

AVIATION SAFETY

# Spotlight

02 2017

## Laser strike

Pointing out the hazards

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# LASER

# STRIKES

## Overview and trends

By Dr Wesley McTernan

**L**aser strikes represent an emerging burden on the aviation community. The increase in attacks may be attributable to a rise in copycat offenders spurred by media coverage of attacks, coupled with the increased affordability and availability of devices.

Offenders may also be motivated by a perception of anonymity; however, authorities are using more and more resources to catch offenders and courts are handing out severe penalties such as fines in excess of \$10,000 in an attempt to deter future offenders.

Laser strikes, also known as laser dazzling or lasing, refers to the use of hand-held laser devices (laser pens) on passing aircraft. During night-time flights, a pilot's eyes adapt for mesopic (low light) vision to help identify objects outside of the aircraft such as terrain and aerodrome facilities, as well as to read flight charts or instrument

displays in the aircraft. However, this adaption to low light leaves pilots vulnerable to light-based optical hazards.

Pilots are particularly vulnerable during take off and landing, as these phases of flight are more cognitively demanding and place the pilot in closer proximity to the laser's origin, increasing its intensity.

Laser strikes have been known to impair a pilot to the extent that a co-pilot has to take over the remainder of the flight, as well as resulting in unscheduled landings leading to considerable disruption to aviation operations. Laser strikes can cause substantial discomfort, and can impair operations through creating glare, flashblindness or a persisting afterimage.

A single laser strike could leave a pilot impaired anywhere from 30 seconds to several minutes or; as in some cases, where a pilot has adapted to complete darkness impairment, it can be up to half an hour (Nakagawara, Montgomery, Dillard, McLin & Connor, 2004).

Although a laser strike by a combatant is not unheard of (there was one reported incident in Afghanistan in 2013 on an ADF aircraft), incidents are predominantly caused by members of the public. Laser strikes as a form of social deviancy gained prominence in 2004 to 2005 because of the rise of inexpensive, commercially available laser pointers and it has been speculated that media coverage of incidents may have spurred copycat offenders (Murphy, 2009). It is plausible that offenders may be motivated by the degree of perceived anonymity in the offence — where it can be difficult for aircrew to identify the source of the attack.

### Global prevalence of laser strikes

Fortunately there has yet to be a reported crash caused by a laser strike; however, this may change as the prevalence of occurrences has increased. Occurrence rates appear to reflect exponential growth since 2004/2005, with the number of reported incidents to the US Federal Aviation Administration (FAA) increased an alarming 176-fold from 2004 when there was 46 occurrences to 2015, which had 7703 occurrences. During 2010 to 2014, incidents of laser strikes were reportedly the second most common (13 per cent) source of pilot incapacity occurrences in high-capacity transport operations according to the Australian Transport Safety Bureau (ATSB) (ATSB, 2015).

Laser strikes on aviation agencies by region

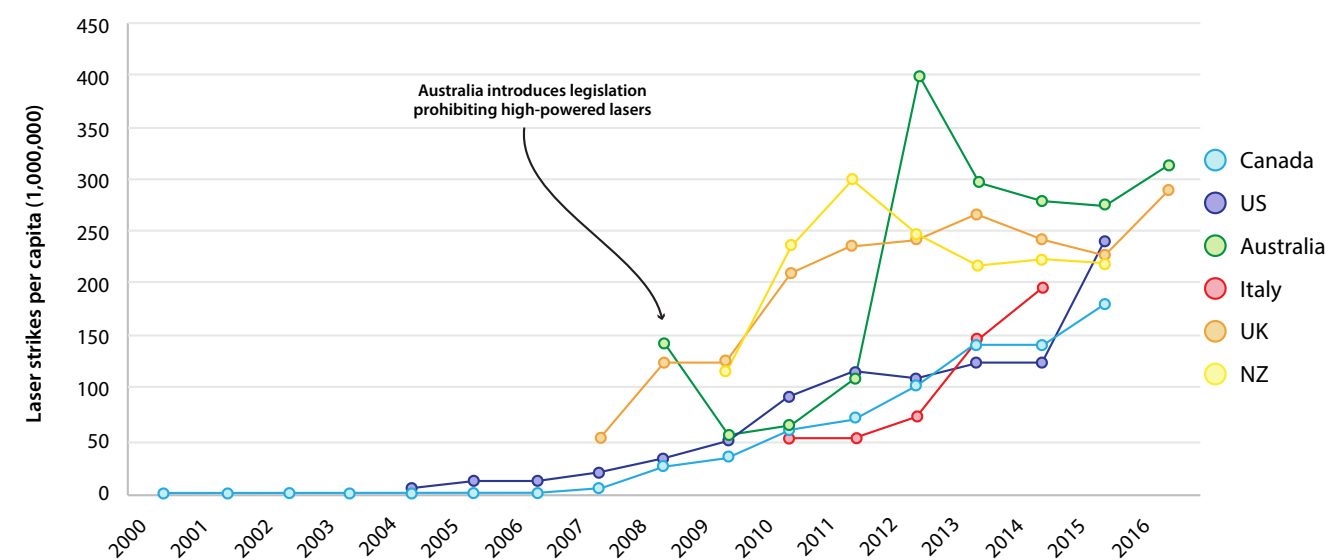


Figure 1. International laser strike incidents by aviation agency region

Figure 1 shows reported yearly laser strikes per capita for aviation safety regulators by region. A sharp decline in reports to the ATSB is observed between 2008 and 2009 following the introduction of legislation restricting the power of handheld devices to 1 millowatt in Australia. Despite changes to legislation, the number of incidents rapidly increases in subsequent years conforming to a general trend of exponential growth observed across other agencies.

This increase in reported laser strikes may be explained by the availability of illegal devices. A 2016 study by RMIT found that in a sample of eight laser pens (four green, four red) purchased either in Australian electronic stores or online, each green laser pen device was 51-to-217 times the legal wattage.

Similarly, an earlier study on hand-held laser wattage, Wheatly (2013) found of 43 devices (a mixture of red, green and violet) advertised as compliant, 95 per cent exceeded the legal wattage. Wheatly proposed that Australia's legislation may actually be detrimental to safety, as sellers are mislabelling device specifications to circumvent these restrictions.

Laser strike occurrence data was collated from publically available aviation

safety data and/or email correspondence with representatives from the ATSB, Canada's CAA, USA's FAA, Italy's ANSV, UK's CAA and New Zealand's CAA. Per capita was chosen over flight hour or movement data due to the hazard being primarily caused by the citizens. Further, the examined countries vary greatly in their number and length of flights as a result of territory size and transport needs, limiting the efficacy of flight hour or movement data for the purpose of examining this hazard. This data is indicative of incident rates, but should be interpreted with caution as occurrence data includes strikes outside of each agency's respective territory.

Laser strikes on Defence aircraft

Figure 2 shows a comparison of laser strikes reported to the ATSB and to Defence between 2008 and 2015. The figure shows that laser strikes, expressed as occurrences per 100,000 movements, are less likely to occur on Defence aircraft than on civil aircraft.

Similarly, Defence have a large proportion of remote aerodromes, whereas targeted attacks are more likely to occur near civilian aerodromes in

major cities. Despite attacks being less likely to occur on Defence aircraft, the number of attacks has still increased nearly two-fold for Defence aircraft between 2010 and 2015, and has increased more than four-fold for civil aircraft.

The majority of Defence flights occur over Australian territory, and subsequently the majority of laser attacks on Defence aircraft have occurred in Australia (84 per cent, 2011-2016). Figure 3 shows the location of laser strikes on Defence aircraft.

Alarmingly, strikes reported in or around Darwin represented more than half (54 per cent) of occurrences in Australia, followed by Williamtown (10 per cent) and Pearce (7 per cent). Defence aircrew, particularly pilots, should be especially aware in these regions when flying at night.

What can you do?

Despite stringent legislation introduced in 2008, a resurgence of laser-strike occurrences is evident in Australia as well as abroad. Defence aviation personnel should remain vigilant, especially when flying near populated areas, and ensure they are familiar with Defence protocol for handling a laser strike.

If you experience a laser strike it is important that the incident is reported to air traffic control in the first instance. This allows air traffic control to inform any aircraft in, or scheduled to be in, the vicinity of the strike to be notified. It is also important that an Aviation Safety Occurrence Report (ASOR) is submitted so that Defence is aware of the prevalence of laser strikes and their locations, and that the Australian Transport Safety Bureau (ATSB) can be notified.

If you experience a laser strike during flight, the following is recommended:

- Avert or shield eyes from the source of the laser.
- Increase lighting in the cockpit. This will make your pupils contract (smaller) decreasing the chance of the laser making contact with them.
- Consider adjusting the flight path so the laser cannot get a clear line of sight with the cabin, such as turning, using the fuselage to block the laser or increasing altitude.
- If the pilot is exposed, consider allowing the co-pilot to take control of the aircraft if available or engaging autopilot.

What is important to remember is that if you are exposed to a laser strike it is highly unlikely that any permanent damage will occur due to the distance between yourself and the device on the ground. However, upon landing if you are experiencing irritation, pain, sensitivity to light, disturbance of vision or black spots it is advised that you consult a medical officer.

The UK CAA offers a self-assessment tool which can help inform individuals whether they may need to seek medical consultation (see p. 8).

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Lower, G. (2008). Aircraft laser pest sent to jail. The Advertiser. Retrieved from <http://www.adelaidenow.com.au/news/south-australia/aircraft-laser-pest-sent-to-jail/story-e6frea83-1111116005019>

Laser strikes in Australia

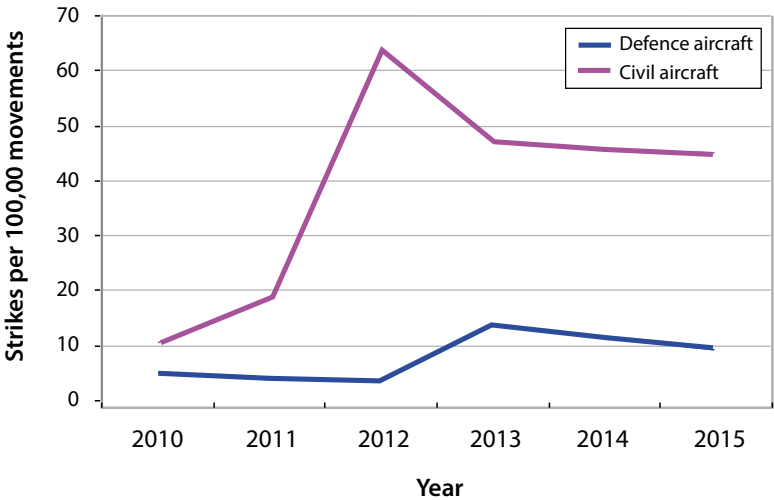


Figure 2. Laser strike incidents in Australia

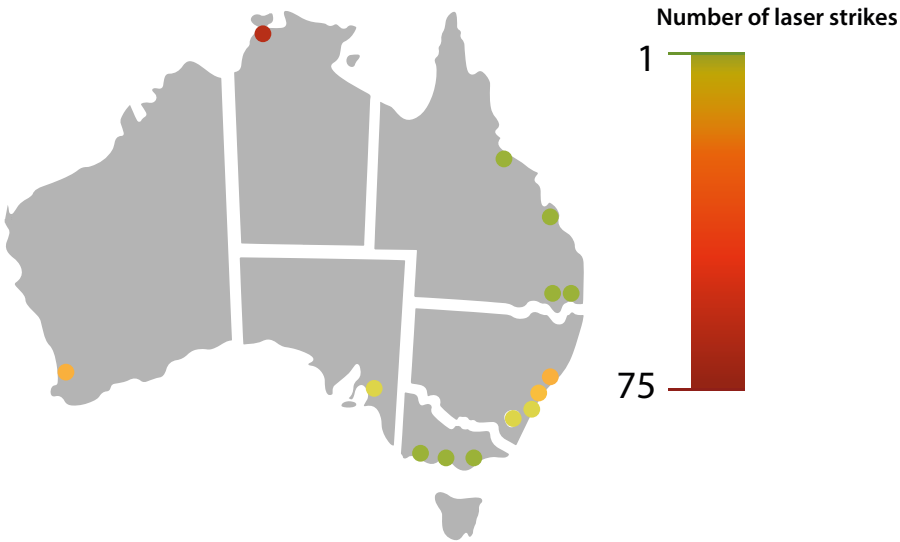


Figure 3. Number of laser strikes reported by Defence personnel (2011-2016)

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# Aviation Laser Exposure

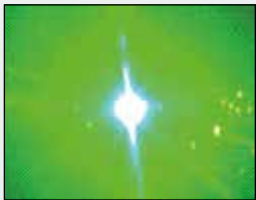
## Self-Assessment (ALESA)

This self-assessment is designed to aid pilots, air traffic controllers, or flight crew members who have been exposed to a laser beam in making a decision on whether or not to see an eye specialist.

