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Contributions by way of articles and photographs are invited from readers across Defence and the retired community in the interest of promoting Aviation Safety. Spotlight magazine staff reserve the right to edit all articles submitted for content, length or format. Contributions should be sent by email: dasa.registry@defence.gov.au



Foreword

elcome to our latest edition of Spotlight Magazine, which is comfortably the largest edition we have ever produced. This edition is a new initiative, planned to be published yearly, which aims to provide you with a comprehensive look at the more significant aviation safety investigations we have completed in the past 12 months.

These investigations will be of professional interest to all those employed in Defence aviation. They are the result of often months of painstaking and detailed investigation, by both DFSB staff and external subject matter experts, to understand the fullest range of factors at play in each incident. Importantly, you will know that each has, as its sole aim, the generation of meaningful recommendations to commanders, aimed at preventing recurrence of the issue and enhancing safety more broadly.

Each of these investigations represents an interesting and educative story. I commend them all to you.

Regards,

GPCAPT Nigel Ward Director DFSB

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the aviation safety magazine of the Australian Defence Force



Please think about the lessons which emerge in each of the investigations detailed in this edition. While possibly not all applicable to your area or aircraft type, I encourage you to ponder how the situations which arose, and indeed the lessons identified as requiring remediation, can be learnt from.

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n 27 January 2018, an RAAF EA-18G Growler, departing from Nellis Air Force Base (AFB), Nevada, USA, experienced an uncontained engine failure during the latter stages of its take-off roll. As the aircraft approached rotation speed – about 140 knots indicated air speed (KIAS) – the ballistic material failure of the right-hand engine caused the almost simultaneous failure of the left-hand engine.

Faced with a resultant fuel/airframe fire and a marked increase in vibration and ambient noise level, the two aircrew enacted their emergency actions for multiple major malfunctions. About four seconds after the failure of both engines, the aircraft suffered the loss of all generated electrical systems, which disabled, among others, the majority of cockpit digital indicators (providing
the aircrew with the warnings and the performance status of
failing aircraft systems) and anti-skid braking.aircraft departed the prepared surface to the right, at about
8400 ft (of a 10,000 ft runway).Carrying an estimated EQ knots of groundspeed into

During emergency (system) braking both the left and right main undercarriage tyres burst, severing the hydraulic line that serves the left-hand undercarriage brake.

Ine that serves the left-hand undercarriage brake.Remaining upright and influenced by the additional dragThroughout, the pilot attempted to keep the aircraft on
the runway using a combination of differential braking (from
a dissipating hydraulic system) and aerodynamic/physical
drag. Approaching the runway's first arresting barrier, theRemaining upright and influenced by the additional drag
of the sand, the aircraft slowed and yawed left (back through
the runway heading) before coming to rest on an adjoining
runway intersection, marginally right of the runway in use,
9100 ft from the initial departure point.

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Carrying an estimated 50 knots of groundspeed into the sand-based margin, the aircraft passed outboard of the starboard anchor housing for the arrestor cable.



Confronted by a significant fuel/ airframe fire, the aircrew made a rapid manual escape from the cockpit, gathering at a safe point upwind of the aircraft. The pilot was later treated for smoke inhalation, while the electronic warfare officer (EWO) remained physically unharmed (save some bruising).

The loss of frame was classified as an accident, which triggered the formation and dispatch of a thennamed Defence Aviation and Air Force Safety (DDAAFS)¹ Aviation Accident Investigation Team (AAIT) to the USA.

Aircraft fragments recovered at the scene of the accident indicated that the right-hand engine of the Growler had suffered an uncontained failure of the first-stage fan disc, which instigated the accident chain of events.

The AAIT undertook a comprehensive investigation into the causal factors behind the failure of the first-stage fan disc. In parallel, the AAIT also analysed potential contributing factors to the accident sequence and all associated human and aviation medical factors before, during and after the event.

During the investigation, the AAIT made use of the engine's original

equipment manufacturer (OEM) specialist facilities, proprietary information, operator and engineering subject matter experts (SMEs), computer-based training and aircraft simulation.

Significant findings

The entire 360° of the failed component was recovered in three segments at the scene of the accident.

Segment 1 was ejected through the engine casing and airframe directly into the runway beneath the aircraft. Segment 2 was located on an adjacent runway approximately 1000 feet to the right of where the right-hand engine initially failed. Segment 3, the largest segment, was lodged in the intake duct of the aircraft's left-hand engine (having passed through several significant engineering/metallic structures in the process).

The uncontained failure of the firststage fan disc was considered to be an unusual event by metallurgists.

The fracture surface on segment 2 exhibited an initial surface-connected zone of discoloured material consistent with tensile overload², followed by a 'clean' metallic region of progressive crack propagation. Identical features were found on

the matching fracture face from segment 3 after soot (from the lefthand engine) was cleaned from its surface. OEM laboratory analysis of the fracture surface revealed that the failure of the first-stage fan disc was due to a defect present within the disc (introduced during the forging process), which propagated through normal engine cycling until it reached a size that resulted in the fracture of the component.

First-stage fan discs originate from forging lots, with varying numbers of forgings comprising a lot. There were three lots of interest which were in in-service EA-18G / F/A-18 engines, necessitating both the RAAF and US Navy to introduce an operational pause (OP) to flying operations. One third of the RAAF's F414 engine fleet was, by analysis, affected and subsequently investigated.

Safety action already taken

Once the initiating component (first-stage fan disc) that triggered the accident sequence had been identified, the AAIT immediately liaised with all relevant EA-18G stakeholders within Australia and the US to establish causal factors and reduce the probability of a recurrence (of the uncontained failure) so far as possible.

Thereafter, the accelerated information flow between the OEM, US Navy EA-18G/F/A-18/Program Office and RAAF agencies resulted in the OP to RAAF-related aircraft and a series of risk-mitigation strategies, most notably, a comprehensive mandatory first-stage fan disc inspection regime.

To preclude future disc failures, the OEM instigated additional non-destructive inspection (NDI) requirements across its forging and machining vendors.

Aircraft data

Nellis AFB was suitable for take-off operations of the accident aircraft. The

environmental conditions at the time of the flight were good and mission profiles/parameters were within the capabilities of the current and gualified aircrew.

Throughout the accident sequence (until successful egress had been completed), the cockpit remained a survivable space. Post egress, once the airframe/fuel fire had escalated, the cockpit, in particular the rear seat area, became a non-survivable space, primarily because of the radiated heat from the fire.

During the accident sequence, the stricken aircraft did not pose any threat to personnel, parked aircraft or facilities at Nellis AFB.

Approximate course of travel – first-stage disc



Segment 3, the largest of the ejected fan segments, punctured a hole in the left-hand engine casing and was recovered from between the lefthand engine inlet and left-hand intake device.

Aircrew/squadron actions

At the point of aircraft rotation for take-off (approximately 140 KIAS), the aircrew experienced an uncontained failure of the right-hand engine with a resultant uncommanded asymmetric yaw to the right before the rapid onset of major engine(s), electrical, hydraulic and airframe malfunctions. The primary consideration for the pilot was to maintain aircraft control before analysing the situation and the crew taking appropriate action; performing immediate action procedures without delay (initially conducting only those steps required to manage the problem).

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Shallow hole on Runway 03L caused by segment 1.



The abnormal levels of vibration and ambient noise, coupled with the loss of all generated electrical power exacerbated the lack of constructive aircraft feedback to the crew. The initial indications (aural, warning and caption) from the aircraft (prior to the loss of all systems other than battery powered) and inherent and spontaneous airmanship led the crew to correctly triage the emergency situation while the pilot maintained directional control of the aircraft.

The rapidity, complexity and severity of the cascading malfunctions that afflicted the accident aircraft is unprecedented within the RAAF's recent 'fast jet' history. As the event unfolded, the crew maintained outstanding situation awareness and Crew Resource Management (CRM), culminating in their safe but rapid departure from the stricken aircraft.

Post the accident, the aircraft presented a broad spectrum of hazardous materials and substances³ to RAAF and USAF ground crews. The squadron's accidentsite management – the collection of all physical evidence, proactive safety assurance and mitigation strategy, and associated controls – was exemplary.

Aircraft damage

During the first-stage fan-disc release, the fuel line from the right-hand engine was severed (by segment 2). It is almost certain that the fuel/airframe fire was initiated by the ballistic damage/severing of the right-hand engine's fuel line.

The airframe OEM is aware of eight thermal damage incidents in the worldwide F/A-18E/F and

EA-18G aircraft fleet(s). Damage to the accident aircraft is significantly more extensive than previous thermal damage incidents and was assessed as beyond both physical and economic repair.

Conclusion

Based on the laboratory analysis of segment 2's fracture surface, the uncontained failure of the accident aircraft's 1st stage fan disc was due to a defect introduced during manufacture, which propagated through normal engine cycles until it reached a size that resulted in the fracture of the component.

The series of cascading malfunctions that the aircraft suffered were as a direct result of the foreign object damage initiated by the ballistic segment three. The aircraft fuel/airframe fire was brought about by segment 2 severing the right hand engine's fuel line.

The accident sequence that befell the aircraft is considered unprecedented within the EA-18G worldwide fleet. The onset and breadth of the numerous serious component malfunctions faced by the aircrew is also unparalleled within recent RAAF events.

Notes

- 1. Rebranded the Defence Flight Safety Bureau in August 2018.
- 2. Tensile overload refers to the failure of a material when it is loaded beyond its ultimate tensile strength.
- Not limited to but including burnt advanced composite fibres, toxic chemicals, radioactive materials, explosive ordinance and devices, batteries, stored energy systems, gas, fuel and lubricants.





Black Hawk rotor strike

By MAJ Jason Otter

t 1914 hrs on 13 June 2017 a Black Hawk helicopter experienced main rotor impact with trees in the Holsworthy range training area during a Night Vision Device (NVD) Mask Assessment Serial. At the time of the occurrence, the squadron was conducting an Aircrew Breathing System (ABS) serial for a qualified Category D pilot.

The aircraft had approached a confined area commonly referred to as Esky Pad. The co-pilot (CP), under direction of the aircrewman, was completing the final 15 ft vertical descent from a hover when an audible noise was heard by the crew. At the same time leaf debris appeared to float in the pilot's field of view.

The main rotor hit a tree – considered to be a small sapling – located at the aircraft's 8.30 position. The noise generated as a result of the contact with foliage was described as being similar to that of a "whipper snipper cutting grass" by the crew.

The aircraft captain (AC) immediately assumed control and stabilised the aircraft in a 25 ft hover. While in the hover for approximately 21 seconds, the AC decided to return the aircraft to the Holsworthy Airfield. The crew reported no anomalies with the aircraft during the nine-minute return flight.

No emergency was declared enroute and the aircraft was released to maintenance pending reporting action at 1930 hrs. When advised that a spare aircraft was available, the crew discussed the possibility of completing the assessment serial.

The AC canvassed the crew about utilising the spare aircraft and a decision to ready the spare was made.

The AC contacted the squadron officer commanding (OC) by telephone to advise that main rotor contact with a sapling had occurred during a



confined area approach. The AC completed the call believing the intention to seek a subsequent flight authorisation was understood. However, the intention to re-authorise and complete a second flight was not understood by the OC. The OC contacted the regiment's commanding officer (CO), where the nature of the incident was discussed.

