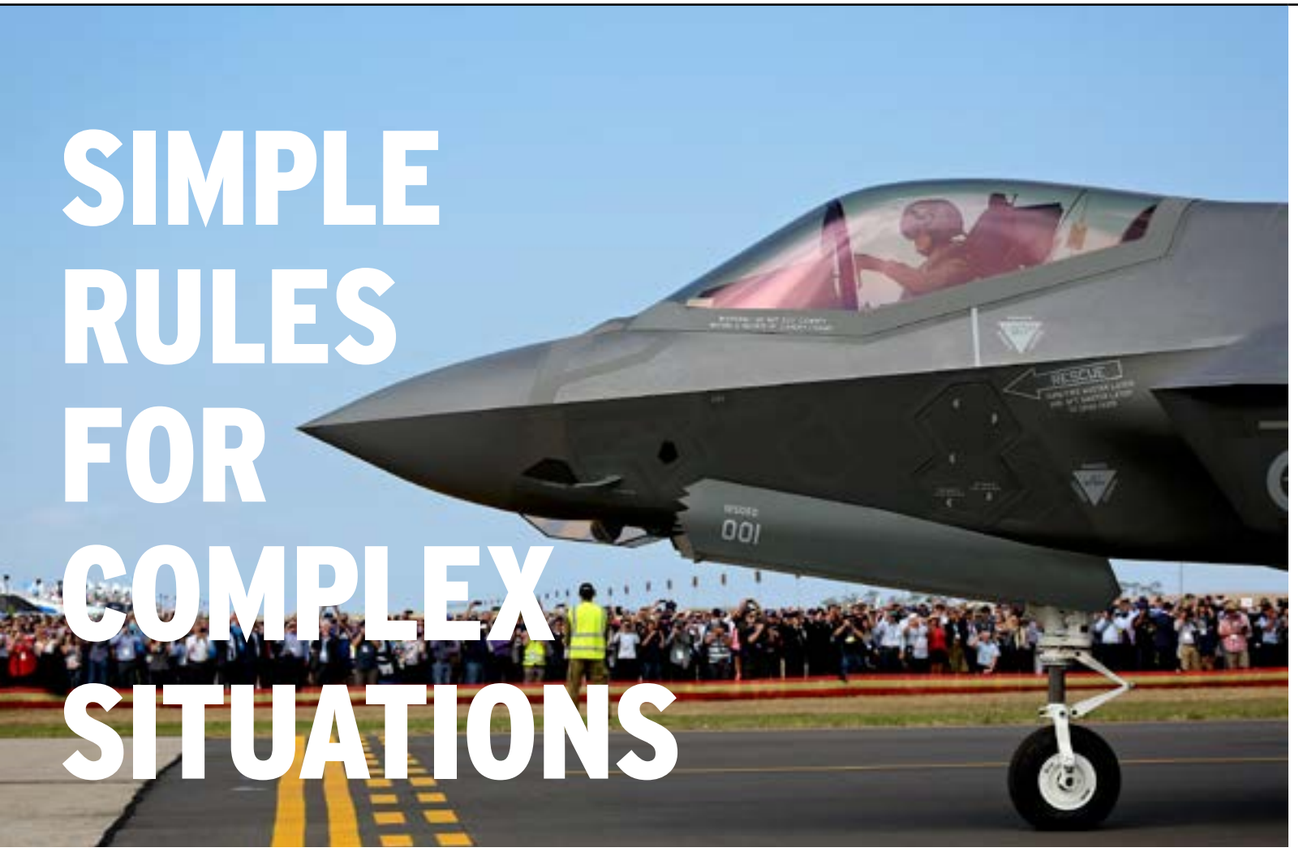
Make time and ask questions. Always make time for the authorisation brief, and remove distractions from interfering with the process. While this may not always be easy to achieve as an exec in a busy unit, it is important, so make it a priority, and make it your habit pattern. Face-to-face is preferred. Attend formation or deployment briefs concerning displays whenever able. Let the captain/s brief you on what they consider important. Apply your experience and/or knowledge when applicable, including asking questions, no matter how basic or detailed. Your questions should not aim to demonstrate your worldly knowledge (or lack of!) but are important in establishing a robust two-way communication process and clearly establishing a common understanding of the task at hand and the limitations and gotchas involved.

Trust. The authorised captain/s are trained and competent to carry out the task. They should not be doing it otherwise. Trust them to conduct their mission professionally and expect them to apply good airmanship.

Debrief. Even if the debrief is just a short conversation following a successful and otherwise uneventful display, it closes the loop and maintains a discipline and habit of always debriefing what you have authorised. When conducting a longer or more formal debrief, let the captain/s to tell you what happened and what they encountered and how they responded. Be open to their input and use what they say to gain insight into their airmanship processes and decisions. It is important to praise good airmanship, not just a 'good show'. It is equally important to not be afraid to provide honest critique – privately of course.

Display flying attracts attention. Aircrew want to be part of it, senior leaders will always be interested, and an entertaining display is a crowd pleaser. A safe display is your desired outcome at all times, as participant or autho. Set the conditions for this to happen. Every time.

SIMPLE RULES FOR COMPLEX SITUATIONS



Original article courtesy Canadian Forces *Flight Comment*

INTRODUCTION by WGCDR James Atkinson

DISPLAY FLYING IS a sidebar to our core roles but is also some of the most challenging and rewarding flying a pilot and crew can experience. It is easy to underestimate the preparation required and the risks involved, after all, even our recent graduates can fly a fighter level at slow speed and high alpha, or fly a formation loop in a PC-21, with minimal additional training.

But to make it look crisp, to perform it at low level, linked with other manoeuvres and in front of a large crowd wedged between other displays requires significant preparation and training. Such preparation and training is almost always conducted under time and resource pressure and so specific supervision is essential.

I was very fortunate to be the F/A-18A Aerobatic Display Pilot and have trained and supervised subsequent pilots. I was also CO CFS when the Roulettes transitioned to the PC-21 and was responsible for their supervision and authorisation during a period of many unknowns.

Training and supervising the airshow pilot is a relevant summary of many of the factors we face as display pilots. As a display supervisor, my role changed dramatically from selecting the right pilots and reviewing training documentation before an engine was ever turned through to almost exclusively controlling distractions on the day of a display.

Sanitising a suitable period prior to the display and ensuring crews are well rested, fed and watered is essential. None of these are guaranteed at an air show.

Some of the most sage words in this article are at the end under 'Pilot stuff'. As a display pilot the pull of press-on-itis was stronger than for any other flying I've done. I have never felt this as a supervisor, though the pressure from pilots is always there whether they express it consciously or not. Although it occurred rarely, there were occasions where I've subtly tuned a pilot's or team's attitude to an unexpected situation, normally resulting in easing back or cancelling a show. As a pilot I might have wanted to continue. But to what end? The crowd will forget about your perfect performance in no time, but they'll never forget an accident.

EACH YEAR, COUNTLESS air displays are performed around the world by military and civil organisations. Airshows and armed forces displays are unquestionably the best way to showcase military and civil aviation and to demonstrate aircraft performance and manoeuvring capabilities.

Because people are fascinated with aviation and aircraft, air shows are always crowd pleasers and usually entail a plethora of related activities involving local communities and businesses.

Most shows are generally well organised and the vast majority are incident-free – but not all. Despite rigorous safety programs, some air displays become the site of tragic accidents.

Low-level flying has inherent risks, particularly when performed near spectators. However, risks can be minimised by the strict adherence to safety altitudes, minimum safety distances from the public (show line), and most importantly, by the gradual introduction of complex manoeuvres in the training of demonstration pilots.

To achieve the objectives of airshows, safety of the public and participating aircrew is of the utmost importance. A perfect airshow safety record may be an elusive target, but it must be the objective of all professionals involved in this type of activity.

Demonstration pilots

The people flying at a particular air display will have the greatest bearing on the safety of that air display.

To fly aircraft at or near maximum performance requires not only a clear mind and good psycho-motor skills but also self-confidence, commonsense and maturity. These qualities are needed to resist peer pressure and the urge to outdo other performers; to avoid pressing marginal weather conditions; and, to decide when to stop because of unserviceabilities or just getting behind the aircraft.

This leads us to the selection, supervision and training of aerial demonstration pilots.

Selection

The selection of air-demonstration pilots is a subjective process but it must be based on qualifications. These qualifications are the individual's maturity, flying background and experience, flying abilities, and suitability for reputational duties.

The demo-pilot slot should not be used as a reward for performance in other jobs, unless the individual clearly has the potential, experience and the ability to be a safe and competent airshow pilot.

Training

Training a new pilot must be a phased program, where manoeuvres are practised first in the simulator, then in the training area, and finally, integrated one by one.

If an experienced aerobatic pilot is available, he or she should fly with the rookie pilot and spend some time on the ground to discuss low-level aerobatic techniques and emergency procedures before progressing to the next phase.

Once the trainee is comfortable with the sequence, the practice altitude can be gradually lowered. They should then brief and fly this airshow sequence in front of supervisors before being certified for the season.

A written description of each manoeuvre and the safety factors and "outs" used must be part of the briefing.

Supervision

The demonstration pilot should be able to rely on the strong support of supervisors and have the opportunity to practice as often as possible. Should the pilot experience stick-and-rudder problems, they should be able to talk freely about them and to go back to the training area for additional training if required.

Workup and currency requirements will be type-specific and must be published in FEG SIs.

Weather

Weather presents major problems to all pilots and show organisers as it increases the difficulty of go/no-go decisions. Some of the aerobatic sequences might have to be geographically displaced, or worse, clouds may be entered during vertical manoeuvring. Poor or marginal visibility (three-to-five miles) leads to inaccurate positioning, loss of show-line visual clues, poor obstacle/terrain clearance, and difficult rejoins.

If weather is a factor, be conservative, fly a low or flat show, or stay on the ground. If flying at a high-density altitude, raise the top of your vertical routines and initiate higher dive recoveries. For level or flat turns, initiate your turns toward the crowd further out.

Terrain and features of the show site

While some show sites are clearly defined, flat and relatively free of obstacles (such as airfields), others can be particularly difficult.

Waterfront sites are usually obstacle-free but vertical depth perception, as well as horizontal orientation can be adversely affected. Here, Inertial Navigation Systems (INS), GPS and HUDs become very useful in marking the centre-stage area and the show-line.

Aerial-demonstration sites located near cities can be difficult and they do occur from time to time. In these

particular cases, obstacle avoidance becomes the number one priority.

Air displays performed near small towns in rolling countryside can be demanding because of hills, antennae and unknown obstacles. Not only is there often no show-line, but setting the altimeter to indicate height AGL is also not as easily accomplished as when taking off from an airfield.

Radar altimeters can be used to cross-check the barometric altimeter in such situations. Performing over an airfield generally provides easy geographical references and just as importantly, rapid access to a landing strip in case of emergency.

Aircraft limits

Aircraft are subject to limits set by Newton's laws. For a given density altitude, the maximum sustainable turn rate is a clearly defined quantity that cannot be exceeded. Therefore, key altitude and airspeed numbers (gauge points) must be used by aerobatic pilots to determine where turns must be initiated to avoid busting the show-line and minimum safe altitudes.

Reference charts must be drawn for various flight conditions; such as the various density altitudes likely to be encountered during the season. Dive-recovery altitudes must also be plotted and safe altitudes for vertical manoeuvre recovery initiation precisely defined.

Aircraft systems

Pilots must know which aircraft systems are critical for their show and which ones aren't. For example, on the Hornet the VOR/ILS is not critical, while the INS is of primary importance since it drives HUD symbology. Flight-control systems are vital and if an advanced flight simulator is available, flight-control emergencies must be practised for the most critical phases of the show.

Fuel reserves

Often pilots are put in a position where they must fly their routines at a higher-than-usual gross weight because of the fuel reserves they must carry. This in turn affects manoeuvring capabilities and requires greater safety margins.

Flight tips

During the pre-flight check, set the cockpit mirrors for proper in-flight use. They will be invaluable, particularly during vertical climbs where you not only will need to achieve a perfect 90 degrees climb (use the HUD and wingtip references), but where you will also need to line-up the aircraft's lateral axis in a perfect 90 degrees with reference to the runway axis (use the stab/vert tail alignment) for looping manoeuvres.

During the take-off run, check the acceleration of the aircraft (airspeed against clock) to monitor the status of your engines. Once flying, the aircraft should appear to fly on rails whenever it is flying straight and level (just let the aircraft fly itself). Horizontal manoeuvre initiation must be crisp yet smooth, with no hesitation. Vertical manoeuvres must be timely, precise, graceful, and regular in their execution.

Listen to your aircraft. When flying at near-maximum performance, the aircraft always lets you know how happy it is to be doing what you are asking it to do. If a certain roll rate normally requires lateral stick pressure X and the aircraft increases the roll rate on its own, then it may be initiating roll-coupling – you must stop this situation immediately.

The same holds true for pitching manoeuvres; as soon as the aircraft begins to hesitate when you are asking for very high pitch rates, release some aft stick pressure as you are probably asking the aircraft to do more than it can handle.

As you develop proficiency, you will learn the right cockpit picture for each manoeuvre, to the point where gauge numbers will become secondary. Finally, enjoy yourself when you perform, it will show through your flying and people will notice it.

Pilot stuff

Before flying your aerobatic sequence for a practice session or an actual air display, mentally visualise the sequence and review possible emergencies (for example, engine power failure, flight control problems, birdstrikes, grey-out during high-G manoeuvres). These can be practised in the sim for every type we fly (except for RAAF Museum aircraft).

Resist peer pressure and fly your show according to your experience level, the local weather conditions and the limitations of your aircraft. Fly a low show if weather conditions so require. If ever you get behind the aircraft, the show-line, or get too tight, stop your show and reposition.

Never improvise: it's a sure way to get yourself in trouble.

To become an old – not necessarily bold – pilot, always have an out. When planning the show sequence, you must always plan and be aware of outs. For example, if the aircraft can sustain 7.5 G during a flat turn, then plan a 6.5 G turn sequence, so you can tighten up the turn if required.

The same thing applies to vertical dive recovery altitudes, a good 1000 ft safety factor should be built in to any high-performance jet vertical dive recovery manoeuvre.

Since all aircraft have different flight characteristics, I'm not saying a hard set of safety numbers must become the rule for all airshow manoeuvres – but you better have some for your routine. If you don't ensure your gauge points provide a reasonable safety criteria, you could end up as a hole in the ground.

To organise and fly a safe and crowd-pleasing air display is the mark of a true professional.

Armed with knowledge, commonsense, and dedication, you will experience a highly successful event and please countless thousands in the process.

Czar 52: tragic consequences

INTRODUCTION by ACAUST AVM Vincent Iervasi

I REMEMBER DISCUSSING the Bud Holland incident on Flying Supervisors Course in 1997.

Having just returned from an exchange tour with the RAF, I had been exposed to some unique operating conditions where adaptability and flexibility were necessary attributes to complete the mission. However, what I learnt from that experience and reinforced for me with the LTCOL Bud Holland incident, was that the integrity of an independent trust-but-verify process for authorisation and supervision is an absolute critical requirement for a professional organisation whose primary aim is mission success. Don't assume – check.

Flying supervision and authorisation, when done well, enhances mission success as opposed to the perception that it is a constraint. As a supervising and authorising officer I wanted to minimise the circumstances when an aircraft captain was tempted, or felt compelled, to make stuff up as they went along because they felt the situation warranted it. If a pilot wanted to perform an 'inverted wifferdill' at 50 ft, I would be happy to authorise that manoeuvre subject to the individual satisfying me through knowledge and demonstration that they knew how to do it, what to do when it went wrong, and under what circumstances it may be necessary to perform.

Equally, if an individual chose to undertake an 'inverted wifferdill' without authorisation then they would be held accountable for the consequences as they have more than likely exposed themselves and others to a completely unnecessary risk. It takes courage to speak up when something is not right, but it also takes courage to enforce authorisation and discipline. A failure to discipline and correct aberrant behaviour is as bad as the conduct itself.

The story of Bud Holland and CZAR 52 retains relevance today. As display aircrew you are being entrusted with an important public duty. Fly within the limits of your aircraft, your own abilities and your authorisation. Watch for the rush-of-blood-to-the-head moments and similarly be wary of complacency.

As a supervisor of display pilots you need to be prepared to make some tough calls. Choose your people wisely. Hold them to account. Be tuned in to the personalities and personal circumstances of your display crews. Demand the highest of professional standards. Ensure that your display crews read this publication.

This story holds some lessons that I believe are vitally important and timeless. I ask you to take the time to read through it and reflect upon it, as I have done over many years.

By AIRCDRE Mark Lax

WHEN SUPERVISION AND airmanship procedures break down, disaster is often the inevitable outcome. The following tragic accident – caught on film and and beamed around the world – could quite easily, given similar circumstances, have happened in any military aviation force and at any time.

The spectacular crash and subsequent fireball in June 1994 of the giant B-52H, callsign Czar 52, was the culmination of a sequence of events. The termination of any one of these could have prevented the disaster. This is the story of Czar 52's last 18 minutes.

For this particular air show, the crew of Czar 52 was tasked to fly a B-52H handling display for the culmination of the day's flying events. Preparation involved several practice missions and it was during one of these that the accident occurred.

The crew of four were all very experienced, the least of whom, the radar navigator, could still boast 2900 hrs on type.