The eye specialist may be either an optometrist or ophthalmologist. It is extremely unlikely that a laser-beam exposure will result in permanent eye damage. Eye discomfort and irritation during the exposure is common and rubbing your eye can result in an abrasion that may be painful.

If you have experienced one or more of the following after a laser-beam exposure please consult an eye specialist: **Eye problems** — swelling, pain, itching, watering, discharge, dryness or redness of the eye. **Visual disturbance** — blurring, black spot, trouble reading, loss of peripheral vision, floaters, halos, poor night vision, sensitivity to light.

These symptoms may not appear until hours after the incident and may not be related directly to laser exposure but could reflect other eye issues perhaps not previously noticed.



**1. Flash blindness**  
A visual impairment during and after exposure to a very bright light. It may last for seconds or minutes.



**2. Glare**  
Difficulty seeing in the presence of a bright light.

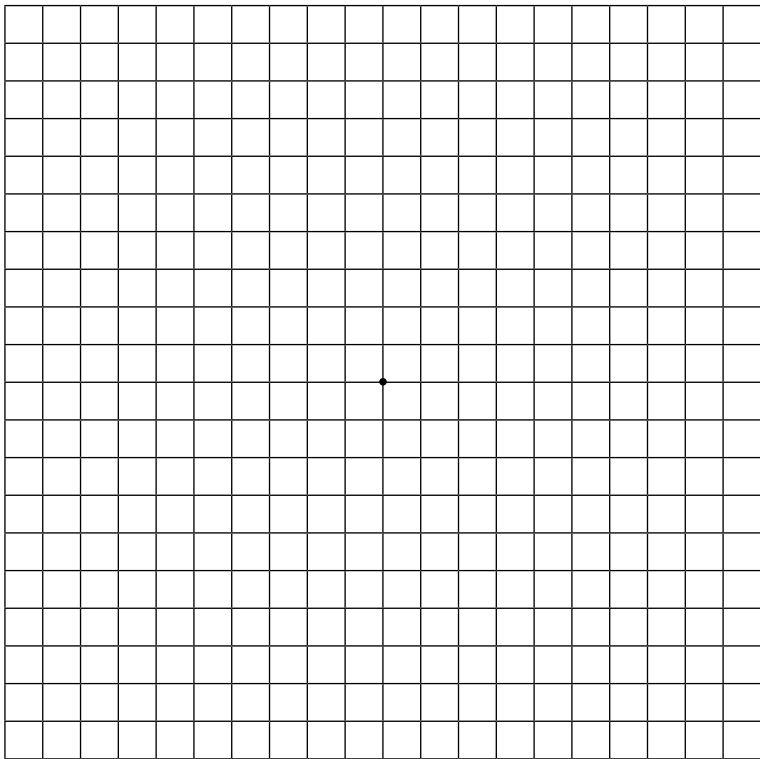


**3. Distraction**  
A light bright enough to disrupt attention.

While viewing the grid from 30cm in front of your eyes, please test one eye at a time to answer the following questions:

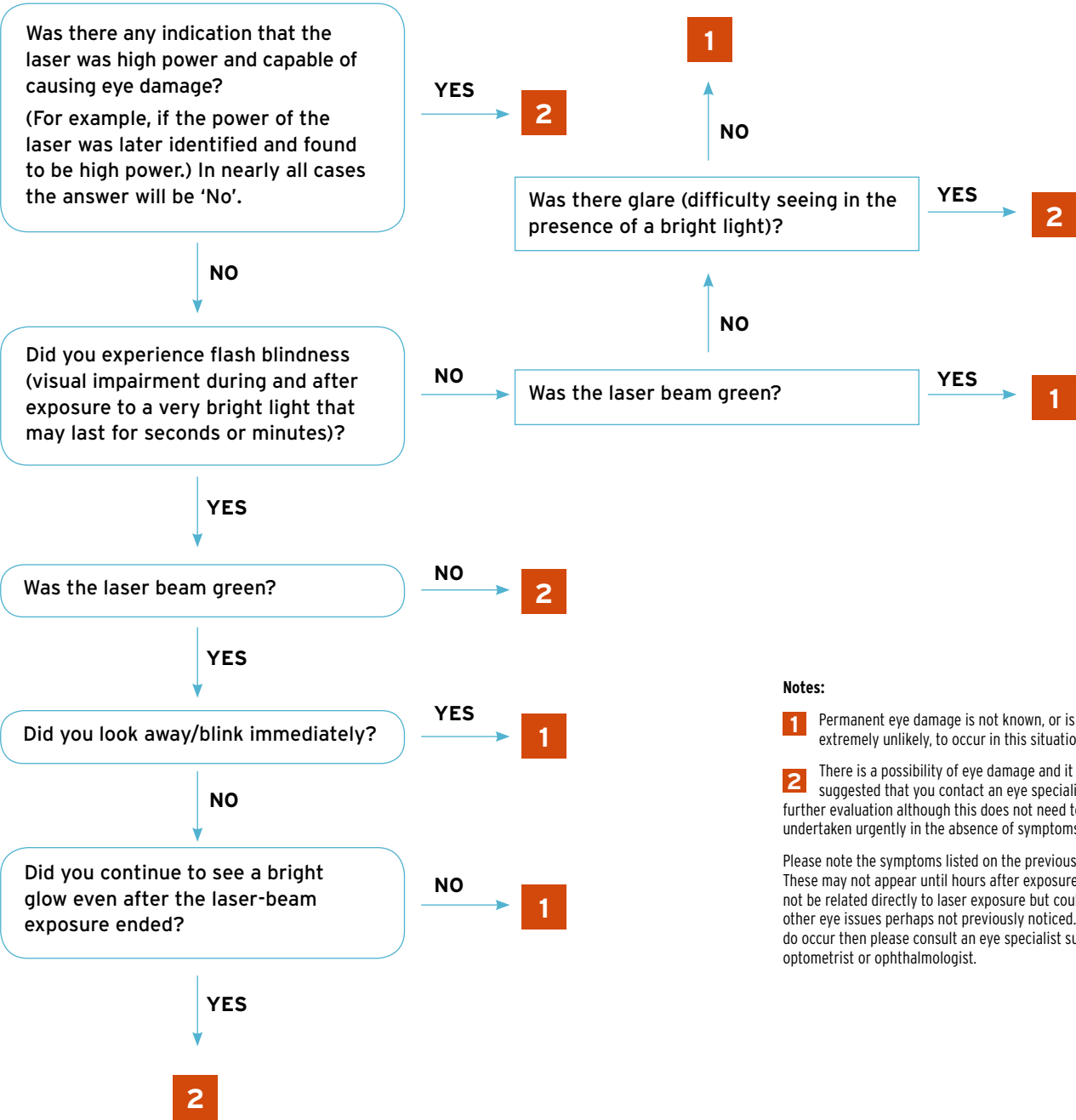
1. Can you see a dot in the centre of the grid?
2. While looking at the centre dot, can you see all four sides and corners of the grid?
3. While looking at the centre dot, do all of the lines appear straight with no distortions or blank or faded areas?

If you answered **YES** to all three questions then please turn to the next page. If you answered **NO** to any of the above questions then you may wish to remove yourself from flying or controlling duties as soon as it is safe to do so and consult an eye specialist.



The dimensions of the grid should be 10cm x 10cm.

In some circumstances it may be possible to have retinal damage without obvious symptoms. The relevance of this is uncertain in the absence of abnormal visual signs (for example, answering "yes" to all three Amsler Grid questions on the previous page) as it is unlikely to have an operational impact or be amenable to treatment. The following is designed to aid a pilot or ATCO in deciding whether or not an assessment should be sought with an optometrist or ophthalmologist after an exposure.



**Notes:**

**1** Permanent eye damage is not known, or is extremely unlikely, to occur in this situation.

**2** There is a possibility of eye damage and it is suggested that you contact an eye specialist for further evaluation although this does not need to be undertaken urgently in the absence of symptoms.

Please note the symptoms listed on the previous page. These may not appear until hours after exposure and may not be related directly to laser exposure but could reflect other eye issues perhaps not previously noticed. If they do occur then please consult an eye specialist such as an optometrist or ophthalmologist.

This ALESA tool has been published with permission from the UK Civil Aviation Authority.

For further information, the British Airline Pilots Association (BALPA) has produced an advisory information sheet which will be available on their website [www.balpa.org](http://www.balpa.org).



# Pointing out the hazard

## Risk of eye injury from lasers

By Dr Adrian Smith, Institute of Aviation Medicine

**L**aser illumination of aircrew in flight can pose a significant hazard to flight safety. Aircrew exposed to lasers in flight can experience degraded night vision and flash blindness from the bright light, the lasers can obscure the visual field by producing glare across the canopy or window, and attempts to illuminate the aircraft with a laser can be distracting.

Despite these significant threats to flight safety, it is very unlikely for aircrew to experience permanent damage to their vision or injury to their eyes after an in-flight lasing event.

Laser eye damage results from the total dose of the laser energy that

strikes the eye; damage to vision is determined by the total dose that enters the pupil. When considering the risk of eye injury, the total dose of laser energy is determined by the power of the laser, the distance between the laser and the eye, and the total time spent looking at the laser.

There are many factors that contribute to the risk of eye injury and permanent vision damage being so uncommon in aviation. These include:

- The power of a laser reduces over distance, and the beam size widens over distance.
- The distance between the laser and the aircraft, both horizontal separation and altitude, commonly exceeds the hazard distance for hand-held laser pointers. This means

that less of the laser energy reaches the eye, and the power of the laser at that distance is too low to produce permanent eye injury.

- The eyes normally blink when they detect a bright light, limiting exposure to a laser to <0.25 seconds. People who consciously resist the normal urge to blink — those who stare at a laser — have the greatest risk of eye injury.
- The aircraft attitude, orientation of the cockpit windows relative to the ground, the jitter seen tracking a moving aircraft with a hand-held laser, and the very small size of the pupils within the cockpit space make it difficult for the laser to enter the eye for long enough to cause injury. However, aircrew who stare at the

laser are aligning their eyes with the laser, focusing the beam into their eyes, and increasing the amount of laser energy entering the eye.