A second flight was authorised by the original authorising officer (AuthO) on the understanding that the aircraft had only experienced a minor sapling strike. The extent of damage from the blade strike had not been confirmed by maintenance or the operating crew.

The occurrence was not considered by the crew as a serious incident, notwithstanding the perceived need to contact the OC on return to Holsworthy and before conducting the next flight.

The incident crew departed and completed the co-pilot ABS assessment. No confined-area operations were conducted during the second sortie and it was completed without further incident. It was only as the aircraft was returning to Holsworthy that the OC became fully aware of the situation.

Further telephone contact with the CO occurred when the crew returned to Holsworthy Airfield confirming the status of the rest of the night-flying program and recommending the remainder of the night's assessment sorties be postponed until the following night. During this telephone call the CO was made aware that the incident crew had flown a second sortie.

Upon inspection of the aircraft by maintenance staff, damage was evident on all four main rotor blades. Main rotor contact extended from blade tip inwards 1200 mm on the underside of each blade.

Planning considerations

The incident sortie was a scheduled flight-assessment sortie for a junior pilot. Its objective was to assess the competence of a pilot performing duties as flying pilot while using NVD and ABS.

The assessment required competence to be demonstrated at a level of NVD CP, within a crewed operating environment. Qualification on the use of the ABS was a prerequisite for the junior pilot before commencing special operations (SO) CP training.

The sortie was planned to incorporate a confined-area approach for the CP on NVD, as the flying pilot. The CP was the only crew member utilising the ABS. The remaining three crew members were not wearing ABS as a risk mitigation measure in that wearing of ABS increases the complexity of

Left: The sheoak main trunk and branches following main rotor impact.



Top-down-view of Esky Pad showing the position of the aircraft and the stump located to the rear of the aircraft.

operating on NVD. The incident flight was to remain within Holsworthy restricted airspace for the duration of the sortie. There was no requirement to land off the confined area approach. The decision to conduct a confined area approach and landing to Esky Pad was the decision of the AC.

At the time of the occurrence Bureau of Meteorology METAR information stated a visibility in excess of 10 km, wind 250 degrees at less than eight knots, with overcast conditions and a cloud base of 5600 ft AGL. It was night and the moon had not risen at the time of the occurrence. The crew described the conditions as "dark, heavy overcast".

The confined area Esky Pad is an elongated confined area bounded by a gravel road to the east and vegetation increasing in height from three to five metres on the immediate boundary and 10 to 15 m within 20 m of the centre of the open space. Inspection of the confined area found that two trees had been impacted by the main rotor. The largest and most prominent was a 15- to 20-ft tall sheoak, with a diameter of up to 70 mm at point of impact.

The second was a single 20 mm diameter eucalyptus sapling within the sheoak dripline. Damage to the upper canopy was consistent with a vertical descent onto both trees. The debris field consisted of splinter fragments of tree varying in size up to 20 cm in length extending from the nine o'clock through to four o'clock position based on an aircraft landing heading of 221. The main rotor contact ceased within 30 cm of reaching the larger diameter 200 mm main trunk

of the sheoak where the consequences would have been potentially more significant.

The selected landing location was unsuitable for a landing into Esky Pad. Suitable landing points for a single aircraft could be achieved closer to the centre approach end of the confined area.

The AC was a Category B Qualified Flying Instructor (QFI). The CP, who was under assessment, was a Category D pilot.

The left-hand-side of the aircraft was crewed by a Category A aircrewman and the right-hand-side by a Category D aircrewman.

Technical aspects

All four main rotor blades were damaged as a result of contact with a tree line on the southern boundary. The damage sustained during the contact required all blades be removed for repair, and was consistent with a descent onto a sheoak. Brush marks extending 1200 mm from the blade tip were evident on all four blades.

Aircraft Maintenance Procedures Manual for Sikorsky Model S-70A-9 Helicopter at Chapter 1-7-50 describes the servicing – Sudden Stoppage. This servicing must be carried out by maintenance staff on aircraft that have had blade damage caused by striking an object.

The senior maintenance manager (SMM) was informed of a discrepancy between the CAMM2 documentation

error (10 to 20 mm sapling) and the actual (60 to 70 mm tree branch). Maintenance was aware that damage had occurred; however, the appropriate maintenance action was not initiated. This could be explained in part by the assessment that MRH/drive systems did not come to a sudden or complete stoppage in line with the title of the S7 servicing. This title is misleading: the servicing is required when a blade strikes an object causing visible damage. Sudden stoppage is not the only prerequisite for the servicing.

Damage was evident and should have initiated the servicing. The anomaly was not detected prior to the aircraft entering deeper level-R servicing.

Safety analysis

The selection and use of confined areas in the Holsworthy training area is at aircrew discretion. Individual selection of a suitable landing location is determined by the aircrew on completion of an appropriate reconnaissance.

The AC had previously operated to Esky Pad and assessed it as appropriate for the training criteria. The CP had not previously operated to the confined area; however, both the AC and the senior aircrewman were familiar with the layout and hazards. Both the AC and senior left-hand-side aircrewman identified the stump as the primary obstacle in Esky Pad and believed the pad was suitable for a Black Hawk when positioned in the first third of the pad (southwest approach direction). Two of the four crew members had landed in the Esky Pad within the previous six months.

The AC, as assessing officer, did not require a landing following the confined area approach. The AC intended for the CP to fly the approach to a logical conclusion, that may or may not include a landing within the confines of Esky Pad. The reduced clearances and obstructions within Esky Pad provided a challenging environment in which to assess the trainee.

Astronomical data for the sortie indicated that there would be zero moon illumination throughout the sortie. Any attempted landing in a single aircraft confined area such as Esky Pad with known obstacles would be considered difficult. The selection of Esky Pad for a confined area approach was not inappropriate if terminated when appropriate CP standard had been achieved.

The transit to and initial reconnaissance for approach to Esky Pad was conducted by the CP as the flying pilot. The assessed pilot's approach brief was to conduct a double

angle approach to the centre of the confined area, on a finals heading of 221 degrees magnetic. At 50 ft to run the left-hand-side and right-hand-side aircrewmen provided clearances for the flying pilot, culminating in a hover at an announced height of 20 ft.

Having stabilised in a hover, both aircrewman initiated a series of calls to reposition the aircraft for a landing. The CP in the right seat responded to the direction being provided by the aircrewman.

The first call relating to obstructions within the Esky Pad came from the left-hand-side aircrewman indicating that there were a "couple of small shrubs just under the left". There was acknowledgment from the flying pilot, with subsequent calls clearing the aircraft to lower altitudes approaching ground level. During descent, the AC made a comment to the effect "from memory we usually land a bit further back in the pad". This comment, which was 23 seconds before main rotor contact, was not acknowledged by the crew and the calls for descent and minor lateral adjustments continued.

wrong.

Responsibility for obstructions on the left-hand-side of the aircraft appears to have been deferred to the AC and lefthand-side aircrewman. The reluctance of both aircrew on the right-hand-side of the aircraft to respond to the comment by the AC or raise any doubt about continuing with a landing was noteworthy. An unrecognised cockpit gradient existed at the time when it was critical that good communication between all crew members was required. The left-hand-side aircrewman believed that the priority obstacle was the stump at the six o'clock position.

The left-hand-side aircrewman shifted his attention from the small saplings initially referenced to the deadfall/stump located at the six o'clock position.

This stump had been initially identified in the crew's preapproach intra-cockpit communications. Nine seconds before contact both aircrewman had announced "clear down left" and "clear down right" respectively. This clearance occurred at a stabilator-to-ground height of 10 ft. Implicit in this clearance was the requirement to maintain rotor and airframe obstacle clearances.

During the pad reconnaissance, the flying pilot briefed that a landing may not be achievable. This set the appropriate preconditions for a call by any member of the crew to abort a landing within the confined area. The AC's comment about being forward in the pad did not elicit any crew discussion or subsequent change in aircraft position or decent profile. The absence of any crew interaction over ICS in response to both comments indicated that the crew was satisfied with the situation and were cleared to land.

Three seconds later, following a pause in communications, the aircraft was cleared to descend with neither crew member on the left-hand-side of the aircraft aware of an impending contact.

About this time, the left-hand-side aircrewman concentrated on maintaining airframe clearance from the stump at the six o'clock position. At 1914 local, the main rotor contacted trees. The left-hand-side aircrewman announced "hold, hold, come up, come up, come up" and said "we have just clipped a tree". The flying pilot responded by climbing to approximately 25 ft on the radar altimeter and within seconds the AC had taken control of the aircraft.

A breakdown in CRM

The AC and the left-hand-side aircrewman were experienced aircrew. During the sortie brief, the crew was told there was no requirement to land in the confined area. This was further reinforced during the approach brief. Announcements by the left-hand-side aircrewman of small saplings, and the statement by the AC concerning position in the pad, did not alert the crew that something may have been This resulted in the premature cessation of an effective scan during the final vertical descent. The continued delivery of standard patter as normally given by the left-hand-side aircrewman during a descent to land reinforced the crew's view that obstacle clearance had been achieved.

The left-hand-side aircrewman did not detect a slight aircraft drift towards the 11 o'clock position during the final seconds prior to contact. The drift was observed by the flying pilot as a vector in the heads-up display (HUD) but not announced to the crew. Flight data recorder fidelity could not verify the drift due to limitations in the sampling rate. The drift was not announced within the cockpit at the time of the occurrence and was not arrested prior to the vertical descent onto the tree at the 8.30 position.

Post-contact actions

The AC assumed control within five seconds of the main rotor contact, after the CP initiated the climb. The aircraft was stabilised at 25 ft AGL on RADALT within the confines of Esky Pad. Fifteen seconds after main rotor contact, the crew focussed discussions on a tree contacted at the 8.30 position. Within 26 seconds of impact the aircraft was transitioning into forward flight with an associated call over ICS of "we've got no major vibes". There were no other recorded crew discussions prior to the aircraft flying away.

When rotor or airframe contact with an obstruction occurs, the serviceability of the aircraft can no longer be assured. The AC decided that in the absence of vibrations, a transition to forward flight was the most appropriate course of action. There was no discussion of the aircraft serviceability or the potential to reposition in the confined area and land.

The AC did not articulate his thought process in responding to this abnormal situation nor did the remaining crew. While stable in a hover, the left-hand-side aircrewman stated that a small tree had been clipped. The crew did not try to use NVD or white light to assess the size of and damage to the tree before departing the confined area. If this had been done, the crew's assessment of the situation may have been different.

The consistent reference to a small sapling ultimately created a false premise on which all decisions were made from that point. Crew recollections post-incident consistently referred to the tree as a sapling no larger than a finger diameter (15 to 20 mm). Crew members described seeing small leaves and debris floating in the NVD field-of-view at the time of contact. The crew also described the contact as sounding similar to a whipper snipper momentarily contacting grass.