The aircraft captain was the Chief of Wing Standardisation and Evaluation. His co-pilot was the 325th Bomb Squadron Commanding Officer. Also aboard were the squadron operations officer in the navigator's seat and a third instructor pilot, the wing vice commander, who sat in the fourth seat – a heavy push indeed.

The flight sequence

After a maximum rate take-off, the crew immediately began their pre-planned display routine, which commenced with a steeply banked turn, although from the beginning this would be no ordinary display.

Observers later stated that the aircraft regularly banked to between 45 degrees and 60 degrees, and on the straight runs over the runway flew well below 500 ft. The practice included tight turns, high-speed runs and an approach in landing configuration.

About 10 minutes into the display, another indicator of recklessness occurred. After completion of an estimated 150-200 ft run across the airfield, a full power climb was initiated together with an 80 degrees steep banking turn to the right. Part way round the turn, the aircraft entered a partial stall and began a tail-slide, which was quickly corrected.

The aircraft levelled at 1200 ft and turned to approach Runway 23 for a landing run as the show profile had been completed. However, a go-around was initiated because

another aircraft was on the runway. During the go-around the aircraft maintained about 150 kts and 250 ft AGL. As the aircraft rolled left base, ATC staff reported bank angles of greater than 70 degrees and, again, a partial stall occurred, together with another tail-slide. This time the aircraft lost 50-100 ft. The pilot rolled back to 45 degrees and arrested the stall and descent. Now in their final minute of flight, the crew did not put on power nor initiate a climb to circuit altitude.

Amazingly, the aircraft again banked to 90 degrees, stalled and the nose dropped. No attempt to recover was made and the 220-tonne aircraft hit the ground at 95 degrees angle of bank (AOB) nose-down, and exploded.

All crew were killed. Although the co-pilot had initiated the ejection sequence, it was unsuccessful as the conditions were way outside the safe ejection envelope.

The investigation

The investigation into the cause began immediately with the USAF convening a Board of Inquiry (BOI). Very quickly weather, aircraft maintenance and the medical condition of the crew were eliminated as causes and airmanship became the prime focus.

But how could a pilot with more than 5000 hrs on type with an experienced and senior crew, including a QFI, let this happen? What came out of the inquiry will astonish some.

The investigation determined the pilot was manually flying at the time of impact and that from the beginning of the display, the profile was in breach of flying orders, flight-manual limits and flight authorisation from the 92nd Bomb Wing Commander. For example, the flight manual limit for low-and-slow turns in the B-52H was 30 degrees AOB. Bank angles in excess of this are considered steep turns and turns with up to 50 degrees AOB maximum are only permitted above 1000 ft. The aircraft spent less than two minutes above 1000 ft for the entire practice. In addition, manoeuvres below 1000 ft required FAA and Air Combat Command approval; however, none was sought.

Such a violation of procedures may seem extraordinary, but a failing of airmanship was not the only contributing factor in this crash, nor was it the end of the investigation.

Further aspects of accident

Shortly afterwards, a letter was sent to the Commander of Air Combat Command, the overarching command of the 92nd Bomb Wing. The letter alleged a repeated history of flight-discipline violations by the accident captain and a refusal by wing leadership to rectify the situation. The BOI then went on to review the past three years and found a litany of breaches and no corrective action taken.

The failure to act or document airmanship failures also coincided with a rapid turnover of management. This included four wing commanders, three vice-wing commanders, three operations group commanders and five squadron commanders. Effectively, there was no tracking of crew performance.

Aircraft captains with 5000 hrs and crews with more than 2500 hrs each were supposed to be expert. To complicate matters even further, wing leadership didn't know the regulations regarding airshows and so reports from previous shows were ignored.

A list of lucky escapes

During its investigation, which by now centred on the aircraft captain, the following sad sequence involving this officer was revealed:

May 1991. Fairchild AFB Annual Show. Repeated high-bank turns and high pitch angles; high-bank turns over the crowd. No action taken.

July 1991. The 325th Squadron Change of Command Ceremony Flypast. Low flying (100–200 ft AGL) and steep turns. No display approval. No action taken.

May 1992. Fairchild AFB Annual Show. Low, steep turns. High-speed pass with pull-up and wingover. Stated by one witness to be "A little bit insane"! Captain counselled by group commander, but not formally recorded.

April 1993. Global Power mission to Guam. Close visual formation flown, contrary to orders. Crew permitted to leave cockpit during bombing run to observe events, also contrary to orders. No action taken.

August 1993. Fairchild AFB Annual Show. Low flying, steep turns and high pull-ups. A crewmember described the profiles were flown with extreme aggressiveness. No ACC approval sought. Despite the profile being contrary to FAA and ACC regulations, no action taken.

March 1994. Bombing mission to Japan. Very low flying. Aircraft nearly hit a ridge (estimated within 30 ft) but for intervention of co-pilot. Flight by armed bomber over populated areas. Impromptu formation flying, unauthorised.

It was only after reports from the range in Japan that the 325th Bomb Squadron CO sought to restrict the aircraft captain from further flying.

The wing commander verbally counselled him and was assured by him that there would be no further incidents. The squadron commander's request to ground the captain was denied. Unfortunately, the wing commander was unaware of the co-pilot's intervention, did not seek crew input to his decision, nor viewed the cockpit video.

There was no written counselling and no filed report, and the squadron commander did not pursue the issue with ACC. However, he did decide to fly with the captain as co-pilot whenever he flew – a fatal decision.

The set-up

Planning for the Fairchild AFB 1994 annual airshow began in April. Surprisingly, the accident captain was again chosen to fly the display, because he was experienced in the show routine as he had flown it many times before.

There was no objection and no other pilots were considered. On 15 June, the show profile was reviewed, including steep turns, high pitch-ups and formation flying with a KC-135. The ops group leader rejected the profile and the accident pilot was informed: "there were to be no formation manoeuvres, no high-bank angles greater than 45 degrees and no pitch-ups over 25 degrees". Again, no airshow approval was requested from higher authority.

On 17 June, the first practice routine was flown with two show profiles, each following almost exactly the pattern as flown on the day of the accident.

Both violated the wing commander's guidance, but the co-pilot (the squadron commander) amazingly reported "the profile looked good to me; looks very safe, well within parameters".

The wing commander, busy with other matters, saw only a portion of the practice and, trusting the advice from his CO, let the matter ride.

How to impress other pilots and ice-cream lickers...

GPCAPT Dennis Tan
Director Defence Flight Safety Bureau

THE ARTICLE TITLED 'How to impress other pilots and ice-cream lickers...', which I'd written as a DDAAFS desk officer was published in this Focus Special in 2007. The premise of the article was simple enough, "Aim for perfection within the cockpit at all times and always work within the bounds of your authorisation and the limits of your aircraft. Just don't get hung up on trying to impress other pilots because you never will".

That is to say that the general public, aka ice-cream lickers, will always be impressed by your performance at an airshow, even with the most basic of manoeuvres, so you don't need to break the aircraft or yourself to impress your audience. Let's face it, a military aircraft is an impressive piece of machinery and the people who operate, maintain and control them are equally impressive. I'd add too that pilots will generally not let you know that they are impressed by your flying, either because they're actually not, or because they don't want to give you the satisfaction...it's a pilot thing. So, focus on the mainstream audience, the ice-cream lickers, turn some gasoline into noise and show off some of the highlights of the aircraft and you'll be their hero.

As I reflect on the past 15 or so years since writing that article, it's been confirmed for me on so many occasions that these themes of staying within your limits and those of the aircraft are timeless. Stay within your limits; be mentally prepared; be prepared to say 'NO' or even 'YES, BUT...'; and stick to the rehearsed and authorised plan...

Here's an excerpt from the original article:

"Consider what impresses the ice-cream lickers. The fact that you've just turned up wearing a uniform and flying a military aircraft is usually enough. So, there is no need to pull a six–G turn to show how hard you can turn. A four–G turn looks just as tight from the ground and the ice-cream licker won't even know the difference. Come to think of it, from the ground, most pilots can't tell the difference either. Besides, it gives you a margin to play with in case you ever need to turn harder because of an on-crowd wind.

If you are flying a hesitation roll, do a four pointer rather than an eight or 16. It still shows off all sides of the aircraft, will generally be a little less fatiguing on the airframe and, chances are you'll be able to get it right every time. If you think that ice-cream lickers aren't impressed by straight and level, watch the reaction of the crowd when a Hornet flies past straight and level at 500 ft and 500 kts. They just love it.

"Geez mate! Now there's a bloke who roolly knows how to fly." you'll hear from the petrol heads at the V8 supercars.

Years later, I worked my way through the ranks of the Roulettes and eventually became the Roulette Leader and I applied those same ice-cream licker principles. And yes, the feedback from the ice-cream lickers was never any different. They always liked the basic stuff. Just seeing the six aircraft in a triangle shape (wedge) was what the punters liked. People didn't seem concerned at all that we'd removed the low-percentage Vic-barrel rejoin from our display (which is another story in itself).

The complex formations generally containing line abreast formations like Delta (upside down triangle), Card Five, Six Pack or Leader's Benefit rarely rated a mention but relied on the superior skills of my wingmen. And, I've lost count of the number of times that ice-cream lickers have asked all about the impressive manoeuvre right at the end of the show. "Well, ma'am, we call that pitching into the circuit to land".

Working within your limits

REFLECTION by WGCDR James Gotch

WINGS OVER ILLAWARRA is Sydney's air show and the organisers take it very seriously. The array of aircraft is particularly impressive, consisting primarily of warbirds and light civilian types. Throwing a C-17A into the mix would be a marked change of pace and the crew and I were eager to show our favourite aspects of the aircraft.

In conceptualising our routine our first idea was to stick to the aircraft's strengths. The C-17A is one of the few heavy aircraft in the world that performs normal ops at 300 ft and up to 350 knots. However, its ability to use reverse thrust airborne, was probably less appropriate and its short-field capability would have left the organisers with a severe runway repair bill. Regardless, the aircraft possesses relatively high roll-rates, a readily useable ramp/door system and appreciable noise.

The second idea was to use normal manoeuvres and flight profiles. There are plenty of low-level, tactical options that we practise often in the C-17A. All we needed to do was link them efficiently to create the display. Regardless of how tight we kept the turns and changed our velocity, there was always going to be some dead time between passes. Minimising that dead time in a large aircraft is difficult, and doing so may have compromised the quality/configuration of the subsequent passes.

We discussed doing figure eights or steeper turns to minimise the impact, but this did not conform to anything standard and did not fit our philosophy.

This narrowed our options down to three sequences linked together to make up seven minutes. A high-speed, low initial and pitch, followed by a ramp/door open dirty pass, followed finally by a steep approach to assault landing with a low go around (max thrust) for tactical departure – yes, in a big jet that takes seven minutes.

The work up consisted of one simulator session and one aircraft sortie around Amberley. This proved to be the right amount as we could fully explore the extra challenges associated. Chiefly, this was the terrain/airspace/weather awareness (best explored in the simulator) and crew co-ordination (best explored in the jet with all members on headset). The pace associated with running multiple checklists in a short amount of time severely detracts from crew SA and we discussed how we could minimise the checklists needed throughout. There are obviously non-negotiables dependant on OIP, but we looked closely at verbalised versus non-verbalised actions to free up brain space. A further example of why early crew assignments are ideal for a display crew.

While seven minutes was perfectly appropriate for our display, many other displays that day fell slightly short of their allocated bracket and, after inevitable cancellations, the show began to run unacceptably ahead. After the last pass, the ringmaster asked us if we could repeat our display. I replied with a regrettable no, as any variation would be an authorisation breech.

It turned out that my CO, who was also the authorising officer, said he was perfectly happy were I to repeat the display without consulting him first and this featured as part of the following day's authorisation.

When you step into the aircraft, you and the authorising officer should be completely synchronised on the proposed sequence. Sometimes there will be requested variations to your show before, and even after the event. The real prowess lies in having an authorisation that builds confidence for what is acceptable.

There was real value from the main lessons learnt from this show. The mission turned into a task with cargo that, in hindsight, I do not think defensively keeps the display at the lowest risk SFARP. This profile is already quite rare among the heavy aircraft world, so it is difficult to warrant further distractions.

Was I the most appropriate captain for this display? Possibly not. I was a flight commander at the time with the usual steady but high workload, and I was not as current/qualified as others were. Though in the context of who was available, how much notice would they have, and what total experience was on offer, then it becomes more reasonable. I had three weeks of assuredness in the lead up that I would be flying the display, proving plenty of time for planning, liaising and designing. This made me a better choice than the more experienced and recent captains in this instance.

Lastly, it's important to build in fat to ensure errors are difficult to notice. I managed to overshoot centreline on one pass, but my skills (or lack thereof) were more to blame than the lack of turn room. Regardless, no one would notice from the crowd line. The 5 nm run-in, wider circuit spacing and standard manoeuvres meant we had levers at our disposal, creating a comfortable, visually impressive and fun display. Make your plan flexible enough to adapt to the conditions of the day and stick to it.

Globally, the last fatal C-17A display accident was actually a work-up sortie for the 2010 Artic Thunder Air Show conducted by the USAF. While our USAF cousins do business slightly differently, it is difficult to imagine any authorising officer being happy with the notion of retracting flaps and snap rolling well below the minimum manoeuvre speed. This was well beyond aircraft limits and ultimately, it cost that crew their lives.

A superior pilot should never have to use their superior skill

By WGCDR Grant Taylor

SIXTEEN YEARS HAS passed since the Roulette collision in 2005 and I was approached by DFSB to write some thoughts regarding my experiences with display flying – how that has influenced my own flying, and more importantly, the supervision of others when conducting displays.

I have always been struck by the occurrence of fatal CFIT at airshows, by pilots who were current, highly proficient and knew the task they were to undertake along with the location and the weather. It was certainly something that was front of my mind as I progressed through the cat scheme becoming senior enough to lead flypasts or perform handling displays.

I was very conscious of the tragic history of pilots who, for no apparent reason, had lost enough SA to crash during a sequence – which they would have practiced many times. Instinctively I knew that it was the distraction/focus of wanting to put on a good show but how did all of the checks and balances, the margins and buffers seem to fail when it was show time?

I found out how when conducting a flypast for a memorial service at Kings Park in Perth.

I was tasked to lead a four-ship to overfly the War Memorial for a set time on target. Fairly straight forward. I was aware of the strengths and weaknesses of the route I had been given and practiced in the sim with the worst-case weather and a strong Fremantle doctor pushing me towards the city – which I would be turning belly up to. I had briefed to all of this and the wingmen were ready for a tightening turn to overfly the memorial at 250 ft.

Better to reduce the commitment than increase the risk.

I broke on start and sent the three-ship down to the hold while I jumped the spare and then raced down to meet them, rejoined and slotted in out the front with half a hold to push.

There was no doubt that I was rushing, and I felt rushed too. I thought knowing that was enough SA to have dealt with it.

We pushed on time and started the run in. As we approached the city I started my turn left to line up on the target from the east. I was looking into the turn and trying to be as smooth as I could for the formation. I was also aiming to be 250 ft over the memorial – the failing was, I planned to do it visually. And the problem with looking into the turn and being smooth was that we entered a slow and gentle descent, which I didn't pick up on initially.

Furthermore, since I hadn't calculated an AMSL height to overfly the memorial I didn't pick up that I was now lower than I needed to be.

As we rolled out over the Swan River I picked up the memorial... and then the bloom of the hill and trees behind rising up. I pulled up as smoothly as I could and crested the memorial around 150 ft. Untidy... impressive, but untidy. One of the olds and bolds later said as I was beating myself up, "no one lost an eye", but it wasn't through good planning. A little more nose down, a little more speed, a little later reaction and I could have been 'that guy'.

One of the things that struck me in the subsequent investigation was how each member in the chain felt the close call was their responsibility. I felt 100 per cent responsible (and still do), the AUTHO felt 100 per cent responsible and the wingmen also said they had a part to play. That was the outcome, so what was the root cause and what is the fix?

Looking back, I had not planned appropriately. The orders said we could a 200 ft flypast. I was used to 250 ft so I went for that, somewhat naively thinking that my judgement would be enough. What I needed to do was convert that 250 ft AO into an AMSL number, which I could reference at any stage of the turn to quantify where I was reference the target.

This is something I have incorporated into my approval and authorisation process when supervising flypasts as an XO and CO. The Kings Park incident happened 15 years ago, but it still burns me and I don't wish that sort of self-loathing on anyone. Each target needs to have an AMSL number, which the pilot will be aiming for. Judgement is not good enough.

Further on in my career I started to conduct low-level aeros in the Hawk. Having already been burnt by Kings Park I was diligent and read up on the incidents involving crashes at venues. The things that stuck out were – pull-through manoeuvres, QNH/QFE screw ups and the relationship between them both. The good thing is these can be addressed in planning.

The Hawk display has looping manoeuvres, but not where a full 180 pull-through from the horizon is required. Conversely, fatal display crashes usually involve either a barrel roll a Cuban 8 (or reverse Cuban depending what your pilots course called them). Examples are the Thunderbird ejection and the A4 crash in Nowra. The planning set up is this – If you have a pull-through manoeuvre planned, then you need to fly to an appropriate gate height before committing to the pull.

If your QNH has been set incorrectly – such as to airfield elevation – then you've just robbed yourself of that height, possibly to your demise. You now rely on judgement to save things. With you only being 'half a pilot', this judgement might not be enough. From a supervision point of view I will not only quiz the pilots on how much QNH they intend to wind off, I want to know where they intend to do it and what triggers they have to remember. All of these are captured in procedures; however, we humans are fallible and display flying is unforgiving. More layers of process are not necessarily better but hopefully ensure that when a pilot has sacrificed half their brain due to being in front of a crowd, they have that to fall back on.