The Nominal Ocular Hazard Distance (NOHD) describes the maximum distance that a laser has the potential to cause serious eye injury. Most hand-held laser pointers in the community have a power <5 mW, and do not have sufficient power to cause eye injury more than 16m away (in a person who blinks normally), or up to 25 m in a person who stares at the laser for more than 10 s without blinking. Even a 500 mW laser pointer only has enough power to cause eye injury up to 160 m (or up to 250 m if you stare at the laser for more than 10 seconds). Even the most powerful hand-held laser pointer available — the 1000mW 'Wicked' laser with a blue beam — only has power to cause eye injury up to 225 m (or 360 m if you stare at the laser for more than 10 seconds).

For aircrew lased by a common hand-held laser pointer, the distance between the laser and the aircraft is usually much greater than the maximum distance that the laser can cause injury to the eyes. However, the risk of eye injury increases substantially in people who stare at a laser.

The brightness of a laser is related to its colour and the sensitivity of the retina, not its power. Green lasers appear much brighter than a red laser or a blue laser of the same power. The risk of eye injury is not related to how bright a laser appears, but the power of the laser, the distance between the laser and the eye, and the total time of exposure. Even though a green hand-held laser pointer may appear bright to aircrew flying at night, it is unlikely to have enough power to cause eye injury unless they stare at it. The risk of eye injury is greater from a blue laser than a green laser, not because of the colour but because the power of the blue 'Wicked' laser is greater than common hand-held laser pointers, which are green.

### Night vision goggles (NVG)

Night vision goggles provide protection from direct laser illumination; however, they provide no protection against lasers that can be seen outside the edge of the NVG field of view. In addition, some lasers can cause NVGs to bloom or shut-down. Aircrew wearing NVGs should be cautious about relying on the NVGs to protect them from laser eye damage.

### What should you do if you have been lased?

From a medical point of view, aircrew who have been lased in flight — especially those who noticed a bright flash as the laser temporarily hit their eyes — should look away from the laser and shield their eyes if possible. It is very important not to look for the laser source, and not to stare at it. Staring at a laser increases the risk of eye injury substantially. It would be helpful to increase the cockpit lighting, but this may not be desirable in an operational setting.

Transient degradation in night vision is common whenever a person is exposed to a bright light at night, including a laser. Exposure to a bright light at night may be accompanied briefly (5 s) by ghosting or after-images of the light source. This is normal, and does not indicate damage to the eyes or loss of vision. However, if night vision has been degraded by the laser, the affected pilot should consider handing control to the unaffected pilot, or engage autopilot if practical, until their night vision returns to an acceptable level.

If the eyes feel sore or uncomfortable, or if they are very sensitive to light, avoid rubbing them. Rubbing the eyes will make the irritation worse, and could aggravate a superficial laser eye injury.

If visual symptoms persist beyond a few seconds (5 to 10 s), vision may have been compromised by the laser exposure. Aircrew concerned that

**The risk of eye injury is greater from a blue laser than a green laser, not because of the colour but because the power of the blue 'Wicked' laser is greater than common hand-held laser pointers, which are green.**





# DASR 66

## Benchmarking against international standards

By FLTLT Barrie Bardoe

**The ADF has a strong learning and development system for aviation technicians based on attaining Australian units of competency — experience and demonstrated performance. This will not change under the new Defence Aviation Safety Regulations (DASR) 66. Rather, DASR 66 introduces a globally recognised licensing standard for technical personnel.**

These licences consist of core privileges and extensions depending on individual qualifications, training and experience. Personnel will not be required to undertake additional training and will still do the same jobs they are authorised to do after September 2018, without disruption. In cases where a particular skill set is lacking with regard to DASR

66 requirements, individuals will still be licensed but their licences will have limitations (exclusions) reflecting the missing skill set.

DASR 66 licensing allows the Defence aviation technical workforce to be benchmarked against recognised criteria.

DASR 66 represents a great opportunity for Defence's aviation maintainers, allowing their technical skills to be recognised in the wider global aviation community. It also enhances possible military/civilian blended-workforce approaches and enhances sustainment and supply options.

A common licensing approach is also a win for personnel on deployment — an increasing issue as Defence undertakes operations with coalition partners. The Defence Aviation Safety Authority (DASA) will begin issuing draft licenses to eligible personnel from mid 2017.

Those licenses will need to be reviewed for accuracy with the assistance of supervisors. Inaccuracies can be reported to DASA before an individual's Military Aircraft Maintenance Licence is issued for September 2018.

The transition to licencing is being managed with as little administrative disruption as possible but it does require the delivery of training to the regulated community, confirmation by technicians of the accuracy of draft licences, and developing sustainable procedures for licence processing and up-issuing. This is another part of the journey towards the ADF being fully integrated into a globally recognised system of military airworthiness.

DASA is holding detailed information sessions at all locations and until final licenses are issued it is business as usual.

their vision may have been affected by a laser strike should evaluate their vision using whatever visual material is available.

A flight manual, checklist, or map would be ideal, but even looking at the instrument panel would serve the purpose. In good illumination, look at the flight manual or checklist — you should be able to see it clearly. The writing should be clear and even; lines should be straight, and the visual field should be distortion-free; you should not see black spots or areas of darkness. If your visual field is uneven, distorted, or you can see dark areas or black spots, your vision may have been affected. If you can see clearly and read easily, and your visual field is even, has no distortion, and is free of black spots, you can be comforted that your vision has not been affected.

The RAAF Institute of Aviation Medicine (RAAF IAM) is developing a 10 x 10 cm card with a grid on one side and text on the other to assist aircrew to self-assess their vision after an in-flight lasing event. This will be available shortly, and will be distributed to aircrew when available.

### When should you see an AVMO?

Aircrew who have been lased in flight should seek urgent medical advice if they experience eye pain or irritation, or if they are concerned that their vision has been affected. Aircrew who

have been lased do not need to seek urgent medical advice if they have no eye symptoms and their vision is unaffected.

This advice relates to the incidental lasing of aircrew in flight, where the laser is presumed to be a common low-power hand-held laser pointer.

Aircrew who have been lased by blue laser, a military-grade laser, or where aircrew may be operating in a tactical environment where there is a known or suspected threat from high-powered or military lasers, may be at higher risk of eye injury.

Where [there is] use of anti-personnel lasers comprising UV or infra-red energy (with [or] without visible wavelengths), the risk of eye injury is even greater. However the advice remains the same — aircrew who suspect they have been lased should seek urgent medical assessment if they develop eye pain or irritation, sensitivity to light, or vision distortion.

If the laser beam was blue, or if there is evidence to suggest that the laser may have been a high-powered laser or a military-grade laser, IAM recommends that aircrew who have been lased see an AVMO, although in the absence of any eye discomfort or vision impairment, this does not need to be arranged urgently and can be safely conducted the following day.

However, as stated before, aircrew who have been lased in flight should seek urgent medical

advice if they experience eye pain or irritation, or if they are concerned that their vision has been affected.

IAM has produced guidelines for the management of aircrew who have been lased in flight, intended for use by aircrew and aviation medical officers. Report IAM-2017-006-SR will be available from the IAM DRN webpage.

### Summary

Although in-flight lasing events pose a significant hazard to flight safety by reducing night vision and obscuring the visual field, common hand-held laser pointers pose a very low risk of causing eye injury or loss of permanent vision effects.

Common hand-held laser pointers do not have sufficient power to cause eye injury beyond 16 m unless you stare at them, and even the risk of eye injury from higher powered blue lasers is limited to 160 to 225 m with a normal blink response. Staring at a laser substantially increases the risk of eye injury.

Despite the risk of eye injury being low, aircrew who suspect they have been lased should seek urgent medical assessment if they develop eye pain or irritation, sensitivity to light, or distortion of vision.

If the laser beam was blue, or if there is evidence to suggest that the laser may have been a high-powered laser or a military-grade laser, IAM recommends that aircrew who have been lased see an AVMO, although in the absence of any eye discomfort or vision impairment, this does not need to be arranged urgently and can be safely conducted the following day.

### RAAF IAM duty phone

The RAAF Institute of Aviation Medicine provides a 24/7 duty phone — +61 (0)408 234 044. Aircrew who have been lased and who are concerned about their vision can contact IAM at any time on to discuss the risk of eye injury and recommended follow-up.

**...aircrew who have been lased in flight should seek urgent medical advice if they experience eye pain or irritation, or if they are concerned that their vision has been affected.**





# Automation vulnerabilities

By Wayne Rosenkrans

A US study of flightpath-management anomalies updates recommended solutions.

**A**lthough difficult, flight-path-management tasks are handled routinely by professional pilots operating highly automated aircraft. The most demanding situations still tend to significantly increase the pilots' task complexity and workload, according to a US working group of subject matter experts.

For example, in cases in which air traffic control (ATC) suddenly issued an amended

clearance/vector changing the preplanned flight path — say, for temporary deviation from a complex instrument flight procedure — some pilots told the working group they struggled, at times, to recover the optimum flight path by relying solely on modes of the automated systems. Moreover, complete or partial reversion to manual flight operations to resolve brief confusion could be problematic, the working group's analyses showed.

Actual and potential safety consequences of this and related problems and new recommendations for integrated solutions, form the core of the final

report on operational use of flight-path management systems, issued in late 2013 by the Flight Deck Automation Working Group.<sup>1</sup>

Kathy Abbott, chief scientific and technical adviser for flight deck human factors at the US Federal Aviation Administration (FAA) and a co-chair of the 34-member working group, said the airline industry's "impressive safety record" partly can be attributed to flight crews intervening, as expected, to mitigate flight path-related risks during flights, underscoring the reason for addressing persistent problems in flight-path management.

This initiative also dovetails with government-industry efforts in airplane upset prevention, recognition and recovery, the report says.

"Incident and accident reports suggest that flight crews continue to have problems interfacing with these systems and have difficulty using these flight path management systems," Dr Abbott says. "We found vulnerabilities in [automation] mode and energy-state awareness, manual handling, and managing system malfunctions or failures. These included failures anticipated by designers, [failures] for which there were no flight crew procedures, and [failures] in flight management system (FMS) programming."

At a December 2013 investigative hearing of the US National Transportation Safety Board (NTSB), Dr Abbott and working group co-chair — David McKenney, a United Airlines captain representing the International Federation of Air Line Pilots' Associations — fielded questions about the relevance of the new report to an accident five months earlier.

Asked about the integration of philosophies and policies of human-centered design into flight deck automation during the past 15 years, Dr Abbott told the hearing that "one of the important gaps that ... sometimes does happen is a difference between the philosophy and the design, and the way that the systems are actually operated."

Capt McKenney testified: "Manual flight operations is not just the stick-and-rudder skills that everybody thinks it is. The term means [the psychomotor skills,] the cognitive skills, the airmanship, how we fly the aircraft [and] how we use these

automated systems to actually maintain the flight path."

"What we are recommending is that we create an operational policy for flight-path management that highlights that the responsibility of flight-path management rests with the pilot and that the automated systems are only one of the tools," he says.

"Pilots [are trained] to rely on the systems all the time but they are not taught to question the systems. They expect the system to work when they use it and when it doesn't, then they get caught short."

In addition to presenting and cross-referencing exhaustive analyses of accident/incident data, line operations safety audit (LOSA) data, de-identified voluntary reports from frontline personnel and structured interviews with industry specialists, the report integrates some exclusively obtained, confidential material from individuals and organizations.

## Basic findings

The following excerpts selected from 22 of the report's 29 findings reflect the scope of inquiry; (seven findings about research methodology and data limitations have been omitted). The excerpted findings, grouped by related subjects, include:

- Pilots mitigate safety and operational risks on a frequent basis, and the aviation system is designed to rely on that mitigation. Pilots successfully manage equipment malfunctions as threats that occur in normal operations. However, insufficient system knowledge, flight crew procedure, or understanding of aircraft state may decrease pilots' ability to respond to failure situations.
- The highly integrated nature of current flight decks, and additional add-on features and retrofits in older aircraft have increased flight crew knowledge requirements and introduced complexity that sometimes results in pilot confusion and errors in flight deck operations. Complex or unfamiliar airspace flight procedures can be confusing and lead to errors involving flight-path management. ... Increasingly, operators use a documented automation policy.
- Vulnerabilities were identified in pilot knowledge and skills for manual flight operations. ... Pilot use of, and interaction with, automated systems were found to be vulnerable in [several] areas.