During the occurrence, the AC believed that the mainrotor contact had not induced any technical malfunction requiring emergency procedures or bold-face actions. The warning was considered and the AC's situational assessment was informed by the absence of any observed controllability issues or observable change in aircraft feel or response. The crew did not discuss the feasibility of repositioning and landing within Esky Pad.

Contact with an obstruction during flight makes the aircraft's serviceability questionable. Aircraft serviceability is only confirmed following maintenance inspections and / or actions. While stable in a 25 ft hover in Esky Pad, the AC had the option to reposition, land, and seek maintenance support. There was no recorded crew discussion considering a landing within Esky Pad.

As the aircraft departed Esky Pad the AC continued to assess the situation. During interviews, the AC said a subsequent decision to land would be based on whether vibrations were experienced enroute to Holsworthy. He stated there were "no major vibes" multiple times during the return transit.

The AC announced Star Pad as the intermediate landing location in the event of an increase in vibration. A review of the return route shows a number of suitable landing locations available to the flight within R555 along the 17 km flight to Holsworthy Airfield.

The AC did not declare an emergency following the main-rotor contact, therefore the regiment's emergency plan was not activated. A broadcast on the CTAF frequency during departure from Esky Pad only stated "Esky Pad returning to base Holsworthy". The officer-in-charge (OIC) of night flying monitored the transmission.

A second radio transmission advised the operations staff that the aircraft had struck a sapling with no abnormal vibes. No emergency services were activated in response to the radio call.

Post landing and the decision to take the spare

The transit to, and landing at, Holsworthy was unremarkable. Upon shutdown the AC led a crew debrief at the aircraft before placing the aircraft unserviceable. It was at this time that maintenance advised the AC that a spare was available, should it be required.

The AC personally inspected the rotor system under torch light while parked on its post-incident landing pad. Maintenance was advised formally in an entry in CAMM2 that the top of a sapling had been impacted with no anomalies or vibrations noted in the hover prior to a return flight to Holsworthy. The shared mental model of the crew and maintenance upon release was that the aircraft had sustained a main-rotor strike with a small sapling. The extent of damage was not confirmed by either crew or maintenance staff prior to the incident crew departing on the subsequent flight.



Visual assessment focussed on the rotor tip caps as a similar sized sapling had caused extensive damage in an incident three weeks earlier.

Having not observed any remarkable damage under torchlight, the AC phoned the OC and advised him of the strike at 1954 hrs. The conscious decision to advise the OC indicated that the occurrence warranted command oversight.

During the short telephone call between the AC and OC, two separate and distinctly different understandings of what would subsequently occur were formed. The physical environment in which the OC received the telephone call was suboptimal and contributed to this situation.

The OC was told that a sapling had been contacted during a confined area approach and this was acknowledged. The OC, having been notified of the occurrence, did not end the telephone call with the knowledge that the AC was to utilise the spare aircraft and seek a new authorisation in order to complete the ABS assessment serial.

The AC, unlike the OC, ended the telephone call with the view that the command chain was aware of the intent to reauthorise. As a result of the call, the AC's view was that the plan was sanctioned.

As this was the second tree strike to occur in the regiment in three weeks the OC considered the incident significant enough to further notify the commanding officer (CO), who was notified by text message 20 minutes later that the crew were safely back on the ground at Holsworthy.

The original AuthO for the incident sortie landed at 2030 and met with the AC and the left-hand-side aircrewman. The details of the incident were briefed and the narrative continued to describe a small sapling contacting the main rotor system. The AuthO considered the advice of the AC in that the crew was prepared to complete the assessment in a spare aircraft with no individual member raising any concerns.

Particular emphasis was placed on the welfare of the crew. The left-hand-side aircrewman was within three hours of his crew-endurance limit at the time of the authorisation.

The occurrence on the night of 13 June 2017 initiated a sequence of events that highlight deficiencies in communication and decision-making. These deficiencies were evident in the sequence leading to main-rotor contact, the decision to depart and return to Holsworthy and finally the incident crew's decision to seek and be given a subsequent independent authorisation to complete the assessment.

While correct at the time of the message, the aircraft and crew would depart 25 minutes later on a second authorised sortie.

The crew at interview identified no pressure to complete the sortie. During the brief the AC provided ample opportunity for any member of the incident crew to cancel the second sortie if they were concerned.

Conclusion

" In the past 20 to 25 years there has been an increasing interest in, and recognition of, the importance of human error as a contributing factor in workplace accidents/serious incidents (events). In fact, human error attracts more attention than any other topic in human factors, crew resource management or non-technical skills literature. Errors are the cause of most accidents, and accidents are the main reason for the emergence of the field of human factors." – AVIATION NON-TECHNICAL SKILLS GUIDEBOOK, 2018

PC-9 near-miss a divergence in expectations

By LCDR Darryl Whitehead

afety-occurrence investigations routinely reveal the critical nature of non-technical skills (NTS), such as communication, situation awareness, decision-making and teamwork. This article incorporates the research-based literature of the DFSB's Aviation Non-technical Skills Guidebook to clarify the human factors and non-technical skills 'in play' during this near-miss¹. It also amplifies, via the building blocks of spatial awareness [see NTS skills section of this article], how this nearmiss event occurred.

The event

On 11 July 2018, a near-miss event occurred within the RAAF Pearce (YPEA) Circuit Area (CIRA) at about 3000 ft above mean sea level (AMSL) between two PC-9 aircraft from 2FTS. No significant weather was reported (light winds/good visibility) at the time.

PC-9 – Aircraft A – was conducting a student instrument flight (through the Missed Approach Point (MAP) for an Instrument Landing System (ILS) Y approach to runway 18 left (18L)), in a standard right-hand turn at approximately 3000 ft AMSL, when the near-miss occurred.

The other PC-9 – Aircraft B – up for an 'air test', conducted a maximum angle climb from runway 18L, to 3000 ft AMSL, when Pearce Air Traffic Tower (TWR) [alerted] Aircraft B of conflicting traffic (Aircraft A). Aircraft B took avoiding action from the conflicting traffic, ultimately closing (laterally) to an uncorroborated estimate of 300 to 500 ft.

The investigaton team concluded that this near-miss was primarily caused by a divergence in expectations between ATC staff and Aircraft B (in the leadup to the air test). From the initial request made by Aircraft B (air test in the CIRA), the incomplete information flow, paired with the assumptions made by both parties, resulted in the TWR controllers having differing mental models to that of Aircraft B.







Figure 1. Aircraft A/Aircraft B near-miss.

Figure 1 depicts the near-miss event Aircraft A joining YPEA's ILS-Y RWY 18L through initial approach fix SCOUT and Aircraft B conducting a max angle climb from the duty runway.

Had Aircraft B filed a flight plan, flown the air test outside of the CIRA, reiterated the ambiguities of his sortie to TWR (prior to take-off) or flown a conventional departure profile, it is probable that this near-miss would not have occurred.

When TWR and Aircraft B realigned their divergent individual mental models (via the advisory traffic radio call) to a shared situation awareness, the probability (highly likely) of a collision was significantly reduced (potentially averting a collision).

Non-technical skills

Information errors, decision errors and action errors

Errors are the cause of most accidents and accidents are the main reason for the emergence of the field of human factors.

- Information errors. Result from perceiving something incorrectly, or not understanding the current situation correctly. This type of error includes situation-awareness1 problems or errors caused by visual or perceptual illusions.
- Decision errors. Come from the middle part of the informationprocessing model shown at Figure 2. The person carries out the actions

as planned, except that the planned action was not right for the situation. Mistakes are decision errors.

 Action errors. Occur when the actions themselves deviate from an individual's plans. Action errors tend to occur during highly routine activities, or when attention is diverted from a task, either by thoughts or external factors. Action errors are like slips and lapses.

Violations

Violations are defined as behaviours that involve the deliberate deviation from rules that describe the safe or approved method of performing a particular task or job.2

The conceptual boundaries between errors and violations are not always clear as both involve a deviation of action from some required standard of performance.

The question of intent is what differentiates errors from violations and it is what makes them more dangerous than slips, lapses, mistakes, and other forms of informationprocessing errors.

As was the case with errors, the development of a taxonomy of violations has proved to be useful for accident/incident investigation and for monitoring the safety status of an organisation. The seven-category taxonomy that supports the Defence just-culture initiative is described as follows.

Routine violations are frequent, also committed by others in the workgroup, and often condoned by management. These violations usually reflect the practices within the workgroup (that is, the norm).

Situational violations occur when there is a gap between what the rules require and what the person thinks is available or possible. For example, workarounds that help to make up for resource constraints or limitations in the workplace.

Exceptional violations are rare and happen in abnormal situations or emergencies. They usually occur when something goes wrong and the person believes that the rules no



Figure 2. Information-processing model with error taxonomies superimposed.

longer apply, or that applying a rule will not correct the problem.

Organisational-optimising violations are committed to meet performance goals. They are usually a result of a can-do attitude rather than resource constraints.

Personal-optimising violations are committed for personal gain or benefit. For example, finishing a shift earlier, taking shortcuts to reduce personal effort, thrill-seeking, or playing practical jokes.

Serious carelessness reflects a disregard of an obvious risk or a profound failure of professional responsibility. It may also reflect a general disregard for rules and procedures.

- processing information continuously

- updating mental representations/models of the task/ workplace/operational space





Situation awareness

There are numerous definitions as to what situation awareness is. It is considered that the definition proffered by former US Chief Scientist Mica Endsley is

perhaps the most influential in literature on situation awareness. This definition underpins the model of situation awareness presented below. Extrapolating from Dr Endsley's definition, the process of situation awareness would involve:

- continuous extraction of environmental information
- integration of this information with previous knowledge to form a coherent mental picture
- the use of that picture in directing further perception and anticipating future events.

Aviation personnel who are successfully doing these things are likely to achieve and maintain a high state of situation awareness. The activities underpinning the development and maintenance of situation awareness



If they are so dangerous, why do workers commit these violations? Violation behaviour is directly related to how people adapt to the situations that arise in their workplace where behaviour is regulated by procedures, codes of practice, and rules.

Violations occur for many reasons, and are seldom wilful acts of sabotage or vandalism. Most stem from a genuine desire to perform work satisfactorily given the constraints and expectations that exist.

Nature of the iob and can-do attitude

Defence aviation personnel are faced with the challenge of building a bridge between the reality of work demands and rules and regulations which cannot possibly cover every work challenge that arises. Part of the reason why individuals and supervisors take it upon themselves to decide that there is a more efficient way of doing things lies in the can-do attitude that typifies most Defence aviation organisations. Working successfully under pressure and resource constraints is a source of professional pride.

While the benefits of encouraging a can-do culture are numerous, it must be acknowledged that some safety-management strategies can be impeded because of a strong sense of not wanting to let the team down.

Deviation from standard procedures enables tasks to be achieved and reputations as capable operators to be maintained. We know from experience and the wider literature; however, that departures from approved procedures increase the risk of events. Individuals can misunderstand or underestimate the wider effects of decisions



Figure 3. Endsley's model of situation awareness.