I'm thankful that so far these lessons, which I had the displeasure to either experience or read up on, have served me, and more importantly, those who I have authorised, well. From a supervisory point of view my first point about being half the pilot holds true when assessing the task to be completed. Complexity and flexibility needs to be critiqued with the knowledge that the person or people standing in front of you waiting to authorise will be half the pilots when they are overhead. Unless they are psychotic they will be affected. The plan needs to cater for that fact. Last-minute changes may be required, don't be afraid to do so if it seems like everything needs to go perfectly for the flight to succeed.

My take aways are these:

- Work out any AO heights as AMSL numbers to fly. Judgement is not to be relied upon when you are half a pilot.
- Display design is critical to taking out pre-conditions for QNH screw ups or altered start heights.

The plan needs to be robust enough to survive the fact the crew standing at the authorising desk will not be the same crew mentally when they are on display.

"A superior pilot should never have to use their superior skill."

This quote was written on a note on the wall of the XO who authorised the Kings Park flypast. It has stuck with me, I hope it will stick with you too.

PUSH PULL: a medical perspective

By Dr Bob Banks MD

PILOTS KNOW ABOUT G in general terms. Pull the stick back and houses get smaller, positive G (+G) increases, blood goes to the feet, vision turns grey (greyout), or tunnels, or even turns black (blackout). If it continues long enough, G-induced loss of consciousness (GLOC) occurs and you rubber chicken. Do the anti-G strain.

On the other hand, push the stick forward and houses get bigger, negative G (-G) increases, blood goes to the head, eyes bugout. Don't do the strain.

Is that about it? Perhaps, but research has identified something else – the push-pull effect. Consider the following true incident. The instructor took control at 19,000 ft to set the student up for the next manoeuvre. He applied burners, pulled the nose up, then pushed forward into a zero-G, maximum acceleration climb. Maintaining the zero G, with full burner, he rolled inverted, then started to pull the nose down to the maximum G available: about +2 to +3G. The aircraft continued to accelerate through 500 KIAS and broke the 14,000 ft floor of the training area before the student questioned the instructor's actions. There was no response from the back seat. Taking control at 12,000 ft, the student completed an aggressive recovery. The instructor's voice came up on the intercom several seconds later.

Pilot incapacitation due to GLOC? The student thought so. What the instructor thought was not recorded, although amnesia from GLOC is common, and possibly he was not aware. But...GLOC at +2 to +3G?

For several years a few flight surgeons wondered about something that many pilots knew – initial, or starting-G level affects +G tolerance. Starting from zero G, or -G, instead of +1G seemed to decrease G tolerance.

Although not taught in aeromedical training, many pilots learnt to cope. Snowbird [Canadian version of RAAF Roulettes] solo pilots reported that they sometimes hesitated after -G flight to let the body catch-up before pulling hard +G. Top USA competitive aerobatic pilots reported that they trimmed the aircraft to keep flying while they GLOC'd during +G loops that followed -G, clearly not a desirable flying situation. These clues to a problem led to research.

The initial study was conducted at Moose Jaw, Canada. Pilots were wired-for-sound and exposed to flight conditions that included -G. When the data was analysed, it was found that the heart slowed down dramatically during -G (within two seconds), and was comparatively slow to recover during +G that followed (six to eight seconds). This time difference was thought to be the cause of lowered +G tolerance when +G followed -G.

Additional research at the US Navy laboratory in Pensacola, Florida showed that G tolerance was significantly reduced by preceding zero or -G, and that this reduced tolerance was worse with more -G, and more time exposed to the -G. How much tolerance was lost? The average amount of +G tolerance loss among the 12 volunteers was 1.3G in the worst conditions (going from -2G to +2.25G). However, some individuals did far worse. When going from -1G to +2.25G, one subject lost nearly 4G of tolerance, experienced total loss of vision, and was very close to GLOC. In one experiment, 50 per cent of the 12 volunteers greyed-out at +2.25G after -2G.

The results were clear and confirmed that +G tolerance depends on the starting -G, and is lowered if you start from zero or -G. Since -G is commonly achieved in many aircraft by pushing forward on the stick, and +G by pulling back on the stick, this loss of +G tolerance was called the push-pull effect.

Further work has shown that women seem to tolerate push-pull effect better than men. This was found to be due to differences in height and it seems that tall people are more susceptible to push-pull effect than short people. The anti-G strain was found to be effective in countering the problem, but the strain had to be started early and maintained for the entire period the pilot was under increased +G.

Has push-pull effect caused aircraft accidents? Almost certainly, although direct evidence is difficult to obtain. US civil aviation, through the investigative functions of the FAA, has implicated push-pull type manoeuvres as causal to some accidents. Until recently, push-pull effect was not implicated as causal to any military accidents, although several fighter accidents seem to have involved push-pull type manoeuvres, including some Hornets. There is speculation that it may be a hazard in nap-of-the-earth attack aircraft, both fixed-wing and rotary-wing. Many accidents in this mission environment remain unexplained.

In summary, a problem has been identified regarding +G tolerance: the push-pull effect. Thus, pilots should consider the starting +G, in addition to magnitude of +G, rate-of-onset and time of exposure, when considering their ability to tolerate +G. In addition:

- push-pull effect is worse with more -G
- push-pull effect is worse with longer duration of exposure to -G
- the anti-G strain manoeuvre is at least partially successful in countering the problem, but relaxation during +G may allow push-pull effect to return; and
- tall people may be more susceptible to push-pull effect.

About the author: When he wrote this article, Dr Banks was head of Aerospace Life Support Sector, Defence and Civil Institute of Environmental Medicine (DCIEM), Canada

BRAIN DRAIN

When under positive-G the baroreceptors in the neck sense the flow of blood out and contract the veins in order to minimise the blood lost from the brain. This is the reason a G-warm exercise is conducted at the beginning of high-G manoeuvring, to warm up the baroreceptors and decrease their time to initiate the contraction.

The converse is true for negative-G. The baroreceptors sense an increased flow to the brain (rising blood pressure in the brain) and open up the veins in order to reduce the amount of blood (that's great, but it doesn't know that you're upside down or doing bunting manoeuvre).

The so what for the push/pull effect is this. Imagine a manoeuvre that has triggered the body to want to drain blood from the brain so much so that it has opened up the pathway for this to happen – only to then fly a manoeuvre that is going to exacerbate the amount and rate of blood lost. The body isn't going to be able to keep up and it is here that the push-pull effect is at its most dangerous as the chances of GLOC are extreme. Combine that with being close to the ground and it's a very dangerous situation.

From my point of view doing display flying in the Hawk we had an inverted pass followed by a break back into the sequence away from the crowd. I was extremely cautious when rolling upright and applying G to the break. I would wait a second following the roll upright, strain and then smoothly apply the G. Any instance of grey out saw me stop the pull. I also ensured the break was done in a climb away from the ground to provide some margin if I didn't/couldn't manage the G onset.

– WGCDR Grant Taylor

Red Arrows Accident

GLOC during pitch to land

By SQNLDR Martin Keer

A TRAGIC ACCIDENT INVOLVING a friend and colleague in 2011 serves to highlight the inherent risks with display flying that pilots and supervisors should always be conscious of. Red 4 of the Royal Air Force Aerobatic Team, the Red Arrows, had just flown a successful display at Bournemouth seafront in the UK. During the pitch to land following the display, Red 4 suffered supposed G-LOC and the aircraft crashed in open farmland. How was it that an experienced fighter pilot and consummate professional lost his life in such tragic circumstances?

On the morning of 20 August, Red 4 had completed an 8 km run before breakfast. Was the potential for a reduced G tolerance from dehydration considered by the display supervisor? The display on 20 August was the first time that the pilots' partner had attended a display with him. Because of this was there an unusual sense of euphoria post-display that could have distracted Red 4 from completing the correct AGSM during the final pitch to land? Would you have given consideration to this point if it had been you authorising the display?

It was interesting that during the pitch the pilot was exposed to 6.237 G, with the exposure time of more than 3 G equating to 8.75 seconds. This was the highest combination of absolute Gz versus exposure for the whole sortie, including the full display routine. When questioned during the inquiry, some of the Red Arrows pilots thought that display manoeuvres would expose them to higher risk of G impairment than the pitch to land. It was also found that the thigh zips of the pilot's G-suit were not fully zipped up and were a factor in the accident. How often do we as pilots and supervisors carry out buddy-buddy checks of our safety equipment?

The display team pitched to a downwind height of 500 ft. It was reported that had the downwind height been 1000 ft or higher it was likely that Red 4 would have had sufficient time to recover the aircraft. It is interesting that something as seemingly innocuous as the downwind height following the pitch would likely have changed the outcome of the situation. Would this aspect of the sortie been relevant to you as a supervisor?

Interestingly, there had been a number of G-LOC occurrences throughout the RAF during previous years. A number of these had been discussed at unit level and procedures amended locally in an attempt to prevent recurrence. However, the incidents were never formally recorded and little, if any, corporate knowledge remains of the events.

More often, lessons drawn from accidents have an enduring quality. It is in this context that they are highlighted in order to prevent recurrence and enhance air safety within the display flying arena, but also the wider Air Force. The RAF Service Inquiry into the incident surmised that the "potential for such an accident could have been identified more clearly in advance and more effective mitigations put in place".

As supervisors, there is the potential to focus on the most intense aspects of a flight or a display routine or those aspects that are perceived to have the highest risk. In this example it is not only the high intensity of a full display that deserves the focus of a supervisor. More, the seemingly benign transit post-display and the subsequent benign pitch to land. G-LOC was the cause of this accident; however, what other factors are we potentially complacent about during recovery or transits after the big event?

The convening authority comments in the Service Inquiry are of particular relevance to display flying and to us as supervisors.

"Elite units, and perhaps particularly so, require a healthy degree of external oversight and assurance that mitigate the chronic risk that over time 'we're different and we do it this way', supplants prudent and probing critiquing of procedures, techniques and standards".

"This occurrence must serve as a salutary reminder of the vital role an actively questioning and conscientious mindset in supervisors plays as an essential defence against the thinkable. Such questioning must not be constrained by artificial, or even convenient boundaries, but should be cast widely, pursued with appropriate vigour and be exhaustive, if only to ensure that the truly relevant risks are captured fully – this activity may be labour intensive and, at times, a seeming distraction from other priorities but the potential consequences of deficiency in this area have been painfully exposed in this accident and it must therefore always be accorded appropriate emphasis in future".

Unauthorised flypast

Point Cook 1983, Porter A14-702

DEPARTING RAAF BASE Laverton, the pilot intended to conduct a low-level flypast at RAAF Base Point Cook before continuing on to Canberra.

On contacting Point Cook Tower, the pilot requested permission to conduct his flypast, but below 200 ft above ground level (AGL) rather than the previously cleared 200 ft. Tower advised that there was no traffic in the area and that he could operate unrestricted.

The aircraft was seen approaching the base at a very low altitude, climbing to clear trees along the perimeter fence before entering the Point Cook area. The aircraft flew along the northern taxiway towards the Number One Flying Training School (1FTS) building, where the students had gathered to watch the flypast.

During the flypast the aircraft was observed flying at an estimated 60 knots and below the highest point of the hangar roof (measured at 25.3 ft). The aircraft continued on this track until close to the Point Cook control tower, where it then climbed to clear a wind sock (47 ft high) and commenced a left turn around the control tower.

As the Porter climbed over the wind sock it began to turn left sharply and appeared to be buffeted by the gusty wind, which at this stage would have been against the entire underside of the aircraft. During the turn, the aircraft lost height. As it descended, angle of bank was reduced but the left wing hit the concrete runway in front of the control tower, followed by the nose and left wheel. The Porter slid a further 65 m onto the grass.

The left wing-fuel tank ruptured and the ensuing fire was brought under control within two minutes by a responding fire tender. Two doctors and a number of medical assistants responded to the crash alarm and were on scene within three minutes of the crash. However, the pilot died at the scene.

Crew

Pilot. Category B 2217 hours total with 1187 hours Porter.

Accident summary

The flight was to be the first of a two-stage redeployment to Oakey with Canberra as the intermediate overnight stop. The pilot had been participating in a task in the Melbourne area for the preceding five days and had spent the previous night at Laverton. The flight plan for Canberra was submitted with Laverton operations that morning.

The pilot's intention for a display at Point Cook was not included in the flight-plan details but he sought clearance for the display when making his taxi call to Laverton Tower. Point Cook Tower issued a clearance via Laverton Tower for the aircraft to fly past at 200 ft AGL.

On contacting Point Cook Tower, the pilot requested clearance to conduct two passes below 200 ft AGL in direction 230 degrees magnetic. The Tower cleared him to operate in the circuit area unrestricted.

Evidence indicated that the aircraft entered the Point Cook airfield boundary below 200 ft AGL and proceeded along the taxiway and parking areas below 50 ft AGL. The aircraft manoeuvred to conduct a tight left-hand turn around the tower and shortly afterwards was seen to impact the ground and burst into flames.

Investigation points of note

Flypasts at Point Cook. At the time, it was practice that different types of aircraft conducted approved flypasts of RAAF Base Point Cook. This was normally a local arrangement, authorised by the Point Cook Air Staff Officer and designed to provide interest for the student pilots and a degree of incentive during their training. The Formation Standing Order (Point Cook) limited overflight to a minimum of 200 ft.

Authorisation. The pilot had been authorised to operate in the Melbourne area by the tasking Operation Order, which restricted operations to not below 200 ft AGL except on landing and take offs. Although the pilot could self-authorise flights in relation to the tasking, he was not able to authorise flypasts and displays, or flights below 200 ft AGL in non-designated low-flying areas.

It was common knowledge within the pilot's squadron, that special requirements and authorisation for flights into Point Cook were required, in that pilots were to receive a comprehensive briefing by the senior Army member at 1FTS. (The pilot had attempted to contact the senior Army member prior to the flight but the member was unavailable at the time the phone call was made.)

Pilot history. The pilot's recent experience was extensive and consisted of mainly low-level night operations. He had no recent display-flying experience. He was known to be careful and thorough in conducting his flying operations and had not previously been known to engage in flying of an unauthorised or flamboyant nature.

Contravention of Orders. The overflight of Point Cook below 200 ft AGL by visiting aircraft contravened one of the orders within Formation Standing Orders (Point Cook). It also contravened one of the Army Flying Orders, which prohibited low flying outside designated training areas (of which Point Cook airfield had no such classification) and another Army Flying Order that required authorisation, rehearsal and briefing for any display. Contravention of these regulations was considered by the Court of Inquiry (COI) to be a contributing factor of the accident.

Psychological factors. The investigation attempted to understand why the pilot elected to conduct a low-level flypast, knowingly in violation of accepted procedures. While the reasons for the pilot doing so would never be known, the investigation acknowledged the friendly rivalry that had always been a feature of RAAF-Army aviation relations.

Three weeks before the accident, aircraft from 1FTS visiting Oakey conducted a low-level approach over the pilot's squadron crew room. Such occurrences were not considered atypical. In conversation with a gathering of fellow Army pilots in the Point Cook Officers' Mess the evening before the accident, the pilot commented on his disappointment with the lack of flying involved in the Melbourne task, as well as his imminent non-flying posting, which he was not looking forward to. (The return flight to Oakey was to be the pilot's last flight prior to posting.)

Low-level flypasts at Point Cook were also discussed, potentially initiated by the pilot's flypast in a Nomad aircraft over Point Cook that afternoon at 500 ft AGL. When notified on the morning of 07 December that the final flight of the original task was cancelled, the pilot decided to redeploy back to Oakey via Canberra. His passenger, a squadron maintenance member, decided to fly direct to Oakey in another aircraft.

The Court of Inquiry (COI) considered that the emotional causes for the pilot to conduct the flypast were such that when these last two constraints were lifted, he was more than likely determined to fly over 1FTS.

Dashed line indicates aircraft flight path.

Weather. The weather at the time of the accident was recorded as wind 210/20 kts gusting to 30 kts, 7/8^{ths} cloud cover at 3000 ft and 30 km visibility. The wind was considered a contributing factor in the cause of the accident.

The wind strength and direction, when coupled with the associated mechanical turbulence in the lower layers generated by the hangars and other airfield structures in close proximity to the manoeuvre, was deemed by the investigation team to be sufficient to make conditions unacceptable for high angle of bank, close to stall-speed manoeuvring.

Stall speed. The investigation noted (based on interview of the experienced pilots and air traffic controllers that witnessed the accident) that the final left turn was flown in a slight climb at approximately 70 degrees angle of bank. The stall speed of a Porter at the estimated 5000 lbs all up weight (AUW) in a 70 degree level turn was calculated at approximately 77 kts.

The investigation team noted that, even ignoring the slight climb, aircraft parameters only left a 5 kt margin to the flap-limiting speed[1]; a speed the pilot's training would see him not intentionally exceed. Stalling was deemed the only explaination for the high-rate of descent of the aircraft about half-way around the Tower.

Court of Inquiry findings

The COI made the following findings:

The primary cause of the accident was the pilot electing to disobey orders by conducting an unauthorised flypast. The final manoeuvre he attempted exceeded the capabilities of the aircraft in that: he attempted to turn the aircraft too tightly which resulted in a stall, and he allowed the aircraft to reach an excessive angle of bank and rate of descent at an altitude too low to permit recovery.