**"Pilots [are trained] to rely on the systems all the time but they are not taught to question the systems. They expect the system to work when they use it and when it doesn't, then they get caught short."**



- Data-entry errors, together with cross-verification errors, may cause significant flight-path deviations leading to incidents or accidents. ... Pilot-to-pilot communication and co-ordination have improved and been more formalized; however, communication and co-ordination vulnerabilities still contribute to accidents and incidents.
- Flight deck task/workload management continues to be an important factor affecting flight-path management. Pilots sometimes lack sufficient or in-depth knowledge and skills to most efficiently and effectively accomplish the desired flight-path management-related tasks.
- Current training methods, training devices, the time allotted for training, and content may not provide the flight crews with the knowledge, skills and judgment to successfully manage flight-path management systems. Flight-instructor training, experience, and line-operation familiarity may not be sufficient to effectively train flight crews for successful flight-path management.
- Air traffic service personnel often do not have sufficient knowledge of how airspace procedure design and clearances affect flight deck-operations and often lack knowledge of aircraft capabilities. Communication and co-ordination between pilots and air traffic services [have] vulnerabilities that can affect flight path management.

Other findings point to significant variations in flight-deck equipment design; potential differences in flight paths that should be identical within a given airspace; inconsistent application of human-factors expertise; government-industry discrepancies in using the term human-factors specialist; improved US regulatory expertise in human-performance evaluation but constrained resources to meet current demands; excessively lengthy government processes for aircraft certification and operational approvals for new technologies and supporting policy/procedure approvals; and insufficient regulatory consideration of

automation integration and flight-crew effects.

## Recommendations

The following excerpts selected from 14 of 18 recommendations reflect the scope of inquiry; the four that were omitted concern ways to improve the regulatory process to expedite aircraft/equipment certification, encourage consistency in new pilot-automation interfaces, improve data collection/analysis to advance knowledge of human factors in flight-path management, and improve accident investigation practices in these contexts.

**1.** Develop and implement standards and guidance for maintaining and improving knowledge and skills for manual flight operations that include the following: pilots must be provided with opportunities to refine this knowledge and practice the skills; training and checking should directly address this topic; and operators' policies for flight path management must support and be consistent with the training and practice in the aircraft type.

**2.** For the near term, emphasize and encourage improved training and flight-crew procedures to improve autoflight mode awareness as part of an emphasis on flight-path management. For the longer term, equipment design should emphasize reducing the number and complexity of autoflight modes from the pilot's perspective and improve the feedback to pilots (for example, on mode transitions) while ensuring that the design of the mode logic assists with pilots' intuitive interpretation of failures and reversions.

**3.** Develop or enhance guidance for documentation, training and procedures for information automation systems [including communications automation] (for example, EFBs [electronic flight bags], moving map displays, performance-management calculations, multi-function displays) or functions. Describe what is meant by information

automation and what systems [or] equipment are included; define terms associated with information automation; develop guidelines concerning the content and structure of policy statements in flight operations policy manuals for information automation; and develop operational procedures to avoid information automation-related errors.

**4.** In the near term, develop or enhance guidance for flight-crew documentation, training and procedures for FMS use. For the longer term, research should be conducted on new interface designs and technologies that support pilot tasks, strategies and processes, as opposed to machine or technology-driven strategies. Among contextual notes, the report says: "Consideration should

be given to a new, much simpler flight-path management system design from the pilot's perspective [closely integrating new FMS designs with evolving airspace requirements].

**5.** Research should be conducted and implemented on processes and methods of verification and validation ([including] validation of requirements) during the design of highly integrated systems that specifically address failures and failure effects resulting from the integration.

**6.** Flight-crew training should be enhanced to include characteristics of the flight-deck system design that are needed for operation of the aircraft (such as system relationships and interdependencies during normal and

non-normal modes of operation for flight path management for existing aircraft fleets). For new systems, manufacturers should design flight deck systems such that the underlying system should be more understandable from the flight crew's perspective by including human-centered design processes. Among contextual notes, the report says: "Newer designs should focus on the flight crew's ability to understand normal system operations and their ability to function effectively without error, especially when failures occur. ... The integration of multiple systems should be designed such that the flight crew has clear, definitive and well-understood actions in the event of failures or degraded modes."

**7.** Develop guidance for flight-crew strategies and procedures to address malfunctions for which there is no specific procedure.

**8.** For the near term, update guidance ... and develop recommended practices for design of SOPs [for flight crews] based on manufacturer procedures, continuous feedback from operational experience and lessons learned. This guidance should be updated to reflect operational experience and research findings on a recurring basis. For the longer term, conduct research to understand and address when and why SOPs are not followed. The activities should place particular emphasis on monitoring, cross-verification, and appropriate allocation of tasks between pilot flying and pilot monitoring.

**9.** Operators should have a clearly stated flight-path management policy as follows: The policy should highlight and stress that the responsibility for flight-path management remains with the pilots at all times. Focus the policy on flight-path management, rather than automated systems. Identify appropriate opportunities for manual flight operations. Recognize the importance of automated systems as a tool (among other tools) to support the flight-path management task, and provide operational policy for the use of automated systems. Distinguish

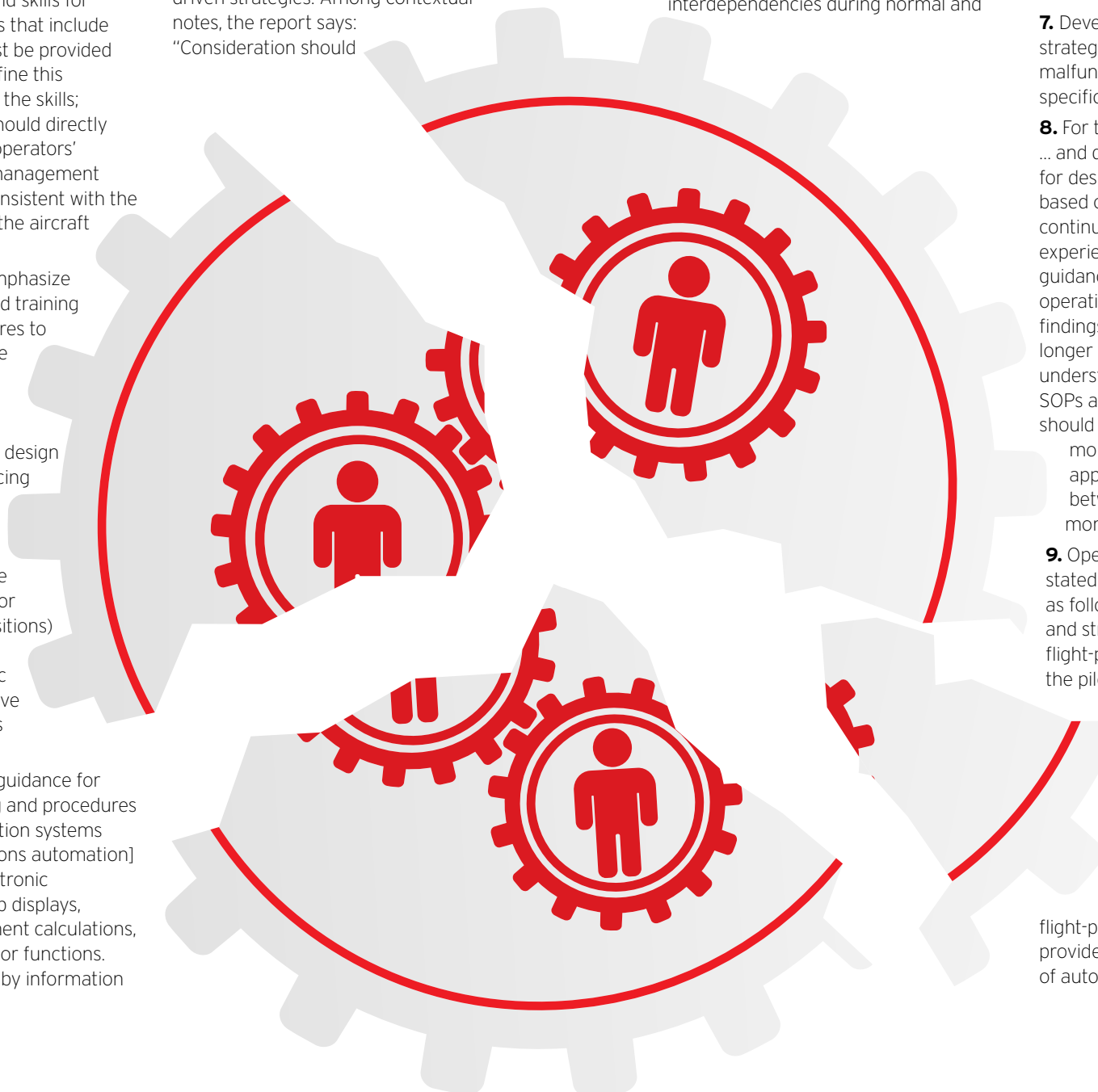
between guidance and control. Encourage flight crews to tell [ATC] 'unable' [to comply with instruction/clearance] when appropriate. Adapt to the operator's needs and operations.

Develop consistent terminology for automated systems, guidance, control and other terms that form the foundation of the policy. Develop guidance for development of policies for managing information automation. Among contextual notes, the report says: "The operator's policy should provide guidance on the operational use of automated systems [including] examples of circumstances in which the autopilot should be engaged, disengaged, or used in a higher or lower authority mode; the conditions under which the autopilot or autothrottle will or will not engage, will disengage, or will revert to another mode; and appropriate combinations of automatic and manual flight path control (for example, autothrottle engaged with the autopilot off)."