- constructing a structured, information-dense, mental representation of the task/workplace
- constantly interrogating the environmental data stream to detect missing, conflicting, updated, and novel information
- generating and challenging expectations
- self-monitoring their performance and that of their crew/team
- self-directing their actions and decision-making.
- Situation awareness can, therefore, be described as a cognitive skill that requires you to correctly perceive and make sense of your current state, use your existing knowledge to develop a mental picture and then anticipate and look for future events and their potential impact on your task. Within a complex environment there are many dynamic elements that may affect your ability to perform tasks safely and effectively, which means that maintaining situation awareness is a constant process.
- Dr Endsley's model of situation awareness is at Figure 3 (from CASA's (2012) Human Resource Guide for Pilots (p.127)). Figure 3 is used to amplify the subject report at Figure 4 (over page).

Situation awareness errors and their causes

A failure to maintain situation awareness is responsible for many of the accidents that are attributed to human error. To help identify the reasons for these failures. Endsley (1995a) developed a taxonomy for classifying and describing errors in situation awareness. Her taxonomy is shown below.

Level 1 errors – failure to correctly perceive situation (lack of attention or poor quality information):

- data not available
- data difficult to discriminate or detect
- failure to monitor or observe data
- omission
- attention narrowing / distraction
- high task load
- misperception of data
- memory loss or failure.

Level 2 errors – failure to correctly integrate or comprehend information (lack of mental models or formation of poor mental models):

- lack of/or poor mental model
- use of incorrect mental model
- over-reliance on default values in mental model

Level 3 errors – failure to predict future actions or future state of the system (provision for future states):

- lack of or poor mental model
- overprojection of current trends, and others.
- Tell-tale signs of lost situation awareness
- statements such as:
- "I didn't realise that ..."
- "We were surprised when ..."
- "I didn't notice that ..."
- "We were so focussed on ..."
- "I was so busy that ..."
- "We were so sure that ..."
- "It certainly wasn't what I expected ..."

Conclusion

It is not surprising that an ATSB study found situation awareness was implicated in 85 per cent of humanfactors incident reports. Gaining and maintaining situation awareness are critical components of each and every aviation member's employment. Without sound situation awareness, even the best trained individuals can make poor decisions. Good situation awareness requires three

elements: noticing information that is relevant to your task, incorporating that information in your mental model of your working situation, and being able to anticipate the impact of that information on the future state of your work situation.

Situation awareness is not just about the individual - team or shared situation awareness is the degree to which every team member achieves/possesses the awareness required to safely conduct their assigned responsibilities. By way of a correlative exercise, Figure 4 overlays the key points of this near-miss event at RAAF Pearce with synonymous taxonomies described in this article.

Recommended links to the NTS Guidebook discussed in this article are at: Website/Objective/ Defence Library (https://objective/id:AB35830796)

References

1. Aviation Non-technical Skills Guidebook by Cooper, R & Fry, C (eds), 2018, Department of Defence, Canberra - Edition 1 (May2018).

2. Fogarty, Cooper, & McMahon, 2016; Reason, 1990

Notes

- 1. Near-miss taken from Aviation Safety Reporting System (Flight Operations Keywords Descriptions)/ATSB is a read across of 'near-collision', which is defined as 'an aircraft comes into such close proximity with another aircraft either airborne or on the runway strip, or a vehicle or person on the runway strip, where immediate evasive action was required or should have been taken'.
- 2. DDAAFS was rebranded as the Defence Flight Safety Bureau (DFSB) on 21 August 2018
- 3. The term non-technical skills (NTS) encompasses attributes including the ability to recognise and manage human-performance limitations, to make sound decisions, communicate effectively, lead and work as a team and maintain situation awareness.
- 4. Both situation and situational are used interchangeably within the literature. However, situation awareness means literally "awareness of the situation" whereas situational awareness means "a type of awareness relating to situations". The former meaning is simpler and clearer - situation awareness is therefore the advocated term.



main participants had significantly different frames for their respective mental models.

Figure 4. PC-9 near-miss information-processing model.

LOSS OF

By MAJ Jason Otter

n 8 February 2018 a Bell 429 helicopter experienced loss of control during recovery from a throttle-initiated, power-terminated autorotation. The flight was a scheduled pilot transition flight encompassing syllabus sorties on instrument flying.

The crew consisted of the aircraft captain (AC), a Bell 429 gualified flying instructor (QFI) and a student pilot (SP), an experienced Squirrel QFI, transitioning to the Bell 429. The sortie was planned as an instrument flight rules (IFR) navigation flight from Nowra to Wagga Wagga; with the return leg flown as a left-hand seat familiarisation for the student. On their return to Nowra, the crew planned to conduct practice emergencies in the circuit.



The crew conducted an ILS approach into Nowra, a one-engine inoperative landing, followed by a circuit landing with a simulated ECU failure. The third circuit was conducted to complete a throttle-initiated, powerterminated autorotation.

When the crew identified that the throttle had not been returned to the fly position during the flare, it was subsequently advanced to fly.

The aircraft contacted the runway on runway heading before becoming airborne. The aircraft rotated through 900 degrees (two-and-a-half-rotations) before the AC regained yaw control. The aircraft was subsequently taxied to the squadron flightline and released as unserviceable to maintenance.

The instrument flight from Nowra to Wagga Wagga and return was uneventful, returning to the Nowra circuit at about 1530 hrs.

AVIATION SAFETY SPOTLIGHT

Two practice emergency circuits were flown to Runway 08 Nowra before positioning for the throttle-initiated power-terminated autorotation to the runway. At 100 kts and 2000 ft AMSL, the AC retarded both throttles to ground idle and the SP entered autorotation.

During the latter stages of the sequence, having developed the flare to an approximate height of 15 ft above the runway, the low rotor-revolutionsper-minute (NR) audio sounded. The audible warning coincided with NR decaying through 95 per cent, as a result of the collective being introduced to power terminate the sequence. The audible warning alerted the crew that the throttles were still in the ground idle position.

At the time of the occurrence the tower was manned by five air traffic controllers, including two trainees. The tower controller monitored the loss of control and the tower supervisor made a conscious decision to delay contacting the aircraft as not to further increase the workload of the aircrew. Only once the aircraft was stable in an air taxi did the tower controller make contact.

Safety analysis

Ground-based witness accounts ranged from those observing the whole evolution to those who observed the dust being generated as the aircraft became airborne and commenced rotating.

All witness accounts describe the aircraft rotating between two-and-ahalf and three rotations and climbing before stabilising and taxiing back to the hard stand. Witnesses described the aircraft having lost control, and some indicated they felt the need to prepare for a crash.

The crew account of the occurrence following the decision to advance the throttle to fly did not align with the ground-based accounts. This is attributable to the high demands/ stressors being experienced by the crew as the situation unfolded. The crew believed they had rotated only once and stabilised the aircraft in a relatively short time frame while acknowledging they had climbed throughout the recovery. Once stabilised, the aircraft was orientated toward the hard stand

Autorotation training

Autorotation practice in rotary wing aircraft is designed to prepare the pilot to respond to emergencies that require rapid descent and landing, usually in the case of an engine failure, or in the event of a tail rotor failure. The likelihood of dual-engine failure in a multi-engine helicopter is considered low; however, there remains potential for total power loss.

Tail rotor failures are still a risk. As with any emergency procedure, familiarity with the manoeuvre supports effective decision-making and a timely and confident reaction in an unexpected and dynamic environment.

There are no references in the brief, instructor notes or flight guides that relate to a mandatory height at which throttles are to be advanced to fly. *The Bell 429 Flying Guide* does not specify the height at which throttles are to be returned to the fly position, only that they must be done "at some stage during the descent, before descending through 300 ft".

Interviews with Bell 429 QFIs indicated that the throttles are returned to the fly position generally well above 300 ft but using slightly different cues depending on the individual. For example, QFIs indicated that they return the throttle to the fly position based on altitude, or on student performance, or a combination of the two.

Of the QFIs interviewed, only one indicated that a positive action (check

of throttles) was conducted at 500 ft regardless of when the throttles had actually been returned to the fly position. There were no reported actions at 300 ft.

Before conducting the autorotation sequence, checks were carried out in accordance with the *Flying Guide* and voice call outs set to 500 ft. The AC retarded the throttles at the planned altitude of 2000 ft and the SP began the autorotation.

The AC indicated that his normal cue for returning the throttle to the fly position was 1000 ft on the altimeter and that the 500 ft VCO was a secondary check. The secondary check did not normally involve any positive actions, such as verbalising the throttle check. During the event autorotation, the AC did not return the throttles to the fly position at 1000 ft on the altimeter, or at 500 ft AGL.

The AC indicated that the focus was on the SP's management of the collective, which is supported by the CVR recording. During the descent, there was some commentary from the AC regarding the NR and the collective settings and the AC spoke over the 500 ft VCO.

The AC indicated the first cue was missed (that of 1000 ft ASML) and second cue (500 ft VCO) was not heard. This would indicate a degradation of level-one situation awareness: perception of cues.

Situation awareness is a cognitive skill and is therefore susceptible to human performance constraints such as memory limitations and distraction. Systems and procedures are designed to support human limitations by ensuring that appropriate cues prompt appropriate behaviours.

The procedural cue used to prompt the return of the throttle to fly is the flying guide requirement to have it done by 300 ft. As evidenced by the interviews with QFIs, this cue does not normally prompt a positive action.



The occurrence overview including witness location.

Instead, QFIs use varied cues that are personal and based on experience. While valid, cues such as these rely on prospective memory (the requirement to remember something in the future) and are therefore susceptible themselves to cognitive limitations.

In dynamic environments, cues need to be strong enough to stand out from other information, including potential distractions. It is likely that distraction in the cockpit caused the AC to miss the first cue, that of 1000 ft AMSL.

Additionally, the AC indicated that autorotation practices were routine, and had been conducted a significant number of times in the past, without incident. The expectation that this sequence would be the same as all the others, and therefore the throttle would be returned to the fly position at 1000 ft on the altimeter, may have reduced the significance of the 500 ft VCO to the AC, and was therefore not listened for and, in fact, spoken over.

The method in which the existing 500 ft VCO cue is used is not considered

strong, in that it functions as a secondary, passive cue, rather than requiring positive action .

Once the crew were alerted to the incorrect throttle position, the AC elected to advance the throttle despite being below the minimum height of 300 ft. At interview, the AC stated that, in hindsight, a much better option would have been to accept the run-on landing to the aligned Runway 08 Nowra surface.

Crew experience

The AC was an experienced QFI with more than 7000 hrs total flight time and significant experience on multi-engine and single-engine helicopter types. Before the event the AC had flown 810 hrs on the Bell 429 helicopter. The SP had recently completed an instructional posting flying Squirrel helicopters before commencing Bell 429 transition training and had previously flown the multiengine MRH90 helicopter type. The SP had 22 hrs experience on the Bell 429 before the occurrence.

Aircraft damage

The Bell 429 helicopter landing gear is a skid-type assembly consisting of two main longitudinal tubes connected by two arched cross tubes as shown. Visual inspection revealed that both the left- and right-hand skid shoes showed signs of localised heating, creating discolouration of the titanium structure.

Discolouration was more prevalent on the right-hand skid shoes with more localised heating towards the rear of the skids. This correlated with the more pronounced gouging of the runway. The observed damage exceeded allowable tolerances and required replacement of both longitudinal skid tubes.