The pilot's decision to conduct the flypast and the impromptu seeking of clearances by telephone and radio just prior to the flight made it difficult for the staff at RAAF Base Point Cook to confirm that he intended to comply with Formation Standing Orders (Point Cook) relating to flypasts.

Court of Inquiry recommendations

COI recommendations included the following:

- Flypasts at RAAF Base Point Cook continue but when the pilot of an overflying aircraft first makes contact with Point Cook Tower by radio, the Control Tower should confirm with the pilot that they are aware of the provisions of Formation Standing Orders (Point Cook) OPS 4-3 relating to flypasts by visiting aircraft.
- A thorough investigation of the existing harness and pilot-restraint system be carried out including:
  - instituting a serviceability test for all inertia reels of this type, including a regular servicing schedule; and
  - the fitment of a five-point harness system to Porter crew seats so as to improve pilot restraint and survivability in the event of a crash.

Applicability to current operations

The practice and associated culture of pilots demonstrating their flying abilities by putting on a show at the end of their *fini* (final) flight before proceeding on posting continued into the 1990s. The change of culture and attitude to aviation safety in the late 1990s was a significant factor (and continues to be so) in maintaining a low accident rate compared to that of the past.

To say that there is no possibility of an occasional pilot conducting an unauthorised impromptu air display, beat-up or flypast would be naïve; however, to stray outside the well-defined boundaries of aviation is not only illegal but also increases the risk of an accident.

References

[1] The flaps were observed to be lowered during the manoeuvring.

Risk controls in display flying

By SQNLDR Garry Downes

IN THE PAST we've simply used phrases like 'see and avoid' as a catch-all risk control for display flying. It's a valid principle but is only one risk control and is the last line of defence.

Defence has a moral and legal obligation to ensure risks to the health and safety of personnel, arising from all military environments, tasks and operations, are eliminated. If it is not possible to eliminate risk, Defence is obligated to minimise it so far as is reasonably practicable (SFARP). The basis for these safety obligations is found in *Commonwealth Work Health and Safety Act 2011*.

Risk management is to be applied to all Defence aviation activities, integrated into decisions for planning, approval, review, implementation and execution of all tasks/activities, at all levels.

Elimination

Assessing opportunities to eliminate risks to health and safety SFARP is the first step in risk assessment. For mid-air collision (MAC), the hazard is an aircraft in motion – own aircraft and other aircraft.

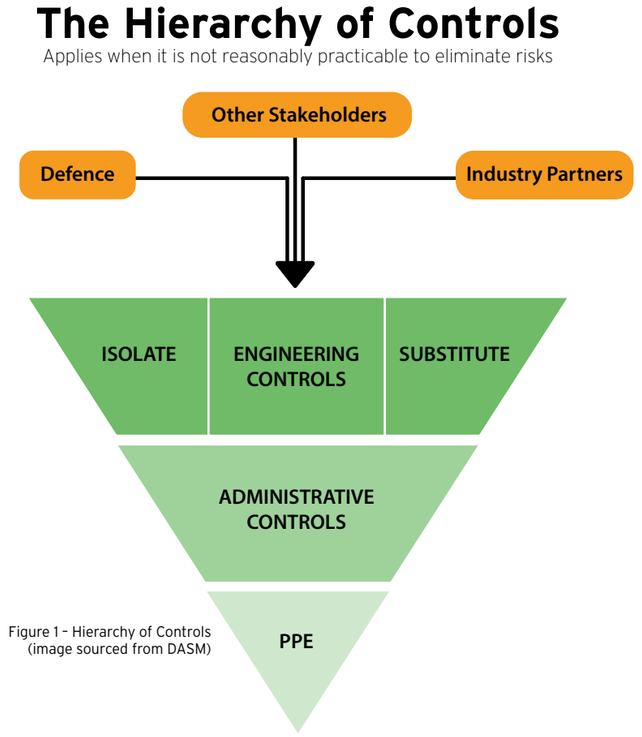


Figure 1 – Hierarchy of Controls (image sourced from DASM)

The risk is two (or more) aircraft colliding. The consequences are variable – the aircraft is uncontrollable leading to flight into terrain, or the aircraft is controllable and able to land, either safely or unsafely (runway excursion). Which outcome; however, depends on the circumstances of the display activity – context is everything. For example, a single-ship flypast is very different to the ADF showcase for an Avalon International Airshow.

Elimination requires the hazard to be removed. With the hazard being other aircraft and without the ability to remove other airspace users, elimination of the hazard/risk may be difficult without taking the step to not conduct the activity at all.

Minimisation

The Hierarchy of Controls (HoC), figure 1, is only utilised where it is not reasonably practicable to eliminate risk.

In minimising risks SFARP, members must consider the risk-control measures in accordance with the HoC. Doing so ensures application of the most effective controls – sometimes referred to as Hazard controls (substitution, isolation, engineering controls) – are considered first. Then we can work through less effective alternatives – sometimes referred to as exposure controls (administrative and personal protective equipment (PPE) controls). In practice, a combination of controls is likely to be required to minimise the risk SFARP.

Substitution

A 'substitution' control requires that the hazard giving rise to the risk is substituted (wholly or partially) with something that gives rise to a lesser risk. Given the hazard is an aircraft in motion, substitution is not a reasonably practical control option.

Isolation

An isolation control requires that the hazard be isolated from any person exposed to it – this involves physically separating the source of harm via distance or utilising barriers.

Isolation of the hazard (an aircraft in motion) may be achieved by implementing airspace measures such as the promulgation of a Temporary Restricted Area (TRA) or Temporary Danger Area (TDA). But doing so doesn't necessarily guarantee isolation of the threat. An aircraft is free to move in the air. A TRA or TDA isn't a physical barrier, therefore, an aircraft may bumble through the exclusion zone or a hobbyist's unauthorised drone may pop up unexpectedly.

Such an occurrence with a drone happened during the final round of the Supercars Championship held in Newcastle in 2019 when an unauthorised drone was spotted over the track. It was detected in close proximity to the RAAF FA-18 Hornet aircraft display flight.

Engineering controls

An engineering control is physical in nature, including equipment/devices (electrical, mechanical), software update, guards, et cetera.

Modern aircraft may be equipped with a range of sensors that could assist with detection of aircraft and advise the crew if a collision risk is sensed. Alternatively the on-board equipment may simply draw the crew's attention to a space in the sky to assist with visual acquisition. Examples of such technology is the Traffic alert and Collision Avoidance System (TCAS) and Automatic Dependent Surveillance–Broadcast (ADS–B).

TCAS is an aircraft collision avoidance system designed to reduce the incidence of mid-air collisions between aircraft. The system interrogates transponders of aircraft in the vicinity to issue two types of alerts to the crew:

- Traffic Advisories (TA) to help the pilots in the visual acquisition of the threat aircraft.
- Resolution Advisories (RA) which are manoeuvres to avoid MAC.

ADS–B uses satellite navigation to broadcast an aircraft's position. Doing so enables air traffic control ground stations to track the aircraft. The broadcast can also be received by other aircraft and provide situational awareness and self-separation.

Although these technologies provide situational awareness of potential airborne threats, these engineering controls may not be available in all platforms.

Other engineering controls that may be available include radios and air traffic control surveillance information, and drone detection equipment.

Administrative controls

If a risk remains after considering substitution, isolation and engineering controls, the risk must be minimised SFARP by implementing administrative controls.

BLUF: improve the way activities are performed. An administrative control includes methods, procedures, warnings, signage, and training designed to minimise exposure to a hazard. A broad range of administrative controls may be possible. For flying displays, administrative controls are most likely to be included in regulations and orders, instructions and procedures (OIP).

Regulations

Whether it's the CASR or DASR, or both, regulations are made to set out the safety standards required in relation to aircraft airworthiness, qualifications of flight crew and maintenance personnel, air traffic control, rules of the air and other safety issues. Within the Defence context, *DASR SPA.30 FLYING DISPLAYS AND FLYPASTS* is the applicable regulation, with supporting AMC and GM.

OIP promote the attainment of a known level of safety for aviation operations, rules by establishing boundaries for conduct of aviation operations. DASR SPA.30 requires that the Military Air Operator (MAO) and establish a system that ensures aircraft conducting flying displays do not compromise the suitability for flight. It is therefore likely that many aspects of administrative controls are implemented in that system and recorded in standing instructions.

One important control is non-technical skills (NTS). When it comes to display flying, particularly for large events such as the Avalon International Airshow, the thorough application of NTS across each participating element (flying crew(s), ATC, ringmaster, supervisor, ground liaison, mission commander, event liaison officers, et cetera) will be an important skill to master.

Personal protective equipment

The last control in the hierarchy is PPE, which should be used along with other controls. From a Defence Aviation perspective, regulations such as DASR ORO.40 – Aeronautical Life Support Equipment will go a long way to ensuring aircrew are adequately protected while committing aviation.

The message

No one factor is likely to be the cause of a safety-related event during a display sequence, rather, a number of contributory factors are likely to combine to create error-producing conditions. Unless you're a Roulette, display flying is not a core mission. Safe execution of a flying display, whether that be aerobatics, a handling display or a flypast, will depend on ensuring multiple layers of controls are determined, implemented and reviewed to mitigate the collective effect and insidious nature of cumulative contributory factors.

The HoC provides the structure to assess suitable controls. The first priority is to eliminate hazards and risks. If this isn't possible then hazard controls (substation, isolation and engineering) are to be considered. Hazard controls such as these require organisational participation and are therefore not quick fixes (generally). After considering these hazard controls, exposure controls are to be considered (administrative and PPE). Exposure controls require both worker and supervisor participation, particularly around individual and team behaviours.

An example

At the Avalon International Airshow in 2019, two risk-of-collision events were investigated. The most significant of these events was a separation breakdown during ADF Opening Display Rehearsal. During the rehearsal, a helicopter element was holding to the north of Avalon in the designated holding area between 100–200 ft AGL. An F/A-18A passed in front of the lead helicopter with a closest point of approach of approximately 300 to 600 ft (100–200 m). The F/A-18A was slightly above the lead helicopter and approximately co-level with a following helicopter.

Can you see the threat(s)?

Key findings included:

- The de-confliction plan failed to provide sufficient separation between the two involved elements for the initial rehearsal.
- All parties formulated information errors (compounded by the briefing location not being conducive to the clear and concise passing of information, particularly those aspects requiring discussion between element leaders.)

Interestingly, and leaning back to see-and-avoid, several helicopter crew members saw the Hornet lead pass in front of the lead helicopter. No helicopter crew saw the second Hornet and neither Hornet pilot saw the helicopter. Don't rely on the last line of defences, use the HoC to ensure a layered approach to risk mitigation in all activities.

SPIN OF THE WHEEL

INTRODUCTION by
AIRCDRE Dave Steele (Ret'd)

IT HAS BEEN nearly 25 years since I called "Smoke on, GO!" for the last time. That evening we celebrated the 25th anniversary of the Roulettes. While a great night and a deserving celebration of a highly successful six-ship display team; there were also reflections on the accidents, including fatalities, that had occurred during those years.

Display flying is demanding and exhilarating, an opportunity to demonstrate to the public our professionalism and our finely honed piloting skills. It should never be dangerous and should remain well within your own personal comfort and skill level.

There should be personal (and team) spare capacity to deal with the unexpected. I speak from experience. As Roulette 1 (R1) my team had an accident during display practice; R6 took about 12 inches off R5's fin (while he was inverted) as they were separating at the completion of the mirror pass at 500 ft departing crowd left. We all got back on the ground safely; R6 via a real glide as he'd had to shut down the engine.

The Roulettes have just celebrated their 50th anniversary. In those intervening 25 years, the Rs have still suffered accidents. What can I tell you that could stop the next accident? I have had plenty of time to reflect on my aviation career these past 25 years.

I consider myself to have been a good pilot and leader. I also believe that at times I was brash and overconfident and even relied on being lucky occasionally. Be confident and assertive, that is what we expect from military aviators. However, be humble enough to work to your limits, rules and procedures – and those of your team. Do not compromise on weather limits or consider something that is abbreviated, unbriefed or unauthorised, or just does not feel right.

You should know when you're at the edge of your manoeuvre envelope; do not be pushed beyond. It takes guts to raise your hand and call "Joker" or to bug out in the middle of a display in front of thousands of spectators. The public expect a professional and safe display. If you can't give them that, knock it off and RTB.

"Smoke on, GO!"

FORMATION AEROBATICS at air displays are events guaranteed to thrill spectators. The pilots and their aircraft typify today's 'daring young men in their flying machines'. However, such crowd-pleasing events are not without an accompanying degree of risk, particularly during display practice sessions, where many individuals are endeavouring to work, seemingly, as one. Following are accounts of RAAF flying accidents during such air-display practice sessions.

Roulettes midair 15 December, 1983

On 15 December 1983, two Macchi jets of the Roulettes aerobatic team collided near East Sale, Victoria. Both aircraft crashed and both pilots, who were flying solo, were killed.

The changeover of the 1983 Roulettes team to the 1984 team had occurred on 21 October 1983. Roulette 1 was unchanged while Roulette 5 became the new Roulette 2. The remainder were all new to the aerobatic team. The show on 15 December was a training sortie – the second full show practice – and was briefed and authorised to fly not below 2000 ft AGL.

The accident occurred in the middle of the display sequence. Following a porteous loop, Roulette 3 positioned himself for the inverted departure opposition pass with Roulettes 1 and 2. Roulettes 1 and 2 were to fly their opposition pass in line-abreast formation from behind the crowd line. This manoeuvre was to be done at right angles to the simulated crowd line with the pass occurring in front of the crowd line. This manoeuvre had been part of the Roulettes display sequence for two years and no problems had been evident in that time.

Meanwhile Roulettes 4 and 5 had completed an opposition pass parallel to the

display axis in front of the crowd line and were positioning behind the crowd line for the next manoeuvre. These pilots were not in a position to see the collision. About 10 to 15 seconds after Roulettes 4 and 5 had completed their opposition pass, Roulettes 2 and 3 collided head-on over the crowd line.

Roulette 1 sustained no damage from the collision; however, the pilots of Roulettes 2 and 3 were killed.

An Accident Investigation Team (AIT) was formed by the then DAFS (now DFSB) and a Court of Inquiry was convened by the Air Officer Commanding Support Command to investigate the accident. The AIT began its investigation late that same afternoon.

Wreckage reconstruction and analysis found no malfunction or unserviceability in either aircraft that had any bearing on the accident. The analysis of the wreckage did show Roulette 3's aircraft (the inverted aircraft) was approximately 40 degrees nose-down in relation to the horizon at impact.

Investigations centred on the reason Roulette 3 was 40 degrees nose-down at impact and why Roulette 1 did not perceive that a collision was imminent and take evasive action from Roulette 3. Roulette 1 in fact noticed nothing unusual with the routine until a very short time before impact when he saw the silver underside of the Macchi rather than the yellow and white upper surface of the wing. This occurred too late to carry out any manoeuvre or transmit a warning call. Roulette 1 did say, that when he had rolled out for the opposition pass, Roulette 3 was heading slightly off track. Therefore, for the collision to have taken place, Roulette 3 must have carried out a track adjustment while flying inverted. One interpretation of the evidence was that perhaps this track adjustment distracted Roulette 3 sufficiently to allow the nose to drop slightly. When this was understood by the pilot, he considered that a collision was imminent and decided to pull clear rather than push or roll upright and pull.

Another aspect examined, concerned the ability of the human sensory system to perceive minor changes in relative motion. The aviation psychologist attached to the investigation provided evidence to show that the change in perspective of Roulette 3 as viewed from Roulette 1 during the initial stages of the manoeuvre could have been below the perception threshold, in other words, the change could be so small that although the eye could see it, it would not be enough to trigger a response from the brain. Additionally, Roulette 1 may have expected to see Roulette 3 in a particular position, which would have delayed recognition of a conflict. Another possible explanation for Roulette 3's actions may have been that as this was his first solo for this particular sequence, when he first saw Roulettes 1 and 2 they would have been above him and descending to fly beneath him. This may have given him the impression that a collision was imminent. Unfortunately no satisfactory explanation for this accident will ever be found and the lessons learnt are not as clear cut as they possibly could be.

Display formation aerobatics is a demanding and exacting profession. There is an element of risk, as there is in all flying, but the margins for error are slimmer than in many of other roles. The selection of crews for this type of flying must be stringent, their supervision must be exacting, their training must be sufficient and their flying professional. On this occasion all of these factors were examined and found correct, and yet, frustratingly, they could not on this occasion prevent a mid-air collision. This type of accident, where no satisfactory explanation can be determined, is rare. The investigation and results are always published for all aviators to read and digest in the hope that somehow lessons can be learnt and as a result, similar accidents can be avoided in the future.

Roulettes midair 10 March, 1988

On 10 March 1988, two Macchi aircraft (Roulettes 1 and 4) from the Central Flying school (CFS) collided over RAAF Base East Sale in Victoria during a Roulettes formation aerobatic practice. Roulette 4 ejected and his aircraft was destroyed on ground impact. Roulette 1 landed his damaged aircraft wheels-up at East Sale, the aircraft sustaining Category-4 damage. Both pilots sustained back injuries, one from the ejection and the other from collision impact forces.