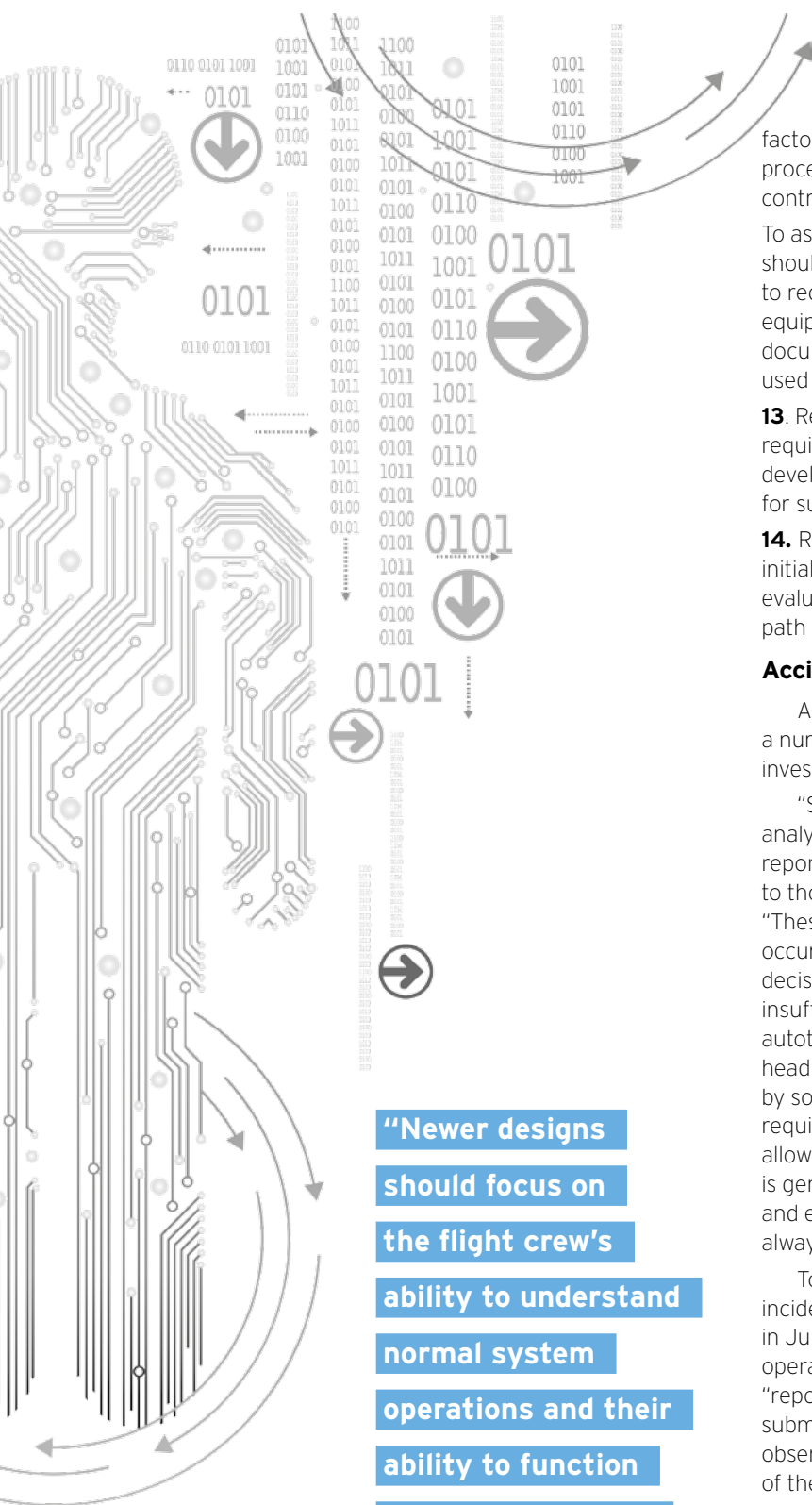
**10.** Discourage the use of regional or country-specific terminology in favor of international harmonization. Implement harmonized phraseology for amendments to clearances and for reclearing onto [approach] procedures with vertical profiles and speed restrictions. Implement education and familiarization outreach for air traffic personnel to better understand flight-deck systems and operational issues associated with amended clearances and other air traffic communications. In operations, minimize the threats associated with runway-assignment changes through a combination of better planning and understanding of the risks involved.

**11.** Continue the transition to performance-based navigation (PBN) operations and drawdown of those conventional procedures with limited utility [or potentially higher risk (for example, those procedures that lack vertical guidance)]. As part of that transition, address procedure design complexity (from the perspective of operational use) and mixed-equipage issues. Standardize PBN procedure design and implementation processes with inclusion of recommended practices and lessons learned. This includes arrivals, departures, and approaches.

**12.** Ensure that appropriate human-







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factors expertise is integrated into the flight-deck design process in partnership with other disciplines, with the goal of contributing to a human-centered design.

To assist in this process, an accessible repository of references should be developed that identifies the core documents relevant to recommended practices for human-centered flight deck and equipment design. Early in the design process, designers should document their assumptions on how the equipment should be used in operation.

**13.** Revise initial and recurrent pilot training, qualification requirements (as necessary), and revise guidance for the development and maintenance of improved knowledge and skills for successful flight-path management.

**14.** Review and revise, as necessary, guidance and oversight for initial and recurrent training and qualification for instructors/evaluators ... to successfully teach and evaluate airplane flight-path management, including use of automated systems.

#### Accident insights

Among the diverse insights brought to the working group, a number are now being considered coincidentally by accident investigators assigned to recent accidents.

"Since the working group completed its data collection and analysis, several accidents have occurred where the investigative reports identified vulnerabilities in the events that are similar to those vulnerabilities identified in this report," the report says. "These vulnerabilities represent systemic issues that continue to occur. ... Other factors that affect the pilots' [automation-related] decisions include the high reliability of the systems (fostering insufficient cross-verification, not recognizing autopilot or autothrottle disengagement, or not maintaining target speed, heading or altitude). ... This may be exacerbated in the future by some new airspace procedures that are so complex and require such precision that flying manually is impractical or not allowed, because of the likelihood of deviation. ... Although there is general industry consensus that monitoring, cross-verification and error management are important, these topics are not always explicitly trained."

To produce the report, the working group analyzed accidents, incidents and normal operations for various periods ending in July 2009 and conducted interviews with manufacturers, operators and training organizations. Other sources were "reports from related activities", including those confidentially submitted by individuals and organizations; various types of observations and analyses during LOSAs, from the archives of the LOSA Collaborative; and personal knowledge and experiences of working group participants, including James M Burin, then Flight Safety Foundation's director of technical programs.

#### Notes

Flight Deck Automation Working Group. Operational Use of Flight Path Management Systems: Final Report of the [FAA] Performance-based Operations Aviation Rulemaking Committee/[U.S.] Commercial Aviation Safety Team Flight Deck Automation Working Group. 5 September, 2013. The third co-chair of the working group is Paul Rallsback of Airlines for America.

The working group defined vulnerability, in the context of flight path management, as "a characteristic or issue that renders the system or process more likely to break down or fail when faced with a particular set of circumstances or challenges".

Abbott, Kathy et al. *The Interfaces Between Flightcrews and Modern Flight Deck Systems*, FAA Human Factors Team Report. June 18, 1996. <1.usa.gov/1cZpsf3>.

## CASE STUDY



## NTSB HEARING ON CRASH OF ASIANA AIRLINES FLIGHT 214

The release in late 2013 of a U.S. government-industry report titled **Operational Use of Flight Path Management Systems** roughly coincided with a public investigative hearing on 11 December by the US National Transportation Safety Board (NTSB). The subject was the crash of Asiana Airlines Flight 214, a Boeing 777, at San Francisco International Airport.

Preliminary NTSB reports and the agency's public statements about the event — in which the aircraft struck a seawall before reaching the landing runway threshold during a visual approach while the glide slope of the instrument landing system was out of service — say one investigator will focus on the pilots' interface with flight-deck automation.

Among subject matter experts called to testify at the investigative hearing were Kathy Abbott, chief scientist and technical advisor for flight deck human factors, US Federal Aviation Administration (FAA), and David McKenney, a United Airlines captain representing the International Federation of Air Line Pilots' Associations. They spoke in their roles as co-chairs of the Flight Deck Automation Working Group, and they also provided personal opinions.

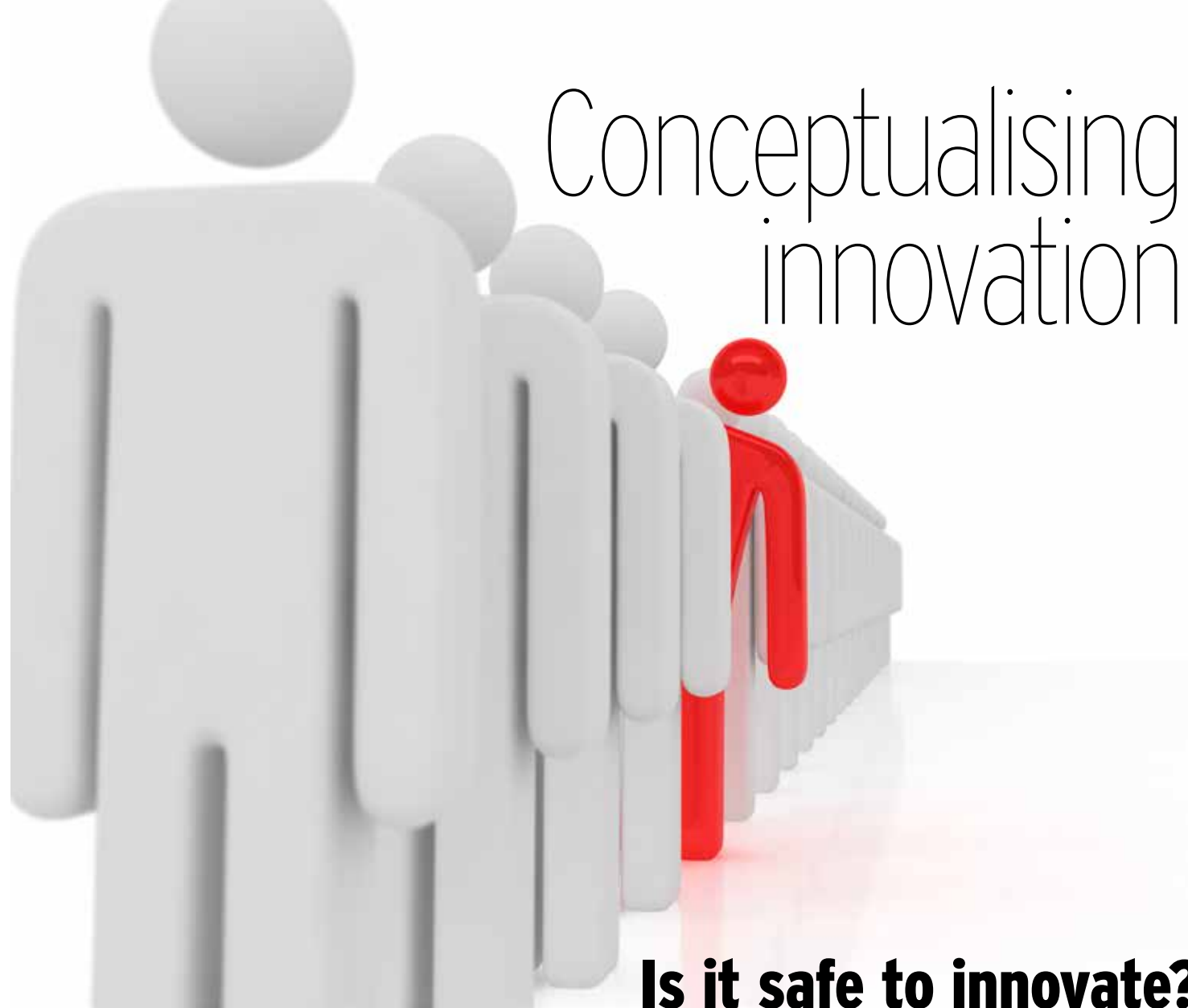
Abbott says, "The working group identified that pilots contribute in a significant way to mitigating safety and operational risk in the aviation system, and the aviation system is designed to depend on

that mitigation. [Automated systems] have contributed significantly to improvements in safety, operational efficiency and precise flight-path management. However, certain aspects of pilot use of, and interaction with, automated systems have been found to have some vulnerability areas.

"We identified vulnerabilities in that pilots sometimes rely too much on the automated systems and may be reluctant to intervene. We saw that autoflight mode confusion errors continue to occur, and we saw that FMS [flight management system] programming and usage errors continue to occur, as well as others. ... The data suggest that the highly integrated nature of current flight decks and additional add-on features, and retrofits in older aircraft, have increased flight-crew knowledge requirements and introduced complexity that sometimes results in pilot confusion and errors in flight deck operations."

Some manufacturers of aircraft and avionics can address automation concerns with current human-factors knowledge, she says, noting in part that "we found that human-factors expertise has been increasingly incorporated into the design process at most manufacturers but is still inconsistently applied at some manufacturers. Furthermore, human-factors specialists or human-factors expertise may not exist in some organizations or is called in very late in the [design/engineering] process."