Main rotor system

The main rotor system composite flexbeam configuration consists of two fibreglass/epoxy yokes assembled in a stacked arrangement. The system is a soft-in-plane flex design with four interchangeable rotor blades attached to the main rotor hub. The lead-lag dampers are of the flat pad elastomeric type. The centrifugal force bearing (pivot/feathering) and the shear bearing are also elastomeric. The pitch horn and grip assembly (grip horn) is a single aluminium forging.

Inspections of the main rotor head

were performed by maintenance staff. While there was no damage identified on the main rotor blades, contact damage was observed between a lead/lag damper and associated yoke.

Damage of this nature had not previously been observed and warranted the removal of the main rotor head for detailed inspection. Preliminary examination revealed contact damage between the lead lag dampers and the yoke, which required full disassembly and OEM engagement.

The flight data recorder revealed that during the occurrence the main rotor slowed from 100 per cent NR (395 RPM) to a low of 59 per cent (229 RPM). The flight manual states that the minimum NR for autorotation is 85 per cent.

The 59 per cent NR was recorded during the recovery of both engines to fly and coincided with the AC applying 85 per cent of available collective range. This increased to 98 per cent during the recovery sequence. As a result of extremely low NR, the main rotor head was exposed to extreme stress. The operating ranges reached during the sequence well exceeded normal operating limitations.

Excess of this magnitude had not previously been observed by the OEM. As a result, the coning angle of the blades was at a maximum due to the reduced centrifugal force (maximum angle at 58 per cent NR) and a sustained high collective pitch setting (98 per cent of available range).

The soft, in-plane design of the main rotor head allowed elastomeric movement in the lead lag damper. The aerodynamic forces acting on the main rotor head were in response to the increased rotor drag, and of sufficient magnitude to permit contact and subsequent damage between the yoke and the damper.

Conclusion

The loss of control had its genesis in a deficient procedural control. The absence of a definitive check height coupled with reduced perception of risk permitted the aircraft to be configured with throttles at idle below the authorised height. The AC's decision to advance the throttles to fly was made late and only in response to an aural warning.

The late application of throttle combined with high collective setting delayed NR recovery led to runway contact and subsequent airborne loss of control for 17 seconds.

The aircraft sustained significant damage as a result of aerodynamic forces associated with the low NR and sustained collective application.



MRH lead-lag damper and yoke damage.

Aviation non-technical skills courses NTS

DASM AL8 introduced a new training framework to replace the CRM and MHF programs

Key changes include:

A change in terminology from Crew Resourse Management (CRM) or Maintainence Human Factors (MHF) to **NON-TECHINICAL SKILLS (NTS)**. The term NTS denotes targeted human-factors training designed to promote reliable and effective performance. It promotes the integration of technical and non-technical training and assessment and recognises that not all Defence aviation personnel work in crew-based environments.

Aviation NTS Trainer Course replaces SFAC and prepares participants to deliver NTS Foundation and Continuation and awareness training.

Aviation NTS Foundation Course replaces CRM and MHF Foundation courses and will be integrated into all initial employment training for aviation-related trades.

Aviation Continuation Training replaces refresher training sessions and consists of targeted scenario-based NTS training packages developed by DFSB. It must be conducted every two years for all aircrew, JBAC, ABM, UAS pilots and operators, engineers and maintenance personnel.

The new framework supports a move beyond classroom-based NTS training to the conduct of skills-based training integrated into the broader training system. There are several evidence-based techniques for assessing performance; DFSB recommends using the Method for Assessing Personnel Performance (MAPP) contained in the DASM.

For more information on NTS visit the DFSB intranet homepage.



By SQNLDR Dave Palmer

n 3 June 2018, a C-17 was landing on Runway 18 at RAAF Edinburgh. After touchdown and application of firm braking, the aircrew heard a loud bang from the cargo compartment. The aircraft was taxied to its parking position and shut-down without further incident. Inspection of the cargo compartment revealed that a palletised container had moved during the landing. It had slid forward, running over a stack of water bottles before impacting the aircraft's crew entry door.

During the landing, passengers had been seated in the cargo compartment, but none were in the path of the container. No personnel were injured during the event.

The RAAF C-17 Globemaster departed Kadena Air Base (Japan) on 3 June, enroute to RAAF Edinburgh. The aircraft was crewed by two pilots and a loadmaster. Four maintainers were on board to provide awaybase support. The aircraft was carrying cargo and five passengers. The cargo included a tow-motor, generator,

As the aircraft decelerated, the crew heard a loud bang from inside the cargo compartment and passengers witnessed the Position 1 Left - Container (P1L-C) slide approximately one metre forward, unrestrained. After completing the landing, the crew determined that the P1L-C had load-shifted, and was the cause of the noise during landing. Subsequently, the crew taxied the aircraft slowly to its parking position at Air Movements. The load-shift caused the crew entry door's partition panel to be damaged beyond limits and was later replaced

been securing packs of water bottles. Damage to the logistics restraint rail system was functionally insignificant but valuable from an investigative perspective. Scrape-marks were found on top of the P1L inboard pawl and metal scrapings were recovered, one was found below a P1L pawl, the other was found on a P1L-C side lip. One side of each scraping exhibited small amounts of green paint.

The P1L-C's nomenclature is Standard 90 Expeditionary Airlift Container, due to its height of 90 in. Its base dimensions are 108 x 88 in, and intended to be compatible with the 463L3 cargo handling system.

The Logistic Restraint Rail System was being used to secure the P1L-C during the load-shift event. The system is designed to accept and lock pallets with a standard

containers and loaded-pallets. Because of construction work on Runway 18, the threshold was displaced at the northern end, reducing the available runway by approximately 355 m, still within the capabilities of the C-17, but meaning that harder-than-normal braking would be reauired.

with a serviceable item. The door's top step was dented and required a blending repair. Minor gouging to the floor occurred when the P1L-C ran over a ratchet strap that had

C-17 Logistics Restraint Rail System

The C-17 is fitted with two rail options for managing and securing cargo - aerial delivery system (ADS) restraint rails. One set of rails, 108 in apart and, logistics restraint rails. Two sets of rails, 88 in apart.

profile (SP) lip that is; 463L pallets. The lip profile is part of the design requirements for containers, as stipulated in the *Airworthiness Design Requirements Manual.*

The rails guide a pallet's lips, restraining it in all directions except axially. Rollers on the aircraft floor take the weight of the pallet, and allow it to be easily moved along the rails. Once in position, locks secure pallets by raising pawls.

Each lock is made up of two pawls. Electrical power raises the pawl into the rail channel. Pallets are positioned so that the pawl raises between gaps in the pallet's lips. This prevents the pallet moving axially. The rail already limits movement in all other directions, hence raising the pawl secures the pallet. The locks can be controlled from within the cargo compartment or at the loadmaster station.

There are seven floor positions on either side of the C-17. Most positions are fitted with two locks (four pawls). Positions 1 and 7 only have one lock (two pawls).

Analysis

Partially open or failed locks could explain why the P1L-C was able to load-shift. The status of the locks was ascertained via multiple sources:

Loadmaster recollection. The loadmaster confirmed all in-use locks were in the locked position prior to takeoff, the Position 1 Control Panel and the Loadmaster Station indicating the P1L lock status as locked.

Visual indicators. These are an additional method for checking the status of the locks. This modification was added following instances of faulty aircraft indications for lockstatus. After this event it was found that the P1L lock was intact, properly connected, operable and physically in the locked position. It was; therefore, determined that the P1L lock was locked during the flight, including during the load-shift event.

Weight and balance of P1L-C

The weight limitation for P1L is 10,000 lbs. If the P1L-C exceeded this limitation, it is possible the locks would be unable to restrain the load. Therefore, P1L-C was independently weighed. It was found to be within 50 lbs of its listed weight (6340 lbs).

The P1L-C was checked for internal weight distribution, and internal load-shift. Equipment within P1L-C was appropriately distributed, and there had been no internal shifting.

Pallet/container lip profiles

The lip profile found on the P1L-C is different to the SP lip observed on other containers and pallets. The P1L-C's lip was approximately the same width, but significantly thinner than a SP lip.

As the P1L-C has a thinner lip profile than other containers, it was investigated as to whether the P1L-C could have passed over the top of locks that were in the locked position. Such movement would require the lip to pass through the gap left between the top of the pawl, and the bottom of the rail. The approximate size of the gap between pawl and rail was 8 mm. The thinnest part of the P1L-C lip was approximately 10 mm. The lip was larger, but only by a small amount.

Boeing Mission Systems provided analysis that was developed after a similar event. That event also involved a P/N 1940 container and stated "The cross section of the pawl/lip engagement showed that the P/N 1940 lip barely engaged the pawl. Furthermore, it was only slightly thicker than the pawl/rail gap. In comparison, the SP lip had significantly more engagement, and could not conceivably fit through the pawl/rail gap. Therefore, the analysis demonstrated that the P/N 1940 container lip provided insufficient resistance to riding over the top of the pawls."

Witness marks

The outcomes of Boeing's analysis was compared to the physical evidence on the aircraft and P1L-C. The P1L pawls showed evidence of damage on their upper surface, consistent with a heavy item sliding over them.

The P1L-C's lips that had begun rear of the pawls showed scrape-marks. This was consistent with having slid over the top of the pawls. The metal scrapings found were consistent with having been liberated from the P1L-C when it scraped over the pawls.

The underside of the rails showed evidence of paint-transfer. Specifically, it appeared to be the green paint of the P1L-C. This was consistent with the P1L-C's lips sliding over the top of the pawls and thus coming into contact with the underside of the rail. The witness marks showed all the evidence that the P1L-C had ridden over the top of the P1L lock during the load-shift.

Interplay of causal and contributory factors

As the P1L-C had flown on C-17 aircraft without incident prior to the event, it is likely that the load-shift occurred due to a combination of factors. The causal factor was the thinner-than-standard lip profile; however, contributing factors were:

- The harder-than-normal braking during landing (noting that the landing was within the authorised operating envelope for the aircraft).
- The single lock available at P1L (noting that the P1L-C was authorised for carriage at P1L, and within the weight limitations of that position).



P1L-C after load-shift (red arrows indicate shift).

Authorisation for P1L-C on C-17

The P1L-C was identified in the C-17A Loading and Lashing Manual at Sect 5, Chap 2 as compatible with the Logistics Restraint Rail System, without further restraint.

The sponsor of the manual is Air Mobility Training and Development Unit (AMTDU). AMTDU is the sponsor of the *C-17A Loading and Lashing Manual*. AMTDU engineering personnel stated that it is likely that the clearance for the P/N 1940 container was read-across from the *C-130J*'s equivalent publication, the *C-130J Loading and Lashing Manual*. Indeed, the grandfathering may have originated with C-130H or earlier.

However, the lock design on the C-130J's rails is fundamentally different to that of the C-17. On the C-130J, the pawls ingress the rail from the side, and take up practically the entire rail cavity. For this reason, it is highly unlikely that the P/N 1940 Container lip would be able to load-shift by moving past locks in the locked position on C-130J.