On the day of the accident, the team planned to fly two media-support sorties in aid of Air Force public relations for the Brisbane EXPO '88 Air Display. These sorties were also intended to be in preparation for a display in Canberra four days later. The display was to be video-taped by a commercial television crew and the Roulette 5 pilot was to carry a television cameraman in the rear seat for airborne filming. The team had not practiced during the preceding five days. The entire day was set aside for media purposes with no additional flying duties for team members. The first half of the display sequence was flown early in the afternoon without incident. The accident occurred during the second sortie, which covered the last half of the sequence.

The sortie proceeded normally until, following a loop in long-line-astern, which was performed parallel to the imaginary crowd, Roulettes 1, 2, 5 and 4 commenced a left turn away through 30 degrees. Roulettes 2, 5 and 4 then started moving into close-line-astern. When Roulette 4, who was the last man in the line astern formation, called "In", Roulette 1 called for a formation change into box formation. At about the time that Roulette 4 called "In", Roulette 1 began a gentle wingover to the right, intending to fly back along the imaginary crowd line. Roulette 1 timed his call so that the team could be in box formation at the apex of the wingover. Roulettes 2 and 5 had stabilised in the echelon right and left positions when Roulette 4, rejoining in the slot position, impacted Roulette 1 from under his belly.

Immediately following the collision, Roulettes 2 and 5 broke away from the

formation, their aircraft undamaged. Roulette 4's aircraft became uncontrollable and the pilot ejected. The aircraft crashed in a farm paddock two nautical miles northeast of the airfield and was destroyed. The pilot landed 70 metres away from the wreckage and was taken back to the RAAF base, suffering back and laceration injuries. Roulette 1's aircraft, although severely damaged, was controllable. After a visual inspection by Roulette 2, the pilot of Roulette 1, now in severe pain from impact-caused back injuries, carried out a near-perfect wheels-up landing at the base. The remainder of the formation members landed without further incident. An Accident Investigation Team (AIT) and the board of inquiry (BOI) was formed by the then DAFS and a BOI was formed by AOCSC. The AIT began its investigations the next morning. The cameraman in the rear seat of the Roulette 5 aircraft had videotaped the collision sequence and provided valuable assistance to both the AIT and the BOI.

Collision dynamics

When Roulette 4 moved from long-line-astern into close-line-astern, then into box formation in one continuous movement, he had generated an excessive closure rate. To recover from this situation, he selected idle power, extended his speedbrake and flew to a position wide and deep of the rest of the formation. When he perceived that he was in a stable situation with no relative movement, he selected his speedbrakes in and started to move into position. Due to flying a wider turn radius than the rest of the formation, Roulette 4 was at a higher airspeed. This excess airspeed converted to forward relative motion and, seeing this, the pilot selected his speedbrake out again but quickly found himself in a position where he was able to see Roulette 1's aircraft only forward of the speedbrake, through the top of his canopy. At this point, Roulette 4 maintained his backstick to remain close to the desired vertical plane while Roulette 1 had released a small amount of back pressure to begin accelerating from the apex of the wingover. The overtake continued and just before impact, only the leader's nose was visible to Roulette 4.

Roulette 4 impacted Roulette 1 from underneath, forward and to the inside right, with his vertical stabiliser, left wing and horizontal stabiliser contacting the lead aircraft's right flap, nosewheel bay and fuselage, around the speedbrake area, respectively.

Roulette 4 then pivoted nose-up and, combined with the forward movement, the top of the horizontal stabiliser scraped the right side of the leader's fuselage abeam the front pilot's position, shattering the canopy by striking it beside the pilot's head. Roulette 4's aircraft then continued to pitch up and roll right with the vertical fin, horizontal stabiliser, tail cone, left tip tank and approximately four ft of the engine tail pipe having been torn off. At impact, Roulette 4's relative pitch angle was 20 degrees higher than Roulette 1.

Cause of accident

The primary cause of the accident was a loss of vertical separation between Roulette 4 and Roulette I. This was attributed to Roulette 4 making an error of skill in persisting to rejoin the formation from a dangerous position underneath the lead aircraft, and, due to sensory illusions, maintaining an unwarranted pitch-up command to his aircraft that resulted in the collision. Further, Roulette 4 did not recognise the development of the dangerous situation.

Contributing factors

Pilot experience. Although Roulette 4 was considered to be an experienced pilot, almost all his flying had been conducted in low speed, non-aerobatic, propeller-driven Army aircraft. After transferring to the Air Force, at CFS, even though he had accrued about 750 hrs in Macchi aircraft, he had minimal opportunity to experience either unusual, unpractised or aberrant formation flying in jet aircraft. In the accident situation, he had put himself in a position he had never experienced before, and did not have sufficient background experience to recognise the developing dangerous situation.

Team selection. With heavy CFS commitments and a very busy Roulettes display program for the Bicentenary, team member continuity became all-important, so that extra time and effort would not be required to train new members. Resignations from the Service and posting turbulence reduced the number of suitable pilots to the extent that the team virtually picked itself. The Roulette 4 pilot was, in fact, the only pilot available for that position.

Human factors – closure rate judgment. From a deep belly position, it is virtually impossible to judge closure rate. This position has to be flown while looking up through the canopy. Closure rate is judged by observing the rate at which an object, in this case the lead aircraft or an area of the lead aircraft, is becoming larger. When looking up through a clear canopy, there are no fixed references on the rejoining aircraft to measure this relative rate of size increase. The problem is exacerbated if the pilot fixates on a small section rather than on as much of the other aircraft as is peripherally available. This natural tendency becomes stronger as the distance is reduced. Another cue to closure rate is relative fuselage angles and relative fuselage angular change rate. Looking through the top of the canopy at another aircraft will produce little, if any of this. Furthermore, there is a natural tendency to pull the control column back while leaning back and looking up.

Human factors – visual illusion caused by aircraft pitch. If an aircraft is stabilised directly under another with the pilot looking up through the canopy and the aircraft is pitched nose-up, provided all the other parameters remain constant, a visual illusion of moving rearward is produced. The reverse happens with a nose-down pitch movement. The closer the other aircraft, the greater the illusion.

Peripheral factors

Formation calls. When Roulette 4 moved from long-line-astern to close-line-astern and called "In", Roulette 1 understood the call to mean that Roulette 4 had stabilised in position, whereas, Roulette 4 understood it to mean that he was under control and was in a position to rejoin the formation as it entered the next stage of the display.

Ejection through a shattered canopy. The AIT's examination of Roulette 1's aircraft revealed the canopy had shattered and a very sharp and jagged edge was positioned slightly forward of the pilot's head. Ejection after the collision may have caused extensive leg injuries to the pilot from contact with the edge of the perspex unless the canopy had been jettisoned first.

Ejection procedure. In addition to other injuries, Roulette 4 sustained bruising to his left elbow. This bruising was consistent with contact with the cockpit frame. He had initiated ejection by pulling the seat pan handle with his right hand only and his left hand was on the throttle quadrant. A two-handed pull, as per SOPs, would have prevented this.

Recommendations

- Only pilots with considerable formation flying experience should be selected for the Roulettes.
- The importance of leaving a formation when visual references are lost must continue to be emphasised.
- The dangers of trying to fly formation directly underneath another aircraft should be re-emphasised.
- All calls used in formation flying must be clearly defined and understood by all members.
- Ejection training should include discussion on jettisoning the canopy if it has been shattered and the use of the two-handed pull of the handle when initiating ejection.

The final manoeuvre

AT 1345 ON 15 August 1962 four Vampire jet trainer aircraft took off from East Sale for a period of formation aerobatic training in the area southeast of the airfield within the height band of 500–5000 ft.

Arrangements had been made with ATC to operate on a discrete frequency so that the Red Sails would not interfere with normal operations. This frequency was not monitored. At about 1400, a Dakota aircraft reported to East Sale ATC an observation of black smoke and an explosion in the Dutson Bombing and Gunnery Range area. Investigations revealed that all four Vampire aircraft had crashed 7.5 nm southeast of the airfield. Rescue and fire-fighting vehicles were dispatched to the area immediately. Shortly afterwards it was ascertained that all six members involved had been killed.

To many around at the time, the accident was almost beyond comprehension: not one, but four aircraft lost in a single instant. The accident, understandably, attracted considerable media coverage both locally and overseas.

The Red Sales accident is one of the more tragic episodes in RAAF non-combat flying safety.

The Red Sales aerobatic team was practicing for a RAAF Open Day Display on 16 September, 1962. The four aircraft struck the ground almost simultaneously in the final stages of completing a low-level barrel roll. They crashed in close proximity to each other in a shallow dive and at an estimated speed of more than 300 kts. The No. 3 in the formation struck the ground slightly ahead and approximately 150 yards to the port side of the others. On impact, three aircraft exploded – wreckage and debris was scattered over half a mile. The wreckage of No. 3 in the formation was not as completely disintegrated as the others as it had levelled out just before impact.

Personnel aspects

All four flying pilots were staff members of the Central Flying School (CFS), as well as members of the aerobatic team. Two other CFS staff members were flying as passengers: one as an observer, nominated to eventually replace one of the team members; the other to assist with the operation of one aircraft's ancillary controls where the pilot was flying from the right seat.

All pilots were very experienced. Their total flying hours were in the range 2500–4000, and hours on type 460–1300. They were all medically fit for flying. The formation leader was selected because he was considered by his commanding officer (CO) to be the most suitable officer. Although he had joined the Red Sales only a short time before the accident, he was considered by his superiors to possess the desired officer qualities and pilot skills to lead the team.

One fact that influenced the CO in his choice was the need to obtain a leader who could be expected to remain at East Sale for two years or more. The other members of the team had been at East Sale for some time and their instructional tour was drawing to a close. Other factors that led to the leader's appointment were:

- he was assessed as above average as a pilot and instructor
- he had been a fighter pilot with overseas forces in Malta and Malaya (a flight commander in the latter –
- he had about 700 hrs Vampire and 350 hrs Sabre flying, and considerable experience in formation flying in both aircraft types and
- he was methodical in his approach to his duties and generally gave the impression of reliability and attention to detail.

At the time of the accident the formation leader was leading his fifth aerobatics sortie; one in June, another in July and the remainder in August. During August, the team had settled down to an increased rate of training, which was to be increased to two sorties per week.

There was ample evidence of the leader's stability and sound temperament. Most witnesses amplified his reserved and careful approach to flying and believed it unlikely that he would introduce any new manoeuvre or variaion to the display sequence in which the formation as a whole was not thoroughly familiar and practiced. It was also considered that he would not intentionally set about peforming manoeuvres below the specified minimum height.

There was no evidence that personal problems, overwork, or undue emotional or physical stress might have influenced his capability as a pilot and leader of a formation.

Formation routine

The standard routine was to carry out a sequence of loops, steep turns and barrel rolls in that order, finishing with a downward bomb burst. The speeds for all manoeuvres were in the vicinity of 300 kts and 3G accelerations were seldom exceeded. On all barrel rolls to the left, the routine was to complete a full roll and then to enter a turn in the same direction.

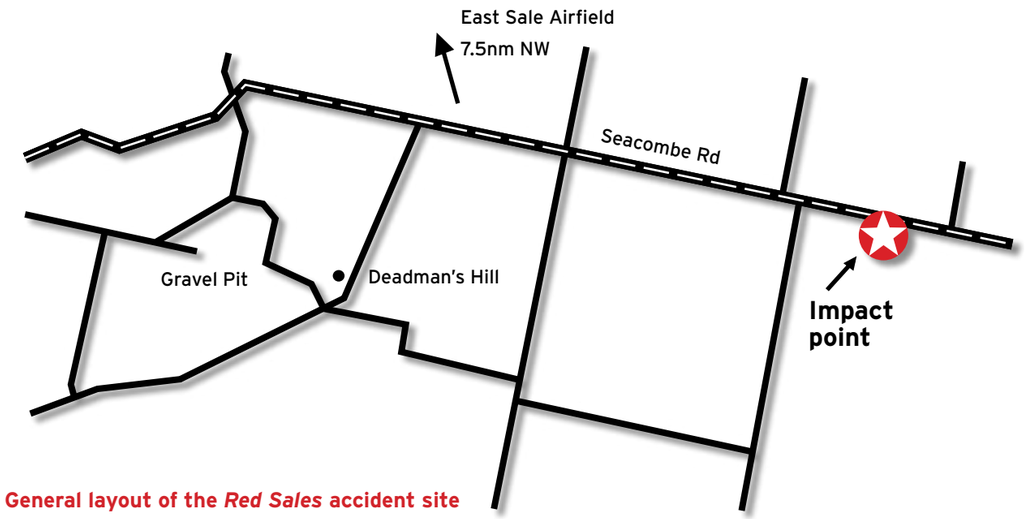
Personnel who had critically observed the team during previous practice sessions over the airfield, assessed the minimum height to be in the order of 500 ft, although one aircrew member, who flew with the team, had cause to comment regarding a flypast before commencing a loop. The height on that occasion was read as 300 ft on the aircraft altimeter.

Eyewitness accounts

Eyewitness accounts suggest that the normal practice routine was being carried out and at altitudes down to the minimum prescribed, if not lower. Loops and steep turns were observed before the formation commenced a climb from which the fatal barrel roll to the left was initiated.

During a test, in which a Vampire aircraft was flown overhead on simulated runs, the witness to the final manoeuvre displayed a sound ability to assess height fairly accurately and indicated that the four aircraft had entered the fatal barrel roll at about 500 ft, with a nose-up attitude of about 10 degrees, which resulted in a maximum height gain of not more than a few hundred feet. After passing the inverted position the formation appeared to dive at a steep nose-down angle, flattening in the final stages before striking the ground.

From a study of the impact area and discussion with witnesses, it was assessed that the formation climbed on a heading of 265 degrees magnetic, which positioned them immediately south of Seacombes Road, two miles from the impact point. The final barrel roll to the left was then commenced, which led to impact with the ground immediately south of the road.



General layout of the *Red Sales* accident site

Discussion of the evidence

Formation flying requires great concentration on control and positioning. It is essential that all formation members rely implicitly on the leader for altitude, attitude and safety considerations. They concentrate solely on precision positioning. It follows that an explanation as to why the leader allowed a hazardous situation to develop will account for all aircraft crashing. No. 3 attempted individual recovery at a very late stage despite the prerogative of the leader to carry out this action for all. This indicates there may have been something wrong with the leader or his aircraft, as he should have had the best appreciation of the situation.

The investigation determined that all engines were under power at the time of impact. Had a power failure occurred in the lead aircraft, the formation would have lost its identity immediately, and at a height sufficient to enable breakaway action to be taken. The leader would not have aggravated the situation by adopting such a flight profile.

There was no evidence to suggest that an unserviceability of engine, airframe, or other equipment was the direct or indirect cause of the accident.

It was considered possible the leader could have encountered control loss due to foreign-object jamming. During recovery from a barrel roll, increasing back pressure is required on the control column. This is so the angle of bank reduces to around about 20–30 degrees. Thus, any restriction that did not occur before this required amount of back-stick was needed would not have been evident to the pilot before this stage of the roll was reached. A pilot confronted with this situation at 600–700 ft would most probably resort to pulling hard. The natural tendency would be to use both hands on the control column.

In such circumstances it would be foreign to remove one hand to use the R/T button on the throttle lever. In such a situation the manoeuvre would follow a flight path closely akin to the last stages of a normal barrel roll. The aircraft would be decreasing its angle of dive, which would give the other members of the formation the impression that recovery was fairly normal. Too low a height would be their first indication of trouble and this when it was too late. This is probably the only type of difficulty that could confuse them. From examination of the wreckage it was impossible to determine whether such a restriction had occurred.

As leader, a pilot would continually cross-reference the ASI and altimeter. An erroneous indication either by an altimeter malfunction or misreading could influence his key positioning. This would not; however, override his visual observations and orientation and action could have been taken to initiate a more positive recovery.

A midair collision immediately prior to the aircraft striking the ground could have been a possible cause but, it could only have occurred at a very late stage of the roll and in such a manner that it was not observed by the witnesses, who watched the aircraft complete an aerobatic manoeuvre and dive into the ground.

The possibility that No. 3 may have collided with Lead is not borne out by the observations of witnesses. Although No. 3 was observed to break from the formation, this was because of his appreciation of the impending impact.

Lack of visibility on the part of Lead might have been a contributory factor, but no substantial evidence to this effect was found. While the final track of the formation was into the sun, the aircraft were on a downward path at the conclusion of the barrel roll. The angle of elevation of the sun at that time of day on 15 August, 1962 was 30 degrees above the horizon; therefore, dazzle from the sun was not considered to have been a direct cause.

Close attention was given to the medical aspects of the investigation, particularly in the case of the formation leader. The fact that Lead had been subject to a medical board arising from an incident in Malaya was well known to many flying personnel at the time. This was the subject of a considerable amount of inaccurate gossip as soon as the accident became known, the reference being to blackouts that Lead was said to have experienced. The medical conclusion was that there was no evidence of physical disability on the part of the formation leader contributing to the accident.

The final manoeuvre

A loose barrel roll is a relatively demanding manoeuvre to perform well; a delicate balance of pitch-and-roll rates is critical. The leader may have allowed the nose of his aircraft to drop to such a degree that recovery from the resultant dive was impossible.