# Conceptualising innovation

## Is it safe to innovate?

...the hearing's other testimony that suggested gaps can exist between airplane manufacturers' assumptions about pilot capabilities to solve immediate problems by reducing the automation level or by full manual flight operations.

"Since a 1996 FAA report on the interfaces between flight crews and modern flight-deck systems, the Automation Subcommittee of the Air Transport Association of America (now Airlines for America) produced four papers on recommended practices for training and use of automated systems, and a US Commercial Aviation Safety Team safety enhancement facilitated further work on mode awareness and automation policy for airlines," she says.

Abbott told the hearing that among the FAA's most relevant regulatory amendments or new regulations implemented between 1996 and 2013 is Federal Aviation Regulations Part 25.1329 on flight guidance systems, which include autopilots, autothrottle/ autothrust systems and flight directors. Others are Part 25.1302, Installed Systems and Equipment for Use by the Flight Crew, covering design-related pilot error, and amendments to Part 25.1322 on flight deck alerting systems. Updated guidance based on the period's research includes Advisory Circular 25-11 on electronic flight deck displays.

NTSB panelists asked the working group co-chairs, "Why did it take 17 years to update the 1996 report?" Abbott said that the deliberative rulemaking processes involved are inherently time consuming, and that automation-related improvements to pilot training — a number of them dating from the 1996 report — needed to be implemented gradually by the industry, given time to become effective and then assessed over a number of years for the FAA to determine the safety results.

McKenney told the hearing that a key 2013 report finding was that during an airline pilot's career, skills evolve over time. "This increase in pilot knowledge and skills is not diminished as a result of the automated systems but is actually increased," he says. "It also requires pilots to be even more of a pilot [in terms of manual flight operations] and also a systems manager, where we have to not only control the aircraft but also manage the additional systems that have been put in the flight deck."

Another working group consensus was that overall there is "incomplete understanding of complex relationships

in modes of flight director, autopilot, autothrottle and autothrust and [FMS] computers, including such things as system limitations, the operating procedures and the need for confirmation and cross-verification — as well as the mode transitions and behavior," he says.

Training improvements that, for now, appear to be most relevant to the current Asiana accident investigation, are knowledge of when to use various combinations of the automated systems, the situations that can lead to distractions and strategies to prevent these distractions, both on the ground and in flight, he says.

Other key areas appear to be knowledge related to the mode logic and maintaining awareness of the state of the system modes, task workload management, automation management, automated system mode management and decision making, McKenney says.

Asked for other personal insights into the context of the Asiana accident, he noted the investigative hearing's other testimony that suggested gaps can exist between airplane manufacturers' assumptions about pilot capabilities to solve immediate problems by reducing the automation level or by full manual flight operations.

"What we are saying with the flight-path management is that ... [although] we train the pilots to operate the systems, we don't train the pilots well [in] actually how they maintain the flight path of the aircraft using the automated systems," he says. "It's more [about how] we interface with the system but not actually how to use that — and especially in unexpected situations where they may find themselves not in the pristine environment [in which] they are trained in the simulator. ... We train how the automated systems work well, but we don't train the exceptions ... . We could do that very easily."

### Notes

Flight Deck Automation Working Group, Operational Use of Flight Path Management Systems: Final Report of the Performance-Based Operations Aviation Rulemaking Committee/Commercial Aviation Safety Team Flight Deck Automation Working Group, 5 September, 2013.

By Tony Bannister-Tyrrell and Kirstie Carrick

**Some readers will no doubt recall the introduction of Total Quality Management (TQM), the transition to RAAFG and its associated programs, the Theory of Constraints and the more recent programs such as 5-Whys, 6-Sigma, Lean and continuous improvement. These programs and others like them, focus attention on business-process improvements, doing more with less and, ultimately, working smarter.**

But when it comes to innovation, how do these initiatives interact with the regulatory requirements of AEO and AMO compliance? Innovation, innovative thinking and innovative decision-making are cornerstones of business-improvement processes but how can these be effectively applied within the aviation maintenance domain? Importantly, at what point does an innovation become a violation?

Effort has been applied to researching innovation in the aviation domains of aircrew, cabin crew, air traffic management, engineering and maintenance. However, similar research effort has not focused on the inter-relationship of innovation and violation. Maintenance manuals, technical publications and procedures are, by design, detailed, descriptive and directive and comprehensively linked to the Original Equipment Manufacturer (OEM). They are routinely subjected to design-engineering reviews and updates yet, within the aviation maintenance domain, procedure non-compliance has been identified as a substantial causal factor in aviation accidents and incidents.

So it should come as no surprise that within the current regulatory framework a decision by a technician, maintenance supervisor or inspector to deviate from an approved procedure is fundamentally a decision-error and potentially an intentional violation. Therefore, to what extent can innovation be recognised as a legitimate action from the same decision process?

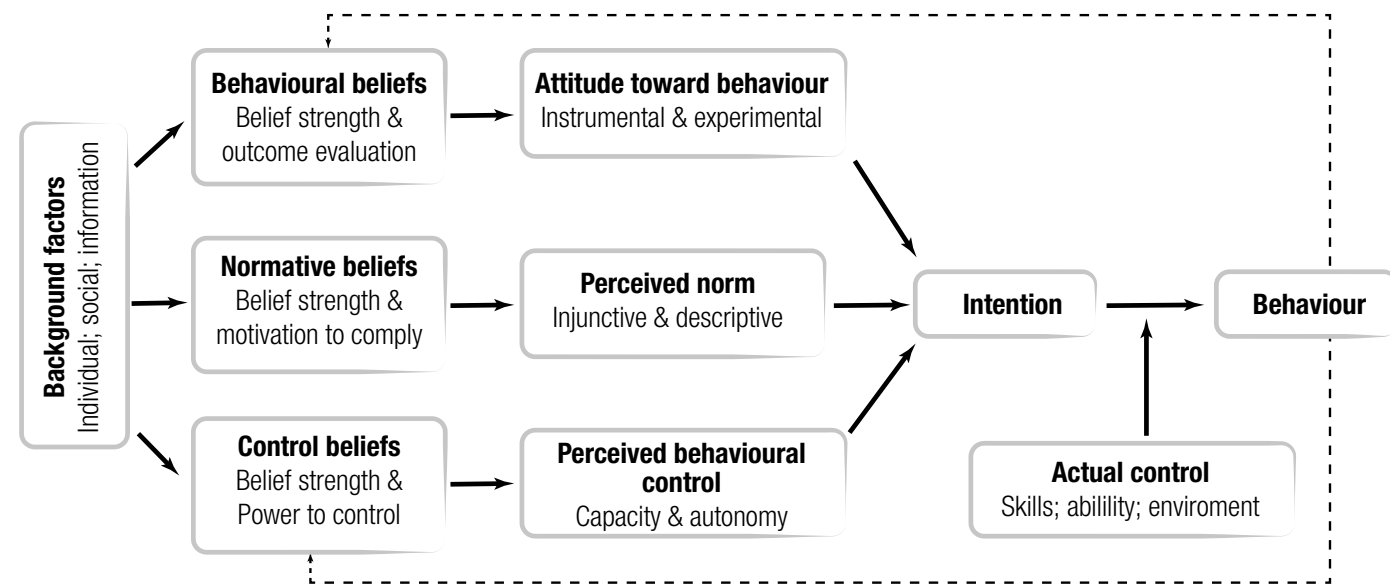


Figure 1. Reasoned action approach

### Defining the problem

In order to understand innovation we first need to understand why an aviation maintenance person would want to deviate from the stated procedure. The research conducted to date suggests there are a number of triggers. These are: wanting to improve the process of the task; reducing required resources (labour, GSE, spares et cetera.); reducing the time taken to complete the task; outdated publications; and, confusing or incorrect publications. Given some of these examples it could be assumed that older fleets were more susceptible to these triggers; however, there is evidence that newer fleets with electronic publications are just as much at the mercy of innovative approaches to maintenance.

What is not evident from the triggers identified above is the primary factor — that being, how was the decision to deviate arrived at? To what extent did the individual's aircraft knowledge and task competency dictate their willingness to pursue an alternate path? In making a deviation decision, what criteria was the risk of that deviation assessed, mitigated and managed against? There is a need to understand the relative importance that each of these elements (knowledge, competency and risk)

has on an individual's willingness to apply an innovative approach to a maintenance task and the extent to which that individual understands or accepts the violation risk.

The constraints and limitations imposed by maintenance manuals and procedures are unlikely to provide any degree of latitude for a technician or supervisor to vary their approach to a maintenance task. Indeed it would be argued by an airworthiness regulator that compliance with the approved publication was the only applicable approach. So the need for process improvement and enhanced resource utilisation requires a balanced approach to ensure that maintenance of an effective systems safety program also caters for the development and implementation of process improvements.

### The violation pathway

Violations are routinely described as mistakes, errors, slips and non-compliances. It has been suggested that these descriptors rarely, if ever, mention innovative approaches to maintenance. Some researchers have gone further and have argued for maintenance personnel to be able to act on the basis of attaining enhanced systems knowledge. James Reason (1997) also argued that departures

from procedures could lead to easier and more efficient ways of conducting maintenance. Therefore, the requirement exists to capture innovative events, to understand the associated decision processes and to ensure that generated efficiencies are conceptualised and enacted. However, where such action is contrary to a regulation, manual or procedure, regardless of the new knowledge or the extent of innovation, it will likely expose the maintainer to an unintended or perhaps intentional violation outcome.

### Decisions and behaviours

Should innovation in aviation maintenance be treated as a raise-train-sustain activity or should it be prosecuted on a capture-and-kill approach? The answer to that question requires an understanding of the fundamentals of innovation within the aviation maintenance domain. Fishbein and Azjen's Reasoned Action Approach (Figure 1) describes a theoretical decision process based upon an individual's behaviour.

In this approach, an intent to pursue an innovative decision is depicted through the diagram as being influenced by beliefs, norms and behaviours, thereby resulting in a decision outcome. Importantly, this

also links to Ajzen's (2012) theory of planned behaviour, which notes that behaviour is guided by intention. Ajzen implies that a strong relationship exists between intentions and behaviour and, secondly, that a change in intention would be followed by a change in behaviour.

Decision-making in the aviation maintenance domain is often the result of changing situations or circumstances. What then is the impact on intent when the maintenance situation changes?

Some researchers have observed that considerable organisational effort would be required to effectively deal with unofficial decision events, where such effort is not supported by fundamental organisational processes. Hence, technicians and supervisors operating outside of system constraints are liable to be exposed to punitive actions for the conduct of an act of violation rather than positive innovations being captured, harnessed and shared.

The issue for airworthiness regulators and compliance assessors is to be satisfied that all required maintenance has been undertaken and appropriately certified. However, given the results of various published research, the apparent tendency of technicians and supervisors towards non-compliance with technical instructions presents a challenge for effective safety management and safety-system functionality.