As there had been no issue on C-130J, it is probable that the C-130J clearance for the P/N 1940 container was used as the basis for a similar clearance on C-17. However, AMTDU were unable to retrieve the relevant engineering document *AMTDU 31/108/18Air Pt 3 (39)*, so this could not be confirmed.

AMTDU conducted a review of air cargo delivery publications and processes after the load-shift event and formalised actions for updating sponsored publications, including the *C-17A Loading and Lashing Manual* to ensure the contents are current and accurate. AMTDU also recorded an action to set-up a formal, regular process for publication review.

Conclusion

The load-shift occurred because the design of the container's lip was inadequate for use on the C-17's Logistic Restraint Rail System. The lip's profile was too thin, allowing the container to slip between the pawl/rail gap. Thus, the container design was the causal factor.

Contributing to the event was the container's position on the aircraft (one lock rather than two), and the forces generated by the firm braking upon landing.

However, the landing was within the aircraft's authorised operating envelope, and the cargo position was appropriate for the container. The container had been cleared for use in C-17 aircraft, and it is probable that this was based on an extant clearance for C-130J aircraft. If that was the case, then configuration differences between cargo systems of those platforms had not been sufficiently taken into account.

AVIATION SAFETY SPOTLIGHT

BELL 429 Cockpit fire

By MAJ Jason Otter

n 14 March 2017, a Bell 429 helicopter experienced a cockpit electrical fire and subsequent partial electrical failure at night, in instrument flight conditions (IMC) during an instrument approach at HMAS Albatross. The flight was a scheduled staff-continuation-training sortie for a squadron crew, consisting of a Navy pilot and Aviation Warfare Officer (AvWO). The flight was planned as a day-and-night sortie under both the visual flight rules (VFR) and instrument flight rules (IFR). The initial leg to Moruya was to be flown visually by day transitioning to a night IFR segment to Canberra and culminating in an instrument approach and landing at Albatross.

On starting the instrument approach at Albatross, the AvWO commented on a faint burning smell in the cockpit. While established on the inbound leg of the approach the AvWO then enthusiastically announced that the aircraft was on fire.

The pilot, on losing cockpit flight displays with an identified fire in the footwell, transferred his attention outside the cockpit focussing on a hole in the clouds illuminated by the lighting of the Bomaderry township. The hole appeared to be forward and slightly offset from the flight path and about one nautical mile in diameter. The pilot was able to positively identify the Shoalhaven River, Pig Island and specifically the Manildra Group Shoalhaven Starches factory.

After descent clear of the cloud base, the AvWO identified the Albatross approach lighting approximately 7 nm south of their current location. The pilot reassessed the initial plan to land in the vicinity of the Nowra Township opting to maintain the aircraft airborne and track for Albatross utilising the Runway 21 High Intensity Approach Lighting (HIAL) and Precision Approach Path Indicator (PAPI).

The aircraft successfully landed at the squadron flightline, with airfield emergency services in attendance. The damage sustained in the initial electrical fire prevented a normal aircraft shutdown. There were no injuries to the crew.

Operational aspects AvWO's comment and attributed it to the aircraft turning downwind with a strong tailwind and There were no operational restrictions applied to possible exhaust fumes. This initial burning smell the flight based on the weather or Notice to Airmen was not discussed further. (NOTAM); however, it was noted by the crew that the majority of the flight would be conducted in IMC and At 21:27:07 hrs the aircraft was approximately 8 nm at 2800 ft AMSL on the ILS Y for Runway that conditions on return to Albatross would require an instrument approach. Deteriorations in local 21 at Albatross, when the AvWO saw fire and conditions at Albatross were forecast to occur for sparks in his footwell and announced this over the internal communications system (ICS). The fire in periods up to 30 mins at the time of the occurrence. Conditions remained suitable for IFR flight with the cockpit was confirmed by the aircraft captain scattered cloud forecast at 500 ft above ground (AC) after a brief discussion. Nine seconds after the initial sighting of sparks the AvWO reacted to level with a broken cloud at 1000 ft. Moderate rain would reduce visibility to 5000 m. a Crew Alerting System (CAS) audible alert with multiple CAS captions, coinciding with audible circuit A flight-authorisation brief was conducted by the breakers tripping.

flight authorisation officer and pilot in command on the day of the flight. A weather update was provided by phone to the authorising officer as pre-arranged and the authorisation completed. The crew conducted the pre-flight brief with no additional restrictions identified.

The aircraft departed Albatross under VFR at the autopilot disconnected, and navigation and 1917 hrs, experiencing deteriorating weather communication systems failed. conditions during the coastal flight to Moruya. The crew elected to return to Albatross after 15 mins The aircraft was in a degraded state. The crew was flying without autopilot stability, visible display and proceed to Moruya IFR and then continue from from the DUs (flight instruments and system Moruya as originally planned. The flight continued monitoring), navigation equipment, and cockpit with the crew experiencing some turbulence lighting. The situation was further compounded by enroute. At 2023 hrs during the Moruya-Canberra leg, a left-static-heater alert prompted the crew smoke in the cockpit, and no normal internal aircraft lighting. The only light sources utilised were crew to reassess the continuation of the flight and helmet-mounted lip lights, augmented by cultural subsequently executed a return to Albatross. and ambient lighting. The crew did not utilise the The crew elected to fly the reciprocal route and available emergency lighting system during the terminate the sortie via the instrument landing system (ILS) Runway 21 approach. emergency.

During the flight and before the emergency, both The crew could not see the intended landing runway due to thick cloud and heavy rain ahead of crew members demonstrated good crew resource them; however, the AC could see cultural lighting of management and immediate risk assessment. They proactively gained updated weather from Bomaderry township off to the 2 o'clock-low region through a break in the cloud. The AvWO could not the squadron duty officer immediately prior to see any cultural lighting to the left of the aircraft. the ILS approach after being notified of amended weather conditions at Albatross. The crew had On direction from the AC the AvWO attempted to comprehensively briefed in-flight and was prepared transmit a MAYDAY on COM1 (Nowra Certified Air/ for an ILS approach into Albatross and, at the Ground Radio Service (CAGRS)). This transmission was unsuccessful due to COM1 failure. time of the emergency, were within ILS approach tolerances.

About 42 seconds after the initial sighting of the sparks and fire, the AvWO stated that the fire was At 2125 hrs, during the instrument approach to Albatross, the AvWO commented on a faint burning out and they had lost the NAV/COM/GPS1. The AC noticed that NAV/COM/GPS2 was faintly illuminated. smell in the cockpit. The pilot acknowledged the

The AC initiated an unaided visual emergency decent clear of cloud emergency descent in response to the confirmed fire and CAS indications. As the AvWO turned aft to access the cabin fire extinguisher, the left, centre and right display units (DU) went blank. All cockpit lighting extinguished,



Damage to N49-047 showing damage to forward left circuit breaker and W101 loom assembly in the vicinity of connector 4296J9.

The AvWO confirmed visual with the Shoalhaven River and that they were still on the ILS below the glideslope. During the descent, the eyebrow lights came back on at full brightness and the standby instruments lighting started to flicker on. The AvWO had readied the fire extinguisher; however, it was not required.

At about +50 to 60 seconds, the right DU came online providing the AC with flight instruments. Flight data recorder (FDR) information showed the aircraft with a rate of descent of 1900 FPM at 1600 AMSL as it descended below the cloud base. This is consistent with the FDR collective lever position being close to a full down position for approximately 20 secs.

At +1:05 mins, the aircraft descended below the cloud base and the AvWO sighted Runway 21 High Intensity Approach Lighting (HIAL). Suspicion of an external COMS failure is raised as no reply to the MAYDAY transmission has been heard. The AC noticed that the COM3 Wulfsberg had lighting and instructed the AvWO to transmit a MAYDAY on COM3. This MAYDAY was again unsuccessful from the AvWO position. AC also voiced his intention to look for a place to land in the paddocks on the southern side of the Shoalhaven River.

At +1:35 minutes the AC stated the rate of decent was under control and that the crew was to look for wires as he is going to land the aircraft in a paddock. Ten seconds later the AvWO stated the aircraft was clear of the river and that his comms was unserviceable. At this point the AC reassessed the aircraft situation, stated that the aircraft was still flying, and asked the AvWO if they should track for the airfield instead of landing in a paddock. The AvWO did not reply and three seconds later the AC asked to be placed on COM3 to transmit a MAYDAY.

The AC informed the duty officer his probable intention was to land in a paddock. During the resultant radio exchange, the AC changed his intended landing point to the runway after reassessing the situation. During this radio exchange the centre DU came on line followed shortly by the left DU.

While the crew did not openly discuss the loss of all flight displays during the emergency, they later recalled the loss of all three display units and communication panels. Restoration of instrumentation on the right DU and return of partial GPS display allowed the crew to reassess the unaided emergency landing resulting in the decision to continue to Albatross.

Damage to the aircraft

The aircraft sustained damage internally to the forward left-hand circuit breaker panel (FWD left CBP) and also the W101 cable assembly in the vicinity of connector 4296J9. The initial damage was caused by chaffing of the W101 loom across a circuit breaker busbar causing a fire internal of the FWD left CBP. The internal and upper rear face of the FWD left CBP displayed evidence of scorching, charring and melting, caused by the wires in the W101 loom shorting across the emergency bus 1 (EMERG-1) busbar in the location of the co-pilot's intercommunications system circuit breaker (C/P ICS). The busbar linking the EMERG-1 upper row of circuit breakers (C/P ICS; GEN 2 CONT RESET; BUS INTCON; ANNUNC & EMERG lighting; and HOIST CABLE) was melted and an open-circuit condition occurred on the busbar between C/P ICS and GEN 2 CONT RESET circuit breakers.

Safety analysis

The electrical fire and subsequent loss of aircraft systems was a result of an incorrectly installed wiring loom, which suffered chaffing to the extent it caused a short circuit. This resulted in a small fire in the left-hand pilot station footwell. The investigation considered the preconditions that led to this incorrect installation and the missed opportunities to detect the anomaly prior to the release for flight.

Incorrect configuration during HTAWS installation

The damaged loom was compared to three other aircraft. It was discovered that cable assembly W101, at the plug end, has a routing type adapter guide to support the wiring loom. The adapter guide on the incident aircraft W101 loom was configured in a straight line. The comparison aircraft loom adapter guides were found to be configured at an angle, enabling the W101 loom to be routed away from the FWD Left CB Panel. The HTAWS modification required a number of wires to be added to the W101 loom. It is likely the loom routing adapter at the 429J9 connector was incorrectly installed in a straight line configuration during the HTAWS installation.

Scheduled inspections

The scheduled four-yearly inspection was completed on 29 April

2015 concurrently with a two-yearly inspection including unique content separate to that detailed in the fouryearly inspection. This inspection requires a zonal inspection of the instrument and centre console area (zone 212), which did not identify the incorrect configuration of the adapter.

Bell 429 pilot training

It was determined that the primary flight displays were not available to the crew for approximately 50 seconds following the onset of fire. The AC, on observing the cultural lighting of the Bomaderry Township, initiated an immediate visual descent without the use of standby instrumentation. The immediate response to the onboard fire was an unaided visual descent.