The accepted objective in a barrel roll is to produce a helical flight path through 360 degrees in the rolling plane and encircling a pre-selected point directly ahead of the line of flight. The selected point is normally on or slightly above the horizon. Ideally the flight path should describe identical symmetrical arcs above and below the horizontal level of the selected point. To achieve this objective, one of two basic techniques is usually employed:

1. Entry to the manoeuvre is from a shallow dive directly towards the selected point and a turn of approximately 30 degrees away from this point, in the opposite direction of the barrel roll. The nose is then raised and rolled, aiming to keep the 30 degrees angle-off from the selected point constant throughout the helical circumference of the roll.
2. Entry to the manoeuvre is from a shallow dive with wings level and on a flight path positioned to one side of the selected point, giving an angle-

off of 30 degrees from this point. The nose is then raised to 30 degrees above the selected point and rolled, aiming to keep the 30 degrees angle-off constant throughout the helical circumference of the roll.

There are many variable factors that govern flight profile during a barrel roll. The more important ones, each of which is variable, and all of which are controlled by pilot technique, are:

- the maximum nose-up flight angle achieved during the first half of the manoeuvre
- the average rate of roll during the first half of the manoeuvre
- elevator control technique approaching and passing through the inverted stage
- the average rate of roll during the second half of the manoeuvre
- elevator control technique during the latter half of the manoeuvre
- the initial entry speed and,
- engine power setting used.

In the case of a sequence of aerobatics, the aircraft may begin a barrel roll from level flight at the conclusion of a previous manoeuvre because adequate speed has already been acquired and the aircraft is at the minimum specified altitude.

Had the formation leader intended to perform a barrel roll about a horizontal axis, an error of judgment or faulty technique could have resulted in an excessive loss of height. If it was being performed at a very low altitude, then the safety margin would be reduced accordingly.

In this instance the difficulty of recovering a formation from such a situation must be considered, especially as regards restricted manoeuvrability.

Contributory factors

The following factors could have been an underlying cause of the accident:

The accepted practice of observing a minimum height of 500 ft for formation team aerobatic manoeuvres. It is apparent that the Red Sales were in the habit of executing formation aerobatic manoeuvres down to the minimum briefed height of 500 ft. If the formation had initiated their final barrel roll at a height of 1000 ft, the accident would not have occurred.

Insufficient regular practice by the leader in performing the team aerobatic routine at low-level. It is significant that subsequent to flying a total of four dual sorties and one solo lead sortie during practice sessions by the Red Sales before the departure of the previous leader of the team, the leader had led the team on only four occasions, spread over a period of weeks.

Conclusion

Due to the very nature of this accident and the degree of aircraft breakup, post-impact examination achieved only limited results. Consequently, there was insufficient evidence to isolate with certainty any one underlying cause. It was established that the accident to the formation resulted from failure of the leader to carry out timely recovery action when committed to a low-level aerobatic manoeuvre.

While the cause of the accident will never be positively known and certain speculation will always exist, credence must be given to the following three possibilities:

- an error of judgment or faulty technique on the part of the leader in executing a barrel roll to the left at low level
- foreign object restriction of elevator control movement or
- physical disability affecting the leader.

The weight of evidence indicated that the accident occurred as a result of an error of judgment, or faulty technique on the part of the leader.

REFLECTION by GPCAPT Peter Norford

THIS REVIEW OF one of Air Force's most gut-wrenching accidents is a classic in the sense of supervisory judgement and pilot error mixing under demanding circumstances, resulting in multiple fatalities.

The lessons are as applicable in today's fifth generation Air Force as they were on that day in 1962. The aircraft hit the ground serviceable, so it's fair to say that is was the omnipresent mix of supervision and pilot skills that were the primary contributing factors to the catastrophe.

It's easy after the fact to question the selection of lead; was he the right person for the job or just the best fit at the time? Was there not someone else with the prerequisite skills to lead the team? Was it that the lead was in fact plan B? Who made that call and why? The accident report is not clear. But one thing is clear, supervisors have to get it right.

Next, one would question the potential for lead to be somewhat random in the routine flown on the day when someone overheard the lead's brief as including: "I shall.... try not to introduce anything new, nor omit anything". Hardly inspiring for someone on their fifth trip as lead, with only three practices in the preceding 10 weeks and only four weeks out from their first major display. Was the routine on the fatal day an adjusted routine? Did it leave the team low on energy to commence the fatal barrel roll? We will never know.

Low-level, formation aerobatics is some of the more demanding flying one can undertake. A formation barrel roll is arguably one of the more demanding sequences to be flown at low-level. The judgement of pitch rate against roll is critical, especially in formation. Did the lead start on height and on speed? Did lead get the initial pull-up right? Did lead make the check height-and-speed at the top of the manoeuvre? How was the height when committing to the second half of the barrel roll? Was he distracted? Was he looking at the wingman at just the wrong time and failed to get the exit pitch-rate right? We'll never know. But one thing was clear, he got it wrong and or someone failed to call KNOCK IT OFF.

And finally, this accident reinforces the well-worn adage: the earth sucks, it is to be avoided. Whatever you do, at low-level, do it safely, never commit nose low when slow. Take care.

KIWI BLACK

Organisational failure and fatigue leads to diminished capacity

By WGCDR Russell Kennedy, RNZAF

FOR THOSE NOT familiar with the tragic Nowra aircraft accident, a Royal New Zealand Air Force (RNZAF) A4 Skyhawk crashed in 2001 on the western side of the RAN Naval Air Station at Nowra, NSW with loss of the aircraft and pilot.

On Friday 16 February, 2001, the pilots of RNZAF Skyhawks NZ 6202 and NZ 6211 (Kiwi Black) and NZ 6213 (Kiwi 02) conducted a practice for a display to be flown the following day at the Avalon Air Show in Victoria.

At 1416 hrs local time, Kiwi Black formation took off from Nowra and transited to a training area over the sea. Both aircraft carried two 300-gallon tanks, as well as an air-to-air refuelling store (buddy store) on the centre (fuselage) pylon, and each carried approximately 7200 lb of fuel on take-off. Once established in the area at 1000 ft above ground level (AGL), Black One conducted two individual barrel rolls without the air-to-air refuelling drogue extended, then two with the drogue extended.

A plugged formation barrel roll was then flown to a base height of 1000 ft AGL without incident. A second plugged barrel roll was then flown, during which Black One advised that he was tightening the manoeuvre and that the formation would exit the barrel roll slightly low. Black Two reported that he had experienced no problems with the manoeuvre. A third plugged barrel roll was subsequently completed. During the transit back to the airfield, at Black One's suggestion, Black Two dumped about 700 lb of fuel.

At 1435, as Kiwi 02 (the solo display aircraft) took off, Kiwi Black completed a practice flypast in a slight right-hand turn at a height of 260 ft AGL. The formation reversed the turn to the left to position for a wingover. A right-hand wingover was then completed, finishing near the threshold of Rwy 21 at a height of approximately 740 ft indicated (580 ft AGL) on a heading of 252 degrees. During the wingover, Black One commented that the manoeuvre would have to be offset further on the day of the air show. After exiting the wingover, a gradual turn on to 237 degrees was completed, during which the formation was gradually climbed to about 880 ft indicated. A left-hand barrel roll was then commenced from an entry speed of 285 kts. During the exit from the barrel roll Black One transmitted a warning to Black Two, who became aware of both the proximity of the ground and the high rate of descent. He began to separate from Black One by simultaneously moving left and increasing his pitch rate, disengaging from the refuelling drogue as he did so.

Black One failed to recover from the ensuing dive and impacted the heavily wooded terrain adjacent to the airfield, with the pilot sustaining immediate fatal injuries. Black Two narrowly avoided the terrain and climbed to a safe altitude where he was joined by Kiwi 02. Black Two, believing that his aircraft may have struck trees during the recovery, requested a visual inspection. The visual inspection revealed no damage to Black Two and both aircraft returned to land on Rwy 21 without further incident.

Circumstances surrounding the accident

Overview

Recognising early in the investigation that human factors played a significant part in this accident, the Court of Inquiry attempted to identify the chronic (long-term) and acute (short-term) factors that may have affected the accident pilot. A range of predisposing factors were identified, all of which directly affected the pilot's performance.

Over time, these predisposing factors were considered to have adversely affected the pilot in two significant ways: by inducing complacency in his performance, and by leading to diminished capacity. Both of these chronic factors were then compounded by a series of acute in-flight stressors that combined to induce the pilot to make two critical errors, one in technique and one in cognition (relating to altitude).

These two errors, when combined during the accident sortie, resulted in a final failure mode commonly termed Controlled Flight Into Terrain (CFIT).

Predisposing factors

The investigation considered the workload of the pilot to have been adversely affected by the shortage of instructors in No. 2 Squadron, long hours of work leading to compromises of crew duty guidelines, conflicting task priorities, the air show itself and the difficulties he was having in finding time to take leave. As a result, the pilot had reported feeling fatigued for an extended period of time.

At the time of the accident the future of the Air Combat Force (ACF) was in question and the accident pilot was passionately concerned about its future. This probably added to the other stressors identified. The investigation also considered that the RNZAF had inadvertently developed a can-do command culture that, like the flying units, focused on achieving outputs and down-played the effort required to achieve them.

The investigation believed the pilot shared a common perception that command was indifferent to the problems facing his unit. This perception was compounded by the detachment of the unit from its command/supervision chain.

The pilot was an experienced ACF pilot and flying instructor. He had completed tuition in display flying and had served as the solo display pilot in the Red Checkers aerobatic display team. Despite having some experience in Skyhawk handling and aerobatic displays, he had apparently never conducted a plugged barrel roll before the accident sortie. Black Two, while also an experienced ACF pilot, had no experience in formation aerobatics and had similarly never conducted a plugged barrel roll. He had; however, conducted display-flying tuition on his flying instructor course.

Effect of predisposing factors

The investigation considered that a complacent approach to work up for the Avalon display had been adopted. The limited work-up period and the manner in which the work up was conducted were both considered to have been significant contributors to the accident. The investigation also considered the identified predisposing factors to have affected the pilot's performance in another critical way – by diminishing his capacity to accurately process and prioritise multiple sources of information.

Three significant factors created critical distractions for the pilot during his execution of the accident plugged barrel roll. First, the positioning of the dumbbell wingover was poor, so that at a time when he should have

been focusing on the entry to a complex manoeuvre, it was likely Black One was distracted by the requirement to correct the positioning/altitude error. Second, Black One had to periodically communicate with Black Two. Finally, the use of the buddy store during the manoeuvre imposed two distinct airspeed restrictions: a minimum of about 180 kts and a maximum of 300 kts. This aspect of the formation's performance received significant attention.

The use of the buddy store during the plugged barrel roll had channelled Black One's attention to the linked cues of airspeed and power.

The other cue that appears to receive attention, at least in the accident manoeuvre, is the apex altitude.

The accident manoeuvre was flown quite differently to the practice ones and, despite having commenced from a lower altitude, the apex of the accident manoeuvre was at the high end of the target range. This was largely due to the very slow application of roll early in the barrel roll. The inverted attitude was not achieved at the apex during any of the manoeuvres and there appears to be only cursory recognition of this fact by Black One.

At the apex of the accident manoeuvre Black One called "increasing the roll rate" but no significant increase in the rate of roll occurred for almost six seconds.

The other critical cue apparently missed by Black One was the exit attitude. The *Student Study Guide* (SSG) reference clearly states "the attitude on exit should be 20–25 degrees nose-down". This prescribed exit attitude was exceeded on all practice manoeuvres, and excessively so on the accident manoeuvre.

As a result of his channelled attention, the pilot was attending primarily to airspeed and altitude cues during his execution of the plugged barrel roll. He failed to recognise the attitude cues that should have alerted him to a technique error. Having observed the expected cues of airspeed and apex height during the accident manoeuvre, the pilot had no perceived reason to expect that the manoeuvre could not be successfully completed to the base height as before.

In-flight stressors

The pilot's diminished capacity, having been induced by the various predisposing factors, was exacerbated by a number of in-flight stressors. The accident sortie was the only display practice scheduled prior to the actual air show, a short time frame had been artificially imposed on the sortie, and the presence of members of No. 75 Squadron provided a critical audience. The investigation considered it unlikely that the pilot had conducted low-level formation aerobatics in this configuration and at this weight prior to the accident sortie. The change in weight and drag would have had an appreciable effect on the performance of the aircraft during aerobatic manoeuvres, and it certainly added an additional variable to the exercise.

Resultant errors

Technique error. Because of the possibility of rapidly developing high rates of descent on exit, it is important during a barrel roll that the true inverted attitude is achieved at its apex. In all cases on the accident sortie, the roll rate used was insufficient to achieve the inverted attitude at the apex. In fact, it was so slow that the wings were still 42 degrees short of inverted as the aircraft passed through the horizon. The apex speed was 197 kts at an altitude of 3430 ft indicated, or just over 3000 ft AGL. Through the apex, the roll continued at a slow rate, such that the inverted attitude was not achieved until the nose was 37 degrees below the horizon. During the subsequent recovery, the nose attitude dropped as low as 55 degrees below the horizon. From this point on, the investigation considered Kiwi Black to have been outside the ejection envelope. By the time Black One recognised the magnitude of the problem and called for Black Two to pull up, Black One was in what the investigation considered an irrecoverable position.

Cognitive (altitude) error. There is no reason to believe the pilot was not aware of the 1000 ft minimum height for formation jet aerobatics. Further, the fact that the practice manoeuvres in the training area were all performed to a base of 1000 ft strongly suggests this was the planned datum. Nowra airfield sits between 300 and 400 ft above mean sea level (AMSL), with slightly higher terrain to the west. The investigation considered it highly likely that the pilot succumbed to negative transfer, whereby he erroneously applied the datum of 1000 ft AMSL he had used repeatedly during his over-water practice to the practice over the airfield. This view is supported by the gradual but deliberate climb toward 1000 ft (indicated) before the manoeuvre began. The investigation also considered it possible that the pilot was in the habit of setting QFE [height above airfield] on his altimeter for airfield displays, as he would have done with the Red Checkers. This would account for the ease with which negative transfer appears to have taken place.

The two factors of height and manoeuvre are critically linked. Had the accident manoeuvre been flown from the required base height of 1000 ft AGL, the accident would not have occurred. Had a correct barrel roll been flown from the incorrect base height used, the accident would not have occurred.

Cause(s) of the accident

The investigation found the pilot had been exposed, over time, to a range of predisposing factors including latent organisational failures and fatigue. These factors were considered to have adversely affected him in two broad ways – inducing complacency in his performance, and leading to diminished capacity. Both of these chronic factors were then compounded by a series of acute in-flight stressors that combined, leading him to make two critical errors – one in technique and one in altitude. These two errors, when combined during the accident sortie, resulted in CFIT.

RNZAF Safety comment

The inquiry into this tragic accident highlighted some fatal latent organisational failures that continually need addressing.

Ageing equipment, high rates of tasking and a lack of resources are exerting enormous pressures on everyone in the RNZAF.

Now, more than ever, people must be encouraged to speak up if they are concerned about an issue.

DFSB comment

DFSB is grateful to the RNZAF Safety Office for the opportunity to reproduce this account of the tragic Skyhawk accident at NAS Nowra, in 2001.

REFLECTION

by GPCAPT Tim Sloane

I WAS ONE OF the investigators of this crash. Despite it occurring almost 20 years ago, it was not unique; all the contributing factors, both immediate and long term, had been identified in previous crashes and have been repeated since. I have experienced them as both a display pilot and supervisor.

While the immediate causes were the combination of poor technique and incorrect height, there were many human-factors contributors that had been in existence for a long time. Effective supervision could have prevented this crash. The pilot was subject to many pressures in both his personal life and in the task at hand.

A supervisor is not just there for authorising the actual event on the day. Across the longer term, supervisiors must ensure flying displays are safe and relevant to the aircraft and crew's capability. The supervisor must ensure sufficient opportunities for practice working down to the display height incrementally and also manage the life stressors affecting individuals and crews so that they are mentally prepared for the task.

On the day a crew will be subject to even more stress than during the work up. They will be in unfamiliar surroundings, subject to pressure from an expectant crowd and demanding event organisers, and even greater self-imposed pressure. The supervisor needs to ensure that the crew are in the right frame of mind and the environment in which they will be operating is suitable for a safe display (for example, weather, airspace et cetera)

Good, consistent long-term supervision is critical for display flying.

As an airshow ringmaster, I have the same responsibilities as a supervisor. I ensure that everything is in place for the display to be carried out safely. I monitor the display being flown, prepared to 'temper' the performance if exuberance is getting the better of them, or remove any pressure to perform if conditions are not right.

PULLING G IN HELICOPTERS

SOME YEARS AGO, a US Marine UH-1 was lost and one aircrewman killed on an evasive manoeuvring sortie, when the aircrew found themselves in an unarrestable rate of descent.

We normally don't associate pulling G's with helicopters and, consequently, our lack of understanding of this phenomenon has been a contributing factor in past accidents. It will be so in the furutre unless we educate ourselves about exactly what is happening to a helicopter manoeuvring at high angles of bank (AoB).

Other accidents have involved helicopters operating at high AoB close to the ground. In one case the pilot on the controls was cross-cockpit (flying from the left seat and turning right or vice versa), resulting in the aircraft descending and hitting the ground. This accident was not directly related to the above accident but nevertheless reveals that many pilots don't appreciate the aerodynamics of high-AoB flying, close to the ground.

Helicopter aerodynamics

Let's look at the dynamics involved, starting from level flight (rotor thrust equals weight) and then rolling into an angle of bank while maintaining constant altitude and airspeed (Figure 1).

We know from experience that to maintain this energy state requires an armful of collective. This is because of the increased thrust (manifested as collective position) required to maintain the vertical-lift component when the thrust vector is tilted by entering an AoB. Our apparent weight (G-loading) increases proportionally with the AoB when we add sufficient power to maintain altitude and airspeed while banked. To determine G-loading, take the inverse of the cosine of the bank angle.