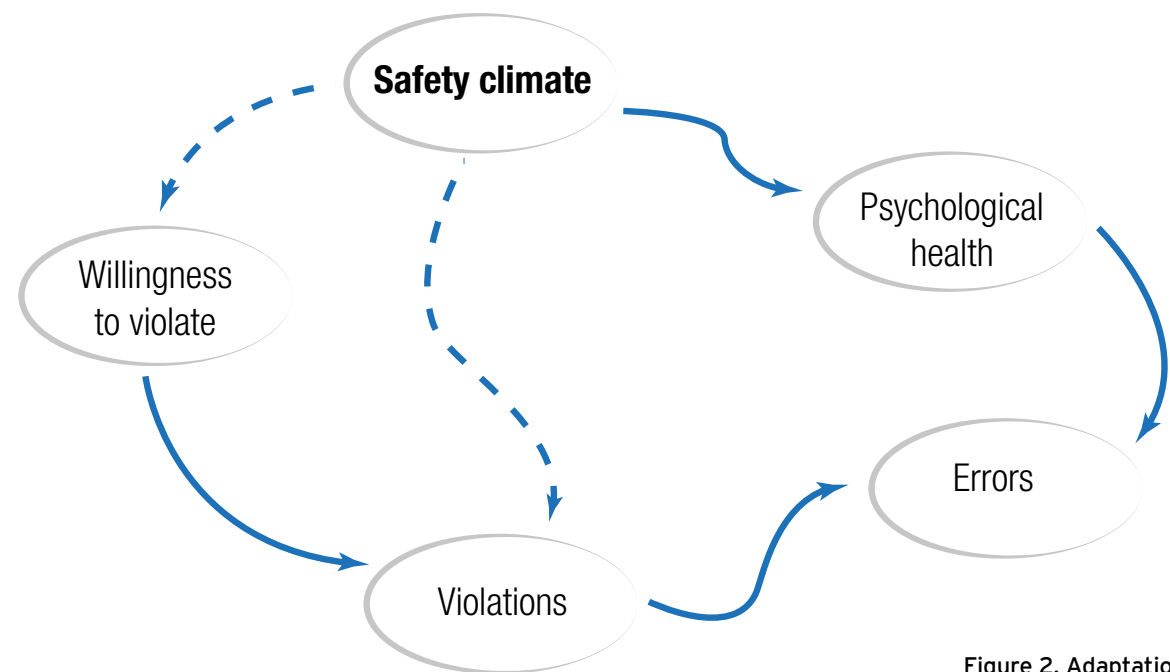
### Workplace learning and culture

When it comes to workplace learning and culture there have been interesting observations with regards to how and why. Much training effort is focused on the how; that is, this is how you do steps one through 10; however, what some have argued is that there needs to be as much attention paid to the why, such as "the reason we do this is ...".

An alternative approach is to focus on tradespersons becoming expert practitioners rather than just learning about how to practice. For the most part procedures seldom deal with the why, yet they become the first line of defence in investigation outcomes where new procedures are introduced to correct a causal failure. Research has shown that individuals are likely to develop sophisticated work-arounds when confronted with over-proceduralisation, especially when such procedures and work practices were laden with dilemmas, inconsistencies, and unpredictability. These work-arounds are not supported by the







**Figure 2. Adaptation of safety climate (Fogarty & Worth, 2003)**

**Addressing innovation within the aviation maintenance domain is yet one more step in the greater safety management journey.**

formal learning process and training regimes, but rather, and perhaps most importantly, they are generated from the applied working environment and norms and organisational culture within which the technicians and supervisors operate.

#### **Safety culture and risk**

Research conducted by Fogarty and Worth (2003) focused on error causation within an ADF aviation maintenance context. In their study they identified the violation pathways, both intended and unintended, and the risk implications of decisions being made by the maintenance technicians (refer Figure 2).

Fogarty and Worth identified that maintenance personnel were willing to commit violations because of ineffective procedures, resource shortages and work pressures. In making these decisions the tradespersons and supervisors saw themselves as working safely and that their knowledge and skill levels were sufficient to achieve a safe outcome despite working outside of approved procedures. Similar results are being replicated in a current study.

Safety culture is often conceptualised as why we do what we do; however, the role of the organisation, its policies and how those policies are enforced is vital

in defining the foundations upon which individual technicians and maintenance supervisors behave. Fogarty and Shaw (2010) observed that despite best intentions, some individuals felt incapable of undertaking maintenance tasks in accordance with published rules and procedures because of the impost of external factors deemed to be outside of their control. Importantly, how an individual decides to act is influenced by; the extant cultural system within which they work; the knowledge held; organisational and personal beliefs; their understanding of the risks associated with the task; and their demonstrated level of task competency.

#### **Maintenance innovation in aviation project**

Our current research project in maintenance innovation, examines aviation-maintenance decision outcomes where innovation was the driving consideration. This is intended to lead to an understanding of the motivators and drivers of innovative maintenance actions and how such decisions are conceived and implemented. The overall intent of the project is to bring into focus the currently blurred aperture between innovation and violation in aviation maintenance and in so doing it seeks to address fundamental human-factors

implications for aviation maintenance and the broader aviation safety expectations and requirements. The project is supported by the University of Newcastle and is approved for ADF participation by the Defence People Research Low Risk Ethics Panel.

Participants for the study are being drawn from aircraft maintenance personnel across the domains of commercial airlines, contractor heavy maintenance, Defence and general aviation. Participation from airworthiness regulators, aviation investigators, policy developers and initiators has also been garnered.

In the context of aviation safety management the intent of this research project is to identify the decision processes, constraints and procedural improvements required to better define, or at the very least diminish, the blurred line between innovation and violation in aviation maintenance. Thereby to develop an understanding of the decision practices that encourage maintenance innovation and which will enable the capitalisation of innovative outcomes whilst ensuring aviation safety remains the paramount priority.

#### **Conclusion**

Opportunities to capture and capitalise on innovative approaches to aviation maintenance are being stifled by a failure to effectively identify extant innovations. Establishing a baseline model that explains and predicts aviation maintenance innovative behaviour will assist in the development of improved decision outcomes. Understanding that violations can be the result of an intended decision process will provide an enhanced framework within which aviation maintainers can function and within which the conduct of maintenance can be more effectively managed. Of equal importance to aviation maintenance task completion is the awareness and acceptance of known risks and the application of a decision rule to manage those risks.

An enhanced safety systems approach is required to identify, validate and initiate innovative thinking and innovation needs to

be distinguished from violation and treated appropriately. There needs to be a process to capture, record and capitalise on innovation that supports and maintains an effective systems safety approach. The observation that “we should not need another accident to remind us that promoting the effective management of maintenance error enhances safety of flight” (Kanki, 2010, p. 693) highlights existing decision event anomalies and the need for improvement. Addressing innovation within the aviation maintenance domain is yet one more step in the greater safety management journey.

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# HIGHLAND tragedy

**O**n the afternoon of 28 August 1972, while on a flight from Lae to Port Moresby, Caribou A4-233 crashed in the Kudjeru Gap some 18 miles (29 km) south of Wau. The aircraft had a crew of three and carried 26 passengers including 24 PNG army cadets. The only survivors were five of the cadets, one of whom later died in hospital from injuries sustained in the crash.

Tasked with carrying out an Army support task, Caribou A4-233 departed Lae for Port Moresby 2.01 pm. The flight proceeded normally and at 2.26 pm a position report was made over Wau at a height of 6500 feet and estimating being abeam Mount Yule at 1450 hours. No further transmissions were heard from the aircraft. At 3.39 pm a distress phase was declared and a search and rescue operation began immediately. Three days later a searching Army Sioux helicopter, found four survivors and, close to last light on that day, a

further very seriously ill survivor was found at the crash site.

## Examination of the wreckage

The aircraft crashed at 4800 feet AMSL on the northern side of a 5000-foot ridge that lies on the western side of the Korpera River in the Kudjeru Gap. Marks in the tree tops 100 yards [914.4 m] south of the ridge line and 50 feet below the crest, plus a debris trail leading to the crash site, indicated that the aircraft was proceeding in a northerly direction before contacting

the trees. The average gradient on either side of the crest of the ridge was 35 degrees.

The debris trail commenced with the green glass from the starboard navigation light, which was found on the south side of the crest.

At the crest, major portions of the starboard mainplane, starboard tailplane and starboard propeller were located and 300 yards further north the debris trail terminated at the fuselage, which was propped up at 70 degrees tail fin uppermost, by a tree.

The forward cargo compartment had suffered massive damage and the cockpit had been completely burnt out. The mainplane section from the starboard engine nacelle to the port wingtip was lying adjacent to the forward fuselage and the starboard engine was found 100 yards away to the east down the steep slope.

## Discussion of the evidence

The accident occurred in transit from north to south on the Kudjeru Valley route between Lae and Port

Moresby. The crew had flown this route four times during the preceding three days and twice earlier on the same day.

The evidence indicated that the initial transit into the valley was at 6500 feet, but cloud prevented the crew maintaining visual flight in the valley and, confronted with lowering cloud over a rising valley floor, the pilot turned back. During the turn or soon afterwards, the aircraft struck trees at about 4900 feet altitude and crashed into heavy jungle some 400 yards from the initial impact point.

There were no major deviations from flight plan, except that the captain had initially elected to remain at 3000 feet after departure from Lae because of weather.

The next call from the aircraft placed it at 6000 feet, and later a position report abeam Wau stated it was at 6500 feet. At this point the captain was probably influenced by the weather in the Wau area, which was clear and had probably decided to transit low level through the valley because 6500 feet could be maintained at the entrance.

As the flight progressed down the valley, cloud cover increased and the cloud base lowered almost to the valley floor.

Approximately 20 miles south of Wau, where the valley begins to narrow, conditions deteriorated and no further visual flight was possible. A turn was made to reverse course to the north and a climb was initiated. At this point the aircraft possibly entered cloud. The right wing struck tree tops at a point about 50 feet below the ridge line. The aircraft continued up the side of the ridge contacting the tops of trees and shedding fragments until several large trees near the crest caused major damage to the right wing and right tail plane. Control was lost and the aircraft continued on a northerly trajectory finally impacting on the northern side of the ridge in a steep nose down attitude.

A detailed examination of the engines and airframe was carried out and there is no evidence to suggest that a technical defect caused the accident. The crew had correctly



reported deviations from flight plan and position reports, and there is no reason to believe that they would not have broadcast a distress message, if some in-flight emergency had arisen. There was no evidence to suggest that crew fatigue had any bearing on the accident. The crew had flown 5.30 hours on the preceding day and approximately 3.30 hours on the day of the accident.