The total loss of flight display requiring the use of standby instruments is not trained for in the Bell 429. Emergency instrument training is limited to a single DU failure requiring the pilot to alter their instrument scan to the centre DU. Before conversion onto Bell 429, limited panel training is undertaken during initial AS350 helicopter pilot training. This training is limited to a main attitude indicator (AI) failure requiring the pilot to fly with reference to the standby AI.

Bell 429 electrical system failure training is limited to an airborne tutorial demonstrating the electrical schematic and associated switches to be used in the event of an emergency.

The use of the emergency utility lights during a loss of cockpit instrument lighting is not formally covered during Bell 429 conversion. This omission may extend to the use of other emergency systems on the Bell 429 given that all training is currently undertaken on the aircraft.

The CVR confirmed that in the lead up to the incident, emergency scenarios had been discussed on multiple occasions during the flight. The decision to discontinue the sortie 20 nm from Moruya enroute to Canberra and return to Albatross was following a practical application of the Rule of Three in that the crew had determined that three amber situations had occurred in the flight, which warranted a return to Albatross.

During the pre-approach brief on return to Albatross the crew could be heard to brief actions in the event of an emergency. The crew continued to refine their emergency plan regarding weather conditions in the vicinity of Gerringong NSW some 20 nm from Albatross and noted that conditions would permit a visual unaided landing in the event of worse-than-forecast weather being experienced in Albatross. These ongoing discussions during the conduct of the instrument approach demonstrated a good level of situational awareness and airmanship evident before the cockpit fire.

The safe landing at Albatross can be attributed to the timely decisionmaking of the crew in response to the on-board fire coupled with the location and immediate weather conditions. Decisive action by the crew in seizing visual flight conditions with a significantly degraded aircraft and descending towards a known geographic feature resulted in the safe return of the aircraft and crew to Albatross.

Conclusion

The on-board fire and subsequent blank DUs experienced during this incident was a result of deficiencies in OEM generated installation instructions. The OEM diagram set the preconditions for an incorrectly configured wiring loom with inadequate clearances. Subsequent maintenance did not detect the incorrect configuration resulting in chaffing leading to an on-board fire. The decisive action by the crew resulted in the safe recovery of the degraded aircraft to Albatross.

AVIATION SAFETY SPOTLIGHT

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Sequence of events

The aircraft was undergoing aircrew pre-flight and the TACCO was conducting pre-flight inspections of searchstores equipment. The AEA was briefing a member of the South Australian Police. The aircraft captain (AC) was outside conducting pre-flight inspections. The TACCO checked the three Sonobuoy Rotary Launchers (SRLs) before moving on to the three SSLs. The last SSL to be checked was SSL 2.

The pre-flight check required the SSL's lid to be unlatched, then opened to inspect the tube for foreign objects. The TACCO placed his right hand on the latch handle and depressed the side-mounted release button with his thumb. Depressing the button allows the latch trigger to be squeezed, enabling movement of the latch handle.

Next, the TACCO swung the latch handle downwards. This released the pressure holding the U-bolt in its keeper; however, it did not remove the U-bolt from the keeper. The TACCO used his left hand to move the U-bolt from the keeper, which completely disengaged the latch and allowed the lid to be opened. The TACCO opened the lid and inspected the tube.

Following inspection of the tube, the TACCO began to close SSL 2. He used his right hand on the latch handle, and his left hand to manipulate the position of the U-bolt. This time, the U-bolt needed to be positioned beneath the keeper. As he did this, the TACCO's fingertip was placed between the U-bolt and the keeper. Almost simultaneously with positioning the U-bolt, the TACCO speedily and forcefully pushed the latch handle upwards to engage the hatch. In doing so, the mechanism tightly pressed the U-bolt into the keeper, thus severing the TACCO's fingertip. The fingertip, severed above the bone, was ejected from the mechanism

The TACCO yelled due to the pain, which caught the attention of the AEA. The AEA approached the scene to assess the situation. The AEA went forward to the aircraft toilet to get paper towel, before returning and using it to stem the flow of blood from the TACCO's finger.

P-8 FINGERTIP AMPUTATION

By SQNLDR Dave Palmer

n 20 March 2018, aircrew members were conducting a pre-flight on a RAAF P-8 at RAAF Base Edinburgh. As part of the pre-flight, the tactical coordinator (TACCO) was performing checks of the search-stores systems, including the Single Sonobuoy Launchers (SSLs). While checking SSL 2, the TACCO's left-hand index fingertip was caught and severed by the mechanism. A nearby Airborne Electronics Analyst (AEA) overheard the TACCO's distress and rendered first-aid. The AEA transported the TACCO to the Edinburgh Health Centre (EDNHC), which provided treatment and on forwarding to a civilian hospital.

The AEA retrieved the severed fingertip and escorted the TACCO down the aircraft's forward stairs. On the ground, the AEA passed the AC and provided a brief report of what had happened, as well as the AEA's plan to get medical assistance. The AEA drove the TACCO to the EDNHC where the TACCO was treated before being transferred to a local civilian hospital.

ACAUTION

Hazardous Pinch Points

Keep hands

clear.

It was later determined that the SSL mechanism had removed the pad of the TACCO's finger, and had just touched the tip of the bone. The TACCO underwent surgery which stretched the finger nerve in order to restore feeling. Post-surgery it was expected that the TACCO would regain full functionality and feeling, albeit with a slight reduction in finger-length.

Hazard analysis

While the TACCO only sustained injury to the tip of his finger, this still necessitated hospitalisation and surgery. The severity of the injury could conceivably have been greater if the pinch-point had occurred further down the finger (consider personnel with smaller hands). Thus the consequence was assessed as major.

Human factors

Although preparing for a mission, the TACCO was under minimal pressure to perform the task. Furthermore, the TACCO was not fatigued or stressed.

The TACCO was performing a routine, familiar task. Cognitively, it is likely that he was applying automatic information processing and had intended to perform the task correctly, therefore, the injury to his finger was the result of an error, rather than a violation.

The TACCO's training, experience and currency was as good or better than his peers. The TACCO was a qualified and

AVIATION SAFETY SPOTLIGHT

competent individual performing the task under low pressure, with low fatigue. Therefore, if the injury could happen to the TACCO, it is reasonable to assume it passes the substitution test and could happen to anyone.

Training

To date, all training on searchstores systems has been conducted by the USN at Naval Air Station (NAS) Jacksonville. The TACCO had completed this training.

A range of RAAF P-8 personnel (aircrew and maintenance) were asked about the training received at NAS Jacksonville. It was found that search stores training was brief, and contained a very limited practical component. Aircrew were required to perform each search-stores task once, on board a P-8. Maintenance personnel performed each task once on a load-simulator. No direction on best technique was provided.

Technique

Generally speaking, it is possible to carry out a procedure in slightly different ways, while still complying with the procedure. Indeed, different personnel had different techniques for opening and closing the SSL:

- the TACCO manipulated the U-bolt below its fulcrum (closer to the keeper)
- the AEA manipulated the U-bolt above its fulcrum (away from the keeper but in the vicinity of other pinch-points)
- a maintainer demonstrated that the U-bolt could be seated and unseated without direct manipulation, but by using only the latch handle.

Procedures

The NATOPS checklist was in use by the TACCO during pre-flight. The NATOPS checklist provides direction to aircrew for search-stores tasks. However, the relevant section of the checklist (Ordnance, Preflight 1-1) simply states to check the three SSLs - there are no warnings regarding SSL-closing hazards.

The NATOPS P-8A Flight Manual covers firing of sonobuoys, but not how to check the SSLs. Therefore there are no warnings regarding SSL-closing hazards.

The Aircraft Maintenance Manual contains a procedure for opening and closing the SSL. Although open to interpretation, the procedure for closing the SSL appears to describe the



Fingers in crush zone.

one-handed technique. There are no warnings listed in the procedure.

Hazard-warning labels

The SSL latch mechanism did not contain any markings to indicate that there was a pinch-point hazard. The addition of such markings would be an effective reminder to personnel that the hazard existed.

First-aid kit

In response to the incident, the AEA sought to provide first aid to the injured TACCO. Rather than use the first-aid kit, the AEA retrieved toilet tissue from the on-board toilet. The AEA was influenced by an email to operators regarding the difficulty in replenishing first aid kits and stating that the kits were only to be used in an emergency. As the situation was unfolding, the AEA was unsure whether use of the first aid kit was warranted, and thus chose not to use the kit.

Conclusion

At a superficial level, the TACCO made a skill-based error while latching the SSL, causing him to injure his finger in the mechanism. However, in-depth examination of the event concluded that the mechanism presents a hazard, which is not articulated in the relevant publications. Furthermore, personnel are not taught a safe technique for latching the SSL, and the equipment is not marked to denote the presence of a hazard.

Response to the incident was well handled. However, the AEA's reticence to using the on-board first-aid kit highlights the importance of empowering personnel to use emergency systems, and the dangers of perceived logistic issues driving safety decisions.

Beyond the SSL, there are other on-board hazards to crew performing manual handling tasks. Managers and commanders should continually assess whether these hazards are being reduced SFARP, IAW their responsibilities, including those defined by Australian WHS law.



By WOFF Norm Stringfellow

n 12 September 2017 at approximately 1020 hrs, the crew of a CT-4B operating in the East Sale training area, experienced a loss of oil pressure while conducting aerobatics. The aircraft captain (AC) carried out the emergency checklist actions for loss of oil pressure and subsequently tracked to West Sale for a precautionary landing.

During the approach the low-volt light illuminated and mild but continuous rough running was experienced, worsening slightly prior to landing. The aircraft landed and shut down and it was noted that there was a large amount of oil present on the underside of the aircraft. The time from the initial oil pressure loss indication to shut down was approximately five minutes. Initial maintenance investigation findings have discovered a failure of the oil pump drive gear coupled with a bent alternator drive shaft.

History of the incident flight

The incident flight was a Flying Instructor Course (FIC) 37 Re-Demonstration and Re-Direct Mutual flight comprising of practice instructional sequences followed by General Flying (GF) sequences including aerobatics. The instructional sequences had been completed and aerobatics were being flown by the AC at about 5000 ft AMSL when the incident occurred.

On the pull out of the Cuban 8, the AC noticed the RPM increase at a higher than normal rate and selected the throttle to idle to prevent an RPM overswing. The aircraft was exited to straight and level at about 4000 ft AMSL at 140 KIAS.

The AC completed the boldface checklist actions for loss of oil pressure, including setting a lower power to keep the propeller RPM out of the governed range. At this power setting the aircraft maintained 300 to 500 ft rate of descent. The AC turned the aircraft toward West Sale for a Precautionary Forced Landing (PFL).

The abnormal engine note continued and worsened slightly on final. The aircraft touched down at the 1000 ft markers and taxied a short distance to the parking apron before shutting down. The low-oil light, zero-oil-pressure

About 40 minutes into the flight, at 1020 hrs, during the inverted phase of a Cuban 8 aerobatic manoeuvre, the lowoil-pressure light illuminated, and oil pressure indicated zero.

At approximately 1022, the low-volts light illuminated and the engine note changed to indicate mild but continuous rough running. A PAN was declared to ATC on Sale delivery frequency; ATC approval was given for a re-join via high key at West Sale. At about 2 nm WNW of West Sale, the AC decided to conduct a straight-in glide approach to Runway 09 commensurate with the surface winds.

reading, low-volts light and abnormal engine note continued until shut down.