Representative bank angles and their associated G-load are tabulated in Table 1. For example, if we are in a 60 degrees AoB (and if we increase our power sufficiently to maintain the same altitude and airspeed), then we are pulling 2G, which essentially means that we weigh twice as much as our straight-and-level gross weight.

What happens if we don't have the power available to lift twice our gross weight, or if we don't apply collective immediately upon rolling into an AoB? Figure 1 shows that we no longer have an equilibrium of vertical forces, hence we accelerate downward in the direction of the unbalanced force. For illustrative purposes, let's assume we are flying at 300 ft AGL and roll into a 60 degrees AoB, while maintaining our airspeed but without increasing our collective power. How long will it take before we hit the ground? The graph below plots the time to impact from various entry altitudes (AGL) and bank angles, assuming no initial vertical velocity.

Actually, the plotted time to impact corresponds to when the altitude sensing

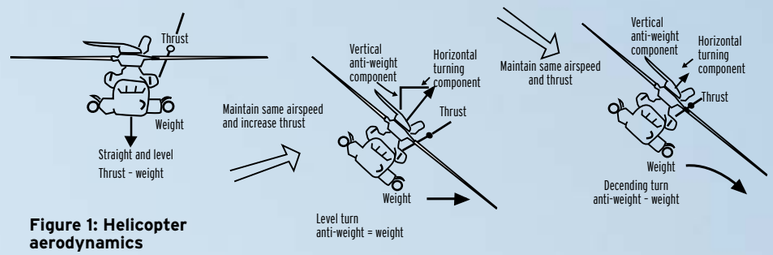
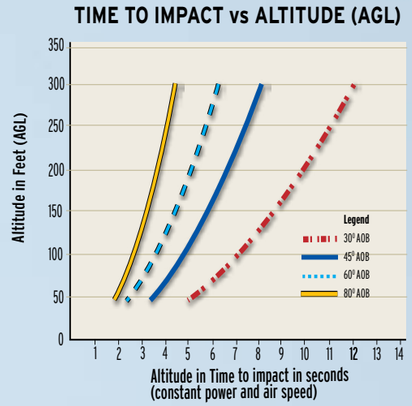


Figure 1: Helicopter aerodynamics

AOB	G-load*
0	1
10	1.02
30	1.15
45	1.41
60	2.00
75	3.86
85	11.5
89	58.82
90	Infinity

*Apparent weight while maintaining altitude and airspeed at listed angle of bank (AoB)

Table 1



port hits the ground, which obviously will be preceded by main rotor impact. This plot is independent of the type of aircraft or gross weight and is merely a function of AoB. A partial application of power or a reduction in airspeed will increase the time to impact and, conversely, power reductions or increases in airspeed will decrease the time to impact. Also, any initial rate of descent present upon entry will decrease the time to impact.

Another factor often not considered is the change in parasite power required. This is due to a change in the area exposed to the free stream flow when we go from straight-and-level flight to an AoB. For our example, starting at 300 ft AGL and rolling into a 60 degrees AoB without any power adjustment while maintaining our entry airspeed, the time to impact is about six seconds – which is about the time it took you to read this sentence.

A moment's hesitation in applying collective or distraction due to radio communication, caution panel/warning light illumination, traffic calls, visual disorientation, or whatever – coupled with a failure to immediately satisfy the power requirements when rolling into an AoB at low altitude – will result in a downward acceleration that puts you just moments from disaster.

TIPS FOR PLANNING HELICOPTER DISPLAYS

By COL Dave Lynch

MILITARY DISPLAY FLYING and flypasts offer unique opportunities to provide both an engaging display to the public of national air power and demonstrate professional military flying.

The integration of low-and-slow rotary wing aircraft flying displays with faster, high-energy aircraft requires consideration of the different energy and space requirements – especially holding areas, ingress and egress routes, which are essential for safe execution, but also provide opportunities and flexibility to display organisers.

Rotary-wing pilots rely on an intimate understanding of the ground. In the planning and briefing phase, analysis of terrestrial hazards (wires, masts, trees) and the manoeuvre area are best undertaken and informed by rotary-wing pilots. Applying good ground appreciation and incorporating that advice is an essential element of the display-site assessment.

The proximity of congested areas will affect the flexibility and the safe manoeuvring area of the rotary-wing display. This can include road-traffic movement, crowd-assembly areas, opportunity spectators, protestors or other proximate events. Consider primary and alternate holding areas, ingress and egress routes based on your analysis and the need to accommodate changing situations.

The co-ordination techniques employed by rotary-wing pilots in the operational domain remain extant and are transferable to the often low-level environment of military display flying.

Rotary-wing pilots are proficient in planning and co-ordinating with other aircraft types normally found below the co-ordinating altitude. At air shows, all aircraft will operate at relatively low altitudes and the flying-display director may not understand the requirements of rotary-wing operations. It is essential that the rotary-wing display is co-ordinated, integrated, briefed and rehearsed to ensure clear deconfliction and planned segregation is maintained.

Rotary-wing aircraft often operate in areas unsuitable for other display aircraft and this requires understanding and planning to ensure safe flying operations in these areas. When operating from and to, the dead side of the display, de-confliction is essential to assure separation from non-display aircraft. All manoeuvring aircraft must avoid operating across the active display area centreline and any active runway centrelines as much as practicable.

Consideration of any sensitive or restricted areas (local police and aerodrome staff would be able to advise on such areas) is important from both a safe air operations and flying neighbourly perspective.

Lessons from overseas air shows have shown the presence of livestock or wildlife conservation areas is occasionally overlooked. Analysis and planning is often conducted remotely or at a different time of year. Other considerations for planning are the seasonal changes in weather, aircraft performance and the effect on flying wildlife, particularly in the low-level altitudes often operated in during military display flying.

Operating low-and-slow has, for many years, been seen as a defence to flying display risk, but this is no longer sufficient or contemporary. Sound planning and co-ordination is essential to ensure military low-level display flying and flypasts are conducted safely and showcase professional military flying.

ROTOR DISC VORTEX: A CASE STUDY

One lesser understood aspect of rotary-wing operations, particularly during low-level formation flying at air displays may be the effect of a helicopter rotor disc vortex on nearby aircraft.

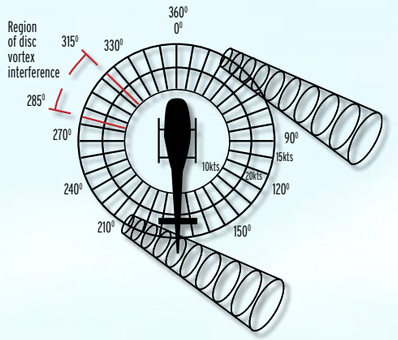
The rotary-wing equivalent of a fixed-wing aircraft's wake vortices may have been responsible for the crash of a Bell 206B in Alberta, Canada in May 1998. At the time, a two-person camera crew in the aircraft were videotaping another helicopter's water-bucketing operation.

The Bell 205 that was being videotaped was being flown in a westerly direction during the water bucket pick-up and climb-out. The Bell 205 pilot observed the Bell 206B on a parallel course about 300 ft horizontally off his right side, at low speed, and just above the trees.

The pilot of the Bell 205 indicated that his track, while flying toward the fire, may have converged with the course of the slower mowing 206B, which was then below and behind him in the right rear quarter.

The 206B suddenly began to rotate to the right. Attempts by the pilot to arrest the descent were unsuccessful and the helicopter entered the tree canopy while spinning. A main rotor blade cut off the tail boom and the fuselage struck the forest floor in a nose-down attitude, resulting in substantial damage. The pilot received head injuries, while the two passengers were not injured.

Studies have shown that the rotor wash from a helicopter in forward flight forms a pair of rotating vortices that act exactly like those generated by a fixed-wing aircraft. The turbulence intensity is directly proportional to the weight, and inversely proportional to the rotor span and speed of the helicopter. The trailing vortices settle or move downward with time, and they can be potentially dangerous for several minutes after the generating helicopter has left the scene.



Since the wind was from the southwest, conditions were favourable for the main rotor vortices from the Bell 205 to drift into the path of the 206B. These vortices would cause a sudden reduction in tail rotor thrust, with a resultant uncommanded right yaw that could develop into a high rate of turn. The 206B pilot's low height over the trees precluded reduction of collective pitch to effect recovery.

HERCULES MID-AIR

THREE CANADIAN FORCES C-130 Hercules aircraft were tasked to participate in a flypast commemorating the 61st anniversary of the RCAF. On completion of the flypast the aircraft were to recover by pitching into the circuit via a low-level break manoeuvre. During this manoeuvre Lead and No. 2 aircraft collided. Both aircraft subsequently fell to the ground inverted, killing all 10 people on board.

Events leading to the accident

For the recovery, the three aircraft were positioned in echelon right with a one-wing-span-spacing between each aircraft. The briefed procedure was to pull up at three second intervals to 10 degrees nose-high and turn left at 2G/60 degrees angle of bank (AoB) to be on downwind at 1000 ft AGL. The run-in was as briefed at 250 kts and 250 ft AGL.

After about 50 degrees of turn (16 seconds after Lead commenced the pull-up and at 900 ft AGL) No. 2 collided with the lead aircraft. The initial contact was No. 2 cockpit striking the underside of the lead aircraft, forward of the left main undercarriage. The violent impact separated No. 2's cockpit from the aircraft and punched a five-foot hole in the floor of the lead aircraft.

Both aircraft were rendered uncontrollable by the collision. The No. 2 aircraft lost both propellers from its right wing, while the tail section of the lead aircraft separated before ground impact. Red-and-white paint on the lead aircraft's empennage indicates initial damage was done by No. 2's propellers. Considerable secondary damage was sustained by buildings, vehicles and a fuel farm that, fortuitously, did not add to the ground fires.

Accident analysis

Both Lead and No. 3 were fitted with flight data recorders (FDR), which were recovered. The information from these, together with eyewitness accounts, aided in the reconstruction of the low-level break. The reconstruction showed that Lead, after initiation of the pull-up, considerably delayed the application of left bank, while both No. 2 and No. 3 added bank immediately after commencing the pull-up. This resulted in separation only in the vertical plane.

Three simulations in USAF simulators, which allow two aircraft-formation, resulted in two collisions and one near-collision. Simulations also showed that the manoeuvre resulted in the preceding aircraft being out of view of the following aircraft from the pull-up until within 45 degrees of downwind. This arc covers the entire manoeuvre in this accident. At no time after the pull-up could the Lead crew see No. 2.

Conclusion

The most likely cause of the accident was the failure of Lead to initiate the 60 degrees AoB turn immediately following the pull-up. This procedure had been used successfully before but no formal procedure existed for lost visual contact. The pilots had only minimal training and experience in the prodedure and, with no published battle-break procedure, relied on handed down information from those who had done it before. Many changes were made by the Canadian Forces to the published procedures, training currency, and authorisation following the accident investigation. The investigation team also recommended:

- priority fitment of Flight Data Recorders and crash-position indicators or emergency locator transmitters and,
- that manoeuvres should be within the visual limitations that an aircraft cockpit imposes.

Lessons learnt

The lessons we can learn from this accident are:

- Whenever a unit is contemplating the introduction of a new manoeuvre, the dynamics of the manoeuvre have to be carefully thought through, briefed thoroughly, and tested by highly experienced aircrew before it can be accepted as SOP.
- In the pitch into the circuit, crews must have visual contact with preceding members of the flight. If you haven't, you must be clear about your subsequent actions. The same goes for turning base. How many of us have counted a formation member short, but turned anyway, expecting him or her to turn up in front shortly, then found him under the belly?

REFLECTION by WGCDR Scott Hyland

SUPERVISION AND EXECUTION lessons identified in this Canadian experience are relevant for the Royal Australian Air Force. The increased risk inherent with air-show missions necessitates specific risk controls, and the requirement to conduct large-aircraft close formation missions is something that needs careful consideration. Critical to successful execution of large-aircraft display flying is rehearsal of well-documented procedures, considered personnel involvement in planning to include pre-conditional off ramps to prevent mission creep, as well as independent supervision.

Close formation in large aircraft has limited operational utility and this unfamiliarity means thoroughly considered and documented procedures are critical. This should include the airshow display specifics, work-up sorties and simulator sessions that gradually introduce aircrew not only to the dynamic sequences but momentum management and visibility restrictions not evident in smaller aircraft. Skimping on this considered approach will short-change crews of valuable experience in what is an unfamiliar sequence.

Personnel selection is equally important and spans flight supervision as well as display crews. Aircrew experience must be commensurate with the demanding nature of flying displays and aircraft captains must be capable of displaying a level of command maturity, where they are able to separate the pressures of the mission from any realised safety breaches. Authorisation officers should also be adequately experienced in the mission set, and provide consistent, distraction-free oversight during the full range of work-up sorties and planning.

To adequately prepare crews for a successful mission (one without incident), crews and supervisors should develop a set of pre-defined off ramps where the display can be aborted. Making this call has its challenges but the expectations of the public should not be first considered as the aircraft is preparing for the run in. The effect of weather and other latent risks can cloud judgement when expectations are high. Supervisors owe it to display crews to prepare them effectively.

Finally, a large aircraft at low level is impressive and crews seeking to operate in the performance margins introduce unnecessary hazards. Operating to the limits may only impress a very small percentage of the audience, which is not worth the escalated risk.

The excitement surrounding display flying is an ever present risk for crews who do not regularly participate in such events. When coupled with unfamiliar sequences, supervisors should remain alert for aggregated risk and embrace the necessity to fully prepare the display crew for the pressures they will experience on the day.

DRONE RACING

By WO2 Chris Payne

SINCE 2017, DRONE racers from the Army, Air Force and Navy First Person View (FPV) Drone Racing Teams (DRT) have collectively hosted more than 70 race meetings and community engagement events. These events have seen the DRT pilots faced with an abundance of locations, governing bodies and restrictions that have required significant consideration and management while also inspiring a passion for drone racing, Science, Technology, Engineering and Mathematics (STEM) and presenting our sport in a safe, dynamic, energetic and professional manner.

To illustrate the journey we have been on, we would like to share some of the experiences that have helped to shape the safety culture within the DRT to enable safe, innovative, dynamic and exciting displays. Firstly, what is FPV Drone Racing? It can be best described as the F1 and Mario Kart of the skies. The drones can be of varying size and class; however, typically for racing these are five-inch quadcopters (Quads). Pilots control the Quad via 2.4 GHz radio link and navigate around a predetermined course at speeds up to 150 km/hr or perform freestyle tricks for points. To do this, pilots receive a direct video feed from a camera positioned on the front of their Quad giving them the Mario-Kart style viewpoint of the course.

Early learning

During some of our initial events the DRT learnt some valuable lessons through collaborating with the civilian FPV community as well as regulators such as CASA, DASA and Defence in general. One of our initial demonstrations occurred at the sports ovals of the Royal Military College, Duntroon (RMC), within CAT C airspace during tower hours. During the demonstration the drones never exceeded the height of the stadium and never left the pilots' line of sight. The demonstration did not break any extant regulations due to the limited controls covering drone use at this time; however, during a review of past events the team identified that if the current regulations were applied to this event it would now be within a CASA defined no-fly zone. The RMC sports ovals are situated within the approach and departure path of the 12/30 runway for Canberra airport. As the 12/30 runway is used by student pilots and smaller aircraft, the potential for interference with other aviation elements at this event should have been a greater consideration.

A second event occurred during the filming of the Army Drone Racing Team commercial on *HMAS Canberra*, while docked in Sydney Harbour. This activity was organised in a rapid fashion, to capitilise on the location and opportunity to fly around the deck of *HMAS Canberra*, displaying both the new warship and the formation of the Army Drone Racing Team. While all paperwork and

permissions where obtained from Defence for the conduct of this activity, when the video was aired the team was contacted by CASA with a please explain. Although we had all the Defence paperwork and operated under the assumption that it had also been cleared by the civil authority, this was not the case. This reinforced the need to seek confirmation and clarification from all authorities prior to conducting any events.

These initial events have allowed us to better educate our team members and highlight the importance of additional checks and balances included as part of the planning and preparation of our events.

Combining innovation, public awareness and safety

Although FPV drone racing is the main focus of the team, the DRT is also heavily involved in educating the community on unmanned systems within Defence as well as inspiring STEM involvement. For this to occur the pilots attend a variety of schools and events and host displays for the public to view and interact with the team pilots. Every event is unique and presents its own challenges such as physical space, security, risk management and availability of personnel.

Sound and movement of the DRT Quads are key to grabbing the attention of our audience and in order to do this safely within the confines of an area as small as 3m x 3m, the team switches out our normal 5 inch racing drones with the smaller tinywhoop (65 mm <250 g) quads and set up a cage. This allows our pilots to showcase FPV drone racing while reducing the risks associated with operating in close proximity to the public.

On occasion, we have been able to work with the event organisers to mitigate risks to a point where we are able to allow flight of these tiny whoops outside the cage. An example of this would be our involvement with National Science Week celebrations in South Bank Piazza in Brisbane.

During this event we were able to fly around inside the upper tiers of the Piazza not occupied by the public. To further mitigate the risks associated with this flying display, the team enforced that these flights would only be conducted by the most experienced and proficient pilots, while other team members acted as spotters and safety members.