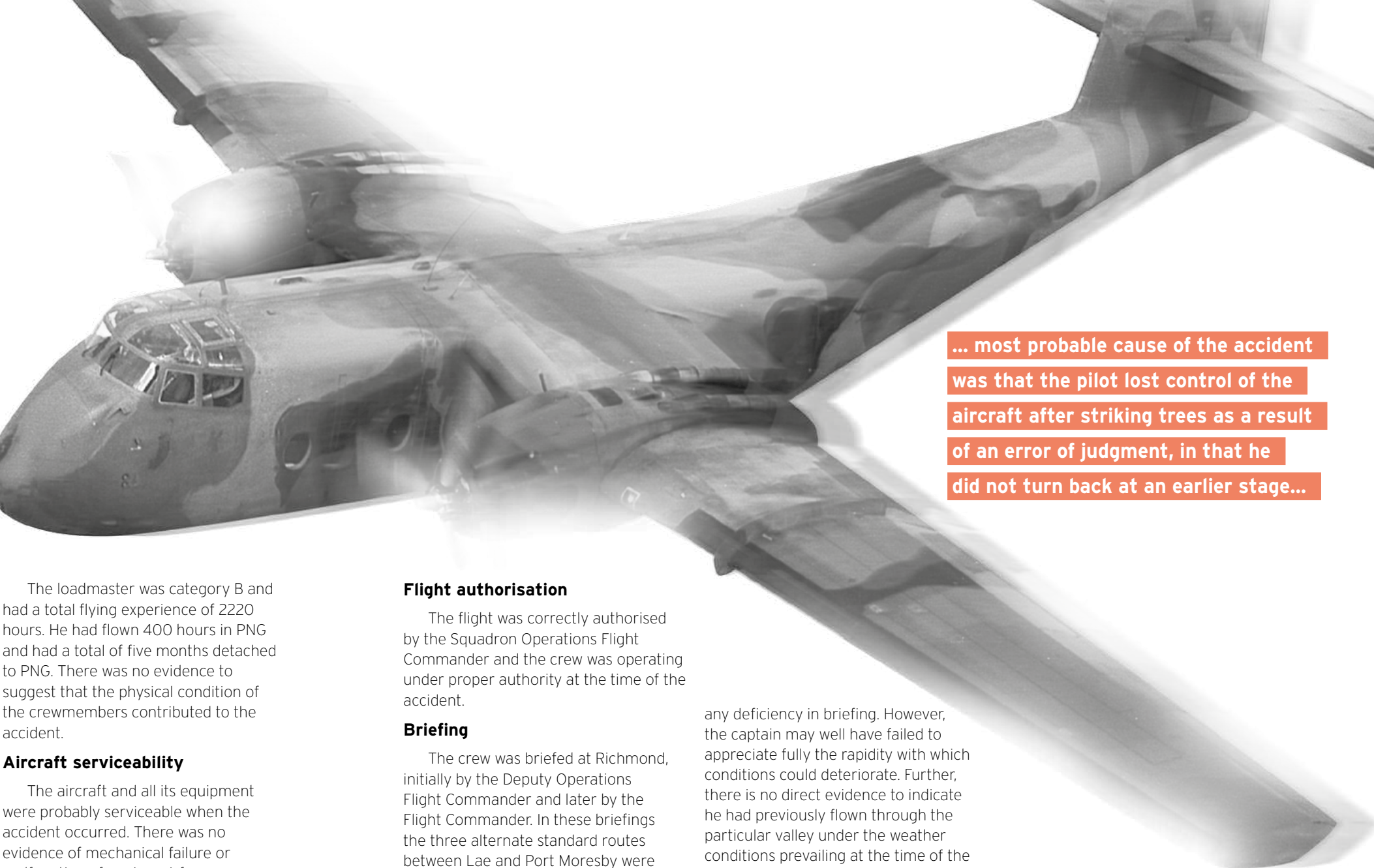
Pilots operating in PNG are generally very conscious that local weather conditions can change rapidly. On the morning of the accident the captain had received the standard area forecast from the Lae weather office but had not received the updated forecast, which was available at Lae, before the last sortie. This is not considered significant as he had just flown over the route. However, this flight had been made at 9500 feet above the weather, possibly because conditions were not suitable to transit the valley at low level.

Considering these possible conditions, the captain's decision to

transit the route low level some two hours later is difficult to understand. It may have been that he wished to avoid flying above the overcast with its associated risk of IMC flight below safety height, should an engine fail.

**The crew**

The captain was a category C Caribou captain, with flying experience totaling 979 hours all types, 712 hours Caribou and 123 hours captain on type. He had flown two PNG trainer exercises during 1971, one while undergoing conversion course and the other preparatory to a four month detachment to PNG in that year. His total in-country flying experience was 216 hours. The co-pilot was a current category C Caribou co-pilot, with flying experience totaling 816 hours all types and 22 hours captain on type. He had flown 195 hours in PNG, completed a PNG training exercise during conversion course and spent three months flying in PNG during 1972.



... most probable cause of the accident was that the pilot lost control of the aircraft after striking trees as a result of an error of judgment, in that he did not turn back at an earlier stage...

The loadmaster was category B and had a total flying experience of 2220 hours. He had flown 400 hours in PNG and had a total of five months detached to PNG. There was no evidence to suggest that the physical condition of the crewmembers contributed to the accident.

**Aircraft serviceability**

The aircraft and all its equipment were probably serviceable when the accident occurred. There was no evidence of mechanical failure or malfunction of engine, airframe or other equipment essential to flight. There was no entry in the maintenance history of the aircraft that was relevant to the accident.

**Weather**

The forecast weather conditions in the crash area were isolated areas of rain with 6/8 stratus cloud with a base of 600 feet AGL in precipitation. Two civil pilots operating in the area soon after the accident reported deteriorating weather with cloud base descending to the valley floor, while visual flight above cloud would have been possible at 10,500 feet. There were no thunderstorms or other dangerous cloud formations evident in the crash area.

**Flight authorisation**

The flight was correctly authorised by the Squadron Operations Flight Commander and the crew was operating under proper authority at the time of the accident.

**Briefing**

The crew was briefed at Richmond, initially by the Deputy Operations Flight Commander and later by the Flight Commander. In these briefings the three alternate standard routes between Lae and Port Moresby were explained and the Flight Commander also instructed the captain to obtain further detailed local briefing from the Squadron detachment on his arrival at Port Moresby.

The captain did not obtain the additional briefing at Port Moresby. During the three days preceding the accident the crew flew between Port Moresby and Lae five times and flew from Lae to Port Moresby on the morning of the day of the accident via the same route albeit at 8000 feet.

They returned to Lae transiting the Kudjeru Valley at 9500 feet approximately two hours before the accident. Therefore, they were familiar with the conditions generally and the accident is not attributable to

any deficiency in briefing. However, the captain may well have failed to appreciate fully the rapidity with which conditions could deteriorate. Further, there is no direct evidence to indicate he had previously flown through the particular valley under the weather conditions prevailing at the time of the accident.

**Conclusion**

The evidence indicates that the most probable cause of the accident was that the pilot lost control of the aircraft after striking trees as a result of an error of judgment, in that he did not turn back at an earlier stage of flight, when confronted with deteriorating weather.

The cause of the accident has been assessed therefore: (a) Aircrew Error: Error of Skill — Collision with the ground.

**Comment**

It is considered that a pilot with more experience in PNG operations would, in the prevailing weather conditions, probably have expected cloud in the valley and elected to transit above the

weather. Further, a pilot with more knowledge of that particular valley, transiting below cloud, would probably have turned back earlier. But the suggestion that a pilot with more local knowledge would have not made the same error is speculative.

No amount of further briefing, counselling or advice would have better fitted the captain for the particular flight on which the accident occurred. The captain had three days experience of local flying immediately before the day of the accident. He had flown between Port Moresby and Lae a total of 20 times, but evidence suggests strongly that he had not previously attempted to negotiate the valley below a low overcast.







3-5 OCTOBER 2017

### SIR REGINALD ANSETT MEMORIAL LECTURE AND DINNER

Tuesday 3 October at Parliament House Canberra, guest lecturer will be Mr John Borghetti Managing Director and CEO Virgin Australia.

**Safeskies Australia**  
PO Box 153 Calwell ACT 2905  
Ph: +61 2 6274 6921  
Email: [office@safeskiesaustralia.org](mailto:office@safeskiesaustralia.org)

### CONFERENCE DETAILS

- Tuesday 3 October: Sir Reginald Ansett Memorial Lecture at Parliament House.
- Wednesday 4 and Thursday 5 October: Conference at the National Convention Centre.
- Conference includes a joint presentation by Australia's four government leaders in Aviation, including Chief of Air Force, Secretary of the Department of Infrastructure & Regional Development, CEO Airservices Australia and Director of Aviation Safety CASA.
- Presentations by top military and managers and policy makers.
- Eminent international and local aviation safety management and policy experts.
- The PG Taylor address will be given by Mr Peter Lloyd AC MiD FAIM FCILT.

Check website for updates and registration: [www.safeskiesaustralia.org](http://www.safeskiesaustralia.org)

# AVIATION SAFETY Spotlight

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# Aviation Safety Training

2017 Courses

## ASO (I)

Aviation Safety  
Officer (Initial) Course

**COURSE AIM:**  
To graduate Unit ASOs,  
Maintenance ASOs  
and Flight Senior  
Maintenance Sailors.

**PREREQUISITES:**  
Personnel who are  
required to perform the  
duties of an ASO.

**COURSE DESCRIPTION:**  
The course provides theory and practical exercises in the broad topics of the Defence Aviation Safety Management System, an introduction to human factors and the organisational accident model, incident investigation and reporting.

## ASO (A)

Aviation Safety  
Officer (Advanced)  
Course

**COURSE AIM:**  
To graduate Base, Wing,  
Regiment, Fleet, Group  
and Command ASOs.

**PREREQUISITES:**  
ASO (I) Practical and  
applied experience as a  
ASO (or equivalent)

**COURSE DESCRIPTION:**  
The course provides theory and practical exercises in the broad topics of the Defence Aviation Safety Management System, advanced human factors and risk management, and base emergency response. Includes a practical CRASHEX component.

## NTS

Aviation Non-  
Technical Skills  
Trainer

**COURSE AIM:**  
To graduate students  
with the knowledge and  
skills to deliver non-  
technical skills training.

**PREREQUISITES:**  
A solid background  
in Crew/Maintenance  
Resource Management  
and/or Human Factors.

**COURSE DESCRIPTION:**  
The course provides the theoretical background of aviation non-technical skills and trains students in the skills and knowledge for delivering non-technical skills training. The course also introduces students to scenario-based training and assessment techniques.

## AIIC

Aviation Incident  
Investigator Course

**COURSE AIM:**  
To develop members  
with the skills to  
conduct aviation  
incident-level  
investigations in  
support of their ASOs.

**PREREQUISITES:**  
Any personnel who are  
involved with Defence  
aviation. There is no  
restriction on rank,  
defence civilians and  
contractor staff are also  
welcome to attend.

**COURSE DESCRIPTION:**  
This one-day course provides theory (taken from the ASO(I) course) on the topics of; the Defence Aviation Safety Management System; generative safety culture; error and violation; the organisational accident model; incident-level investigation and hazard reporting and tracking. Interested personnel should contact their ASO.

COURSE NAME /NUMBER	DATES	LOCATION	NOMINATIONS CLOSE
1/17 ASO Course (I)	27-31 Mar	Canberra	27 Feb
2/17 ASO Course (I)	8-12 May	Canberra	10 Apr
3/17 ASO Course (I)	26-30 Jun	Edinburgh	1 Jun
4/17 ASO Course (I)	TBA		
5/17 ASO Course (I)	TBA		
6/17ASO Course (I)	TBA		
1/17 ASO Course (A)	TBA		
2/17 ASO Course (A)	TBA		
1/17 NTS Course	15-19 May	Canberra	17 Apr
2/17 NTS Course	31 Jul to 4 Aug	Canberra	10 Jul
3/17 NTS Course	20-24 Nov	Canberra	23 Oct

COURSE NAME /NUMBER	DATES	LOCATION
1/17 AIIC	4 Apr	Darwin
2/17 AIIC	6 Apr	Tindal
3/17 AIIC	17 May	Richmond
4/17 AIIC	5 Jul	Edinburgh
5/17 AIIC	2 Aug	Amberley
6/17 AIIC	16 Aug	Williamstown
AIIC	TBA	

All courses are generally oversubscribed, dates provided are for planning purposes and are subject to change due to operational requirements, nominations from individual units or candidates will not be excepted, nominations are to be forwarded with Commanding Officers endorsement to:

- **Air Force:** the relevant Wing Aviation Safety Officer, or for CSG, Staff Officer Safety HQCSG
- **Navy:** the Fleet Aviation Safety Officer and
- **Army:** HQ FORCOMD, Aviation Branch, Force Preservation Section.

For further details regarding the above courses visit the DAAFS Aviation Safety Assurance and Training intranet site or email [ddaafs.setcourses@defence.gov.au](mailto:ddaafs.setcourses@defence.gov.au)



# Are you aware?



The Defence Aviation Hazard Reporting and Tracking System (DAHRTS) **will be replaced in February 2018.**

The Aviation Safety Management Information System (ASMIS) Project is delivering a better aviation safety reporting system that will enhance Defence's ability to learn and take action to improve safety.

Information packs and training opportunities are on the way.

## Get ready for 2018

For more information visit the DDAAFS intranet