Feedback from the public was extremely positive concerning the excitement and buzz that they created. As a majority of these events are attended by minors, an additional level of planning, preparation and training is required in order to deliver our displays in a professional and safe manner. To cover this all our team pilots are required to complete the Defence Force working with minors training.

Acknowledge the good with the bad

Review and acknowledgement of past issues and problems is important to the DRT but so is the identification of what we have done well. One prominent event in which the team demonstrated maturity and professionalism as an organisation was the Avalon Airshow in 2019. This event included seven days of FPV drone racing and the conduct of a flying display over an active runway as part of the Friday Night Alight Spectacular; all of which was achieved within the confines of a tightly controlled drone-free zone. The key to this success was communication, communication, communication. Our UAS event staff alongside a designated display co-ordinator, attended event-planning meetings to provide valuable input into flight safety discussions while also co-ordinating the clearances required from Defence, CASA, MAAA and the event co-ordinators.

In order to fly our FPV racing drones within the drone-free zone, the team hired a two-pole circus tent with a netted surround. The tent provided an enclosed arena to host the races. This, along with a mandated requirement that any quad was only allowed to power up within the confines of the netted area, enabled the teams to complete seven days of dynamic, noisy and fast paced, five-inch FPV racing for the public throughout the airshow alongside the aerial displays of the various multi-national aircraft.

With an event as big as Avalon Airshow, our racing arena was not the only challenge we faced. Our biggest challenge was the co-ordination, rehearsal and conduct of the Friday Night Alight Spectacular display. Due to our racing drones operating on both the 2.4GHz and 5.8GHz there was concern that, because of the number of other aircraft and airshow equipment operating in the area, there was a possibility that the control and video links to our quads could face some interference, resulting in link loss and/or crash of the quad. In order to assess this risk, the display co-ordinator worked with the event co-ordinator to conduct EM spectrum survey of the proposed display locations. These power-up tests were conducted and found that there was little-to-no interference with our links.

The other significant concern held was that during the display a quad could crash into the crowd or onto the active runway causing FOD and potentially closing the runway during the airshow to manned platforms.

In order to reduce this risk, the flight envelope for our display was restricted to the grassed edge of the runway, in a tight band 30 m from the public and the edge of main runway. In addition to this, track setup rehearsals of the display were also carried out enabling DRT pilots to practice the co-ordinated placement of the course under the same conditions that would occur on the Friday night. Due to Avalon being an active runway for commercial flights, there was no opportunity to conduct a flying rehearsal for the team pilots in location. Instead, the team set up a replica course at RAAF Base Williams, which enabled pilots to fine tune their performance and minimise maneuvers towards the crowd, while remaining within the flight envelope.

Conclusion

Analysis and review of all of our events, both the good and bad points, has enabled the DRT to continue to grow our safety culture. Thorough aviation risk management and post-activity review has also enabled us to work with a variety of organisations in order to co-ordinate and participate in groundbreaking events for this new and exciting sport while presenting our sport in a safe, innovative, dynamic, energetic and professional manner.

The Big Show

Exercise Southern Skies 19 – The Edinburgh ATC Experience

By SQNLDR Ash Wright

ON 9 AND 10 November 2019, RAAF Base Edinburgh opened its doors to approximately 70,000 air-show enthusiasts, serving personnel and industry representatives. Quietly working in the background were the air traffic controllers and technical staff of No. 453 Squadron Edinburgh Flight, alongside their Air Show Team (AST) colleagues.

The safety implications of poor planning and execution were apparent to all concerned, with the reward of a job well done highly prized and sought after by the small unit. What the unit lacked in air-show experience, they made up for with hard work and a commitment to putting on a good show for all attending.

Prior preparation prevents...

The enormity of the smallest ATC Flight in 44WG having to prepare for an event as large as Exercise Southern Skies 19 (ESSKY19) was not lost on the team. About 18 months before the event, the Flight recognised that it didn't have the resources to invest in responding to the task at the last minute. The surge occurred at the start of the planning process to make sure they hit their

milestones successfully with the limited resources available. Close consultation and interface with the AST was critical. The SATCO and Air Boss conducted the long-term planning and the Senior Training Officer (STO) and tower supervisors worked with the ringmasters to achieve the desired effect on the days leading up to and during the actual show.

The added activities of an Air Marshal Symposium and STEM day were absorbed into the planning cycle relatively easily; a close working relationship between ATC, AST and 24 Squadron ensured this was the case. The successful planning of airspace, staffing, training, procedures, communications, maintenance and publications, along with State and Federal level liaison, ensured that the skill of ATC and AST was able to be proactively employed. This allowed them to stay ahead of the curve instead of trying to tactically resolve a myriad of operational issues in real time.

The hard work and planning conducted by the ATC maintenance team often goes unrecognised. A close working relationship between the section commanders and flight commander ensured that both the ops section, led by the STO, and maintenance section, led by the maintenance commander were aware of the desired outcome or effect. The maintenance team ensured that the required equipment was serviceable and that there were resources available to rapidly respond to maintenance requirements during the show. The support from the maitenance commander and his team cannot be downplayed, as the technical staff had a direct impact on capability and safety.

Train hard fight easy

Edinburgh Flight's in-house simulator was used extensively to rehearse procedures and various air-show related scenarios. The low traffic volumes typically experienced at Edinburgh created anxiety among some controllers (and the flying community), but the unit worked hard and stepped up to the task. "Busy base practice" has been the norm at the Flight for the past three years and the team were able to successfully adjust to the higher volume and eclectic mix of air traffic.

The relatively young, mobile, uniformed team represented a significant shift from the largely static, highly experienced, civilian-control team that existed up until 2016. However, the enthusiasm of the control staff, who are grounded in a robust safety culture, made transition to high-tempo operations look relatively easy.

Forming the team

With the Approach Control Service provided by Airservices Australia (ASA) in Melbourne, the Flight is routinely presented with a unique set of challenges by way of bridging the gap between civilian technique and military requirements. This was alleviated by the close relationship fostered by the RAAF and ASA team, in particular across the 18 months leading up to the air show. Additionally, Edinburgh Flight dispatched one its most capable controllers to Melbourne the week before the event in order to liaise with the unit's civilian counterparts and thereby ensuring a seamless radar service.

Augmentation by three ex-Edinburgh controllers from Pearce and Williamtown Flights enabled maximum coverage and flexibility. These extra controllers allowed the creation of a temporary position in the already cramped cabin to facilitate general aviation arrivals and process the participant aircraft departure push on the Monday morning after the show.

With minimal time to integrate their teams in the days leading up to the big weekend, the ATCOs at Edinburgh/Melbourne and ringmasters needed to quickly develop mutual trust, understanding and confidence. Their collective professionalism shone, with the effective working relationship translating into a successful ATC/AST service.

The Big Weekend

With all the planning done, the ATCOs, ringmaster and air boss worked hard behind the scenes and with safety at the forefront of their minds, in order to produce a show of the highest calibre. Timings were adhered to with little deviation from the original program. The high level of co-ordination with the RAAF liaison in Melbourne ensured that there was no disconnect between the radar and tower services.

Post exercise

The 2019 Edinburgh Air Show is widely regarded as one of the biggest and most successful RAAF Air Shows to date. The team at 453SQN Edinburgh Flight were rightly proud of their efforts in the long lead up to and execution of ESSKY19. The number one safety lesson? Commence thorough planning early and maximise the use of available resources to minimise the need for tactical level problem solving.

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The Loss of 754

By Ian Pearson

IN 1991, THE Australian Defence Force suffered an extraordinarily high rate of fatal aircraft accidents. Among the six accidents, which ranged from the RAAF Museum's civil-registered Tiger Moth, in which the passenger survived, but the pilot died; to the loss of a No. 33 Squadron Boeing 707, in which all five crew members died; was the loss of the RAAF P-3C, A9-754 on 26 April. That incident resulted in the death of one crew member.

At 0919 hours local time on 26 April 1991, No. 10 Squadron (10SQN) P-3C A9-754 took off from the Cocos Islands for a transit flight to Edinburgh, South Australia. The occupants of the aircraft were the crew (the captain, the co-pilot, two engineers, the navigator and one sensor operator) and 14 passengers, all of whom were aircrew members of No. 92 Wing (92WG). The captain, a qualified right-hand-seat check captain, occupied the right-hand seat. The co-pilot, a qualified P-3C captain, occupied the left-hand pilot seat.

After take-off and with the co-pilot at the controls, the aircraft climbed to 5000 ft before returning to the airfield for an over-fly at a speed of 370–380 knots indicated air speed (KIAS) and a height of 300–400 ft above ground level. At 0924 hours, after overflying the airfield, the co-pilot initiated a pull-up. Immediately after the initiation of the pull-up, the crew heard a loud bang, the nose pitched up and severe vibrations shook the aircraft. The captain immediately reduced speed, climbed the aircraft to 1000 ft and turned the aircraft towards the airfield.

Despite the application of maximum power, level flight at a constant airspeed could not be maintained. In addition, the combined strength of both pilots was required to retain control of the aircraft. When it became apparent that it would not be possible to make the runway, the aircraft was ditched in the Cocos Island lagoon.

At 0928 hours, the aircraft entered the lagoon one mile short of runway 15 and some 500 m from the shore. The impact was gentle and the deceleration, though rapid, was not violent, the aircraft immediately settling to the bottom of the shallow lagoon and filling with water to a depth of half a metre. One crew member was killed instantly when No. 2 engine separated and penetrated the side of the fuselage. The remaining crew and passengers, one of whom suffered minor injuries, exited the aircraft unaided and were ferried to shore by local residents.

A9-754 was one of three 92WG P-3Cs (754, 661 and 663) involved in the search for the bulk ore carrier, *Mineral Diamond*. Given the duration of the search, the aircraft were operating with double crews. In the case of 754 the largely 10SQN crew was augmented by aircrew from No. 11 Squadron, including the tactical co-ordinator, FLTLT (later AVM) Ken Watson.

On 24 April, 661 was tasked to fly a search sortie for *Mineral Diamond* from Cocos to Pearce. Later that day, with the search for the ore carrier called off, 661 completed immigration formalities at Pearce, refuelled and redeployed to Edinburgh. Among those returning to Edinburgh aboard 661 was the 10SQN Executive Officer, SQNLDR (later WGCDR) David 'Harry' Paterson. Twenty-nine years after the *Mineral Diamond* search Harry would recall that:

"My aircraft (661) was the first to leave Cocos on 24 April and the other (754) was to leave in the next day or two. I authorised both sorties before I left. We did a standard departure from Cocos, refuelled at Pearce, and returned to Edinburgh after a 14-hour flight. I expected the other aircraft to do the same. I appointed FLGOFF Willsher as captain of 661 and Paul King as the captain of 754. As we all know, the Canadian exchange pilot Buzz Burry took the left-hand pilot seat for the take-off and the rest is history."

By the night of 24 April there were two 92WG P-3Cs on the ground at Cocos: 754, after its Cocos-Cocos *Mineral Diamond* sortie that day, and 663, captained by FLTLT Bino Barkla, which had arrived that day from RAAF Pearce. At this time 92WG crews enjoyed a close relationship with the Cocos Island community. There was a long history of overnight stays by crews on flights to and from Butterworth and Diego Garcia; and using the airfield as a base for other Indian Ocean surveillance operations. Along with participating in Cocos Islands' Anzac Day commemorations, at that time a number of 92WG (and occasionally US Navy P-3 crews) also observed the island tradition of conducting a high-speed flypast, commonly referred to as a beat-up, on arrival or departure.

Twenty-nine years later, Bino Barkla would recall that:

"After an uneventful transit, I vaguely recall discussion about the possibility of a fly past on Anzac Day but I only remember not being keen to do it as captain, due to a deep-seated dislike for display flying. My negative input may have put a dampener on the flypast idea momentum, sufficient that it did not proceed."

On the morning of Friday 26 April, 663 was the first aircraft to depart Cocos. Meanwhile, aboard 754, Ken Watson recalled there being discussion during the preflight about performing a flypast on departure. Displacing FLGOFF Tom Henniker, the assigned co-pilot of the flying crew, the beat-up would be flown by 'Buzz' Burry, captain of the supplementary crew and right-hand seat check captain for 10SQN. Ken Watson felt that the preflight "had a bit of a bad feel about it" and in discussing the proposed beat-up with the aircraft captain, Paul King, Ken said, "I don't think we need to do it".

Back at Edinburgh, 10SQN Commanding Officer Bob Grey, had no reason to

suspect that a flypast at Cocos was under contemplation by members of his squadron. His first executive action upon taking command in May 1988 had been to issue to his flight commanders the instruction that:

"I encourage you to fly with the crews assigned to your charge as often as you can. You are to authorise all flights by the crews assigned to your charge with the following limitations. You shall not authorise any type of flying display or beat-up. There is to be no unnecessary low flying. Specifically, crews shall not be authorised to fly low over Adelaide beaches or other beaches in close proximity to populated areas. In light of the recent USN P-3 incident at Cocos Island, only standard visual and published instrument arrivals and departures may be authorised there."

Ken Watson later recalled that, sitting at the tacco station on 754 after takeoff:

"At the point of impact, it was fairly benign. There was a big bang and a lot of debris fell down around me. When we stopped, I checked in, arms and legs all serviceable – right, we can flee now. As I turned around, one of the propeller blades had penetrated the aircraft skin into the cabin just behind my head. I remember looking at it and thinking 'huh, the prop came through the wall'! So, another foot or so I would have been in the same boat as Tom. That was an arresting moment. At that stage you were just so happy to be alive. It's in the quiet moments afterwards that you contemplate those situations."

Back in Australia, speed and G limits were initially imposed on RAAF P-3Cs, a board of inquiry (BOI) was convened, and an investigation conducted by the DSTO's Aeronautical Research and Maritime Laboratory (ARML). To some observers at least, both investigations seemed more focussed on why the wing leading-edges had failed, rather than why the wing leading-edges had been placed in a circumstance where they would fail.

Despite numerous other flypasts having been performed at Cocos by 92WG crews, this was the only occasion resulting in such a disastrous outcome. Wing corrosion, which was starting to emerge as a 92WG fleet maintenance issue at this time, was one of the factors advanced as contributing to 754's demise. Notwithstanding that other aircraft suffering from the condition would likely have been involved in flypasts in the lead up to the corrosion issue being identified, no other 92WG aircraft suffered 754's fate.

Commenting on the investigation into the loss of 754, and any link with the US Navy P-3C, Lockheed Field Service Representative, Jack Miller would later recall that:

"I think the common factors for the only two P-3 aircraft in the world to have suffered a WLE (wing leading-edge) collapse, were that they were both taking off from the same uncontrolled airport, and both performed a fast spectacular flyby pull-up with a heavy P-3 for local residents. The USN accident investigation concluded there were no material defects with the USN P-3's WLEs. 160284 was transferred to the USN on 21 February 1977. 754 was transferred to the RAAF on 27 May 1978, 16 P-3s and more than a year later. None of the aircraft in between had any leading-edge losses or collapses."

The crash of 754 resulted in death, injury and great trauma to those in the aircraft, and their families, and the total loss of the aircraft. It also ended the careers of good Air Force officers not directly involved.

Fortunately for Air Force at least, the flying safety culture that saw six fatal flying accidents in 1991, was about to dramatically change for the better. Sadly, it would not be until much later that similar cultural changes would take place in both the Army and Navy.

References

1 The long-term fatal accident rate for 1972–92 was 2.2 aircraft.

2 Released in May 1993, by Defence Minister Robert Ray.

3 Subsequently Mineral Diamond was assumed to have foundered with the loss of all hands in a position 1500 miles to the west of Perth.

4 The comments attributed to Ken Watson are extracts from an interview conducted with him by Dr Stephen Mugford in 2011, and subsequently edited by Ken in correspondence with the author.

5 By coincidence, Paul King was the co-pilot of the No. 10 Squadron crew which refused to fly a sortie from NAS Moffett Field in December 1989 with a captain the crew deemed unfit for flying duties. The slightly notorious incident is remembered by those involved as 'The Mutiny of Moffett Field'. Arguably, in the prevailing circumstances, the unusual position taken by the crew was correct and later vindicated by the captain's posting from No. 10 Squadron shortly after the incident.

6 A US Navy VP-46 P-3C, 160284 suffered wing leading-edge separation after take-off at Cocos on 13 February 1988. 160284 made it back to the runway and was subsequently able to continue its service life.

7 Having been displaced from his co-pilot's seat, Tom Henniker was assigned to ditching station 18, the outer of the pair of emergency 'ditching stations' on the port side of the aircraft, aft of the tacco station between electronic racks B3 and D1. Significantly, this location is in line with the arc of the port side propellers. Realising the fears expressed by Tom Trinder after seeing the damage caused by propeller ingress to A9-296, Tom Henniker was killed when struck by the propeller from No. 2 engine penetrating the fuselage. Off-duty flight engineer, Warrant Officer Davey Jones, occupying ditching station 19, the inner ditching station alongside Tom, suffered arm injuries. In the mid-1990s, Project Air-5140 modifications removed those two ditching stations from RAAF P-3Cs to incorporate the new Sensor Station 4.

8 Arguably the flying safety cultures in Navy and Army did not similarly change until the loss of Sea King N16-100 at Nias on 2 April 2005, and for Army, the loss Black Hawk A25-221 off the deck of HMAS Kanimbla on 29 November 2006.

This article is an abridged extract from Ian Pearson's book, 'Cold War Warriors – Royal Australian Air Force P-3 Operations 1968-1991' which will be published in mid-2021.

There's more to the story...


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