Aircrew

The AC was a trainee QFI on Flying Instructor Course at CFS. The AC held a current aircrew medical, had a total of 850 flying hours (including simulator). This includes 182 flying hours in the CT4B.

The co-pilot (CP) was a trainee QFI on Flying Instructor Course at CFS, held a current aircrew medical and had a total of 784 flying hours (including simulator). This also includes 179 flying hours in the CT-4B.

In the 72 hours before the incident neither pilot reported any activity that would have impacted on their ability to perform flying duties.

Damage to the aircraft

The engine fitted to the CT-4B suffered a failure of the starter-motor clutch spring, which was found to be fractured. This ultimately led to a failure of the oil pump and alternator. The cause of the oil pump failure was determined to be FOD small enough to be picked up from the engine oil sump through the oil strainer pickup, yet large enough to jam the impellers of the oil pump.

The damaged tail of the starterclutch spring was found in the engine sump during engine teardown, along with other small metallic particles.

The starter-clutch spring and oil pump drive gear were analysed by a metallurgist company contracted by BAE Systems, the conclusion being that the starter-clutch spring failure was resultant from "very high cycle fatigue that had initiated at the site of machining-related smearing and gouging at the smallest cross sectional area within the retainer screw cut-out".

The source of the FOD that jammed the oil pump impellers originated from the failed starter-motor spring clutch. From the visual inspection during teardown of the engine it appears that the separated tail from the failed starter-motor clutch spring, had travelled around inside the crankcase gear train.

During this time some smaller pieces appear to have broken away and subsequently picked up at the oil pump inlet strainer assembly. It was determined that the fracture of the oilpump drive gear was by overload in a single event, and was a consequence of the FOD entering the oil-pump impellor mesh and seizing the impellors.

The first sequence of approximately 40 minutes of the incident flight was conducted without incident. The second general flying sequence included some aerobatic practice.

During the aerobatic portion of the flight the aircraft was in the inverted phase of a Cuban 8 manoeuvre when the low-oil-pressure light illuminated. The aircraft captain exited the Cuban 8 into straight and level flight.

The aircraft captain selected the throttle to idle, and states he heard the engine spool up but there was no propeller RPM over-swing. The aircrew both stated that there was an engine change in tone heard. After about 30 seconds to one minute, both crew expected the oil pressure to recover as the aircraft was now in a straight and level flight configuration. The oil pressure did not recover as expected, so the crew conducted the loss-of-oilpressure boldface actions.

After approximately two minutes from the loss-of-oil-pressure indication, the crew noticed that the low-voltage light was now on and the gauge indicating zero volts coupled with the ammeter also showing zero charge. This indicated an alternator failure. The crew also noted that the engine tone changed again and indicated mild but continuous rough running.

The crew declared a PAN to ATC and elected to head for West Sale for a precautionary forced landing (PFL). The engine tone continued and worsened slightly on final approach. The aircraft landed and taxied a short distance to the West Sale parking apron for shutdown.

The low-oil-pressure light, zero oil pressure, low-volts light and abnormal engine tone continued until shutdown. The engine-shutdown sequence appeared to be a standard, normal engine shutdown; that is, the engine did not wind down faster than normal.

Of note in this incident – from the initial oil-pressure light illuminating until the normal engine-shutdown sequence was completed – the engine was without engine oil pressure for approximately four-and-a-half minutes. The CT4B Operating Manual includes a warning that states: "Experience has shown that after a total loss of oil pressure, mechanical failure can occur within five minutes."

CT-4B oil system – basic

The Continental engine fitted to the CT-4B has a wet-sump oil system with a sump capacity of 10 quarts, which is attached to the bottom of the crankcase. The oil system incorporates a low-oil-pressure warning light mounted on the centre instrument panel, illuminating when the oil pressure falls below five psi.

The engine is lubricated by a forced feed system. The oil pump picks up oil from the sump, and under suction draws oil through the pressure oil screen, the oil filter, the engine oil galleries, oil cooler and bearings. Oil is gravity fed back to the sump through drain holes. A pressure relief valve in the crankcase cover regulates the pressure in the main oil galleries. Excess incoming oil is returned to the sump.

CT-4B oil system – aerobatic

The Aerobatic Oil System consists of a Christen oil separator, adapted Christen G-sensitive oil valve, sump baffle and interconnecting plumbing. It provides engine lubrication, with minimal oil loss during aerobatic flight. The Aerobatic Oil System is a selfcontained extension of the standard engine oil and breather system.

As the system control valves are gravity operated, no electrical power is required. The system functions in all inverted and negative-G manoeuvres with possible limitation in vertical and diving flight attitudes. The aircraft may be flown inverted for as long as oil and fuel pressures are maintained. All components are located on the engine to optimise the aerobatic flight envelope.

The *CT4B Operating Manual* includes a caution within the Aerobatic Oil System description regarding inverted flight or practice spins. This caution states that these manoeuvres must be discontinued when the oil-pressure light illuminates.

The operating manual also includes a note that states: "During aerobatic flight, the oil may become aerated. It is not uncommon for the oil pressure to subsequently drop to below 30 psi. Oil pressure may take up to three minutes to recover.".

Oil pump reliability

The oil pump used in the Continental Engine fitted to the CT-4B has proven to be a very reliable component having more than 300,000 hours of engine operations by BAE Systems. There have only been three oil-pump failures recorded, with the previous failure occurring greater than 150,000 hours before this incident.

Safety action

Initially BAE recommended that all CT-4B aircraft cease flying until a determination was made into the cause of the failed oil pump. Additionally, BAE Systems halted all CT-4B flying operations with their other contracts until an engineering assessment was completed.

Based on initial investigation findings and the oil pump reliability, BAE released all CT-4B aircraft as serviceable for flight on the 18 September 2017.



Failed oil pump drive gear and drive key.



Bent alternator drive shaft with drive gear removed.

A BAE Systems Safety Risk Assessment dated 15 September 2017 was conducted as a result of this incident with the determination that the risk of further oil pump failure for the CT-4B fleet was assessed as low.

Conclusion

The initial failure of the starter clutch spring led to the failure of the oil pump. This is the second occurrence for this item (starter-motor clutch spring) to fail over the life of the CT-4B, and only the third oil pump failure in more than 300,000 hours of engine operations by BAE Systems.

The AIIT determined that the crew actions were correct, timely and appropriate in the situation that developed during this sortie. Crew members' prompt actions recovered the aircraft safely into West Sale. The engine has been replaced on this aircraft and flying has resumed for the CT-4B fleet with no further fleet-wide implications.

ARH cowl failure

he aircraft was conducting a continuation sortie in the vicinity of Mount Bundey Mine/Finniss tactical flying area and upon return from the sortie, the Forward Arming and **Refuelling Point team member** receipting the aircraft advised the aircrew that a panel was open. Following aircraft shutdown, the upper fixed cowl right-hand access door was found to have separated along the top side of the upper fixed cowl. The access door was held in place by 30 mm of remaining structure, the extended folding stay and the rear latch.

Following the discovery of the damage, power was removed from the aircraft and it was placed in quarantine, with the damaged area photographed. The remainder of the regiment's flying program was cancelled. Of note was that both the front-and rear-door locks were in the closed position and that the remaining structure, folding stay and rear lock, were retaining the door to the aircraft.

Analysis

Aircraft maintenance documentation, as recorded in CAMM2 was reviewed by the investigation to determine if there were any technical aspects that contributed to this event. Key points to note from this review are listed below.

- There were no outstanding maintenance issues in the maintenance log.
- There are no recorded contributory deferred defects identified.
- The aircraft was released as serviceable for the event sortie.

Investigation

At the start of investigation it was ascertained that all recommendations from a previous investigation into the upper fixed cowl access-door failure on another aircraft had been accepted and implemented.

Inspection

The aircraft sustained damage to the upper fixed cowl and the righthand access door. The upper fixed cowl and right-hand access door were sent to Defence Science and Technology Group (DSTG) for forensic investigation by the Forensic Engineering and Accident Investigation Department.

The cowling composite structure initially fractured from the forward edge adjacent to the right-hand access door forward hinge, before fracturing to aft of the rear hinge. The folding stay and the rear latch prevented the complete departure of the door from the aircraft.

The inner fire panel was observed to be in the open position, with the fire panel retaining tab in the unlocked



The upper fixed cowling and right-hand access door damage.

position, contrary to the correct stowed position for flight.

With the fire panel in the upper position, the inner door spring-loaded rigid stop was in the outwards positon.

The investigation noted that both the front and rear door locks were in the closed position. Of the forward lock's four retaining rivets, one was missing the rivet head and another was loose, allowing slight movement in the lock.

There was minor surface rubbing and wear between the inner surface of the right-hand access door and the outer surface of the upper fixed cowl; however, on fleet inspection, the wear evident on the aircraft was no more noticeable than on other aircraft. The front and rear locks, including the lock arms and mechanical stop were inspected for damage, with none evident.

Failure mode

Paint transfer was identified between the rigid stop and the lower edge of the access door, indicating pressure had been exerted on the access door by the rigid stop.

Red dust from flight operations was also present in the area under the upper fixed cowl, with increased dust in the vicinity of the right-hand access door and, importantly, in the area under the internal fire panel, indicating the panel was in the upper position for a period of flight operations.

The investigation team and DSTG were unable to conclusively determine if the internal fire panel was left in the open position before the incident flight, or if the damage had occurred on a previous instance of the panel being left in the upper position. While it is possible the aerodynamic forces could move the panel into the open position if the retaining tab was left in the unlocked position, it is very likely that the panel was left in the open position.

The damage to the forward lock rivets is very likely to be due to the pressure exerted on the access door by the rigid stop. Once the door lock rivets failed, movement could occur within the lock, and this allowed the access door to move beyond serviceable limits.

It is highly likely that the cracking in the composite structure started due to vibration within the access door, attributed to movement within the forward lock following the above mentioned damage. It cannot be determined at which phase of the flight the upper fixed cowl fractured. If the door had been lost due to excessive aerodynamic loads, it is possible that damage to the main or tail rotor could have eventuated.

Maintenance

The final maintenance action carried out in the vicinity of the upper fixed cowl right-hand access panel was the before-flight servicing. The signing tradesman followed the correct servicing schedule; however, it is highly likely that on this occasion (or a previous action where the area was accessed) an action error was made and the internal fire panel was left in the upper position, subsequently leaving the inner door spring-loaded rigid stop in the outwards position.

Inspection of other aircraft in the fleet showed typical wear to the rigid stop and corresponding wear to the underside of the access door (where the door had been closed with the rigid stop in the outwards position). The level of paint transfer witnessed on the event aircraft was significantly greater than that on other aircraft. The signing tradesman, and other tradespersons believed that it was not possible to close the access door with the rigid stop in the outwards position.

In order to ensure an enduring resolution, ARH Structures Engineering Team was tasked to include wording in the BF servicing to ensure this misunderstanding is clarified, with a note to confirm the rigid stop is not in the outwards position on closing of the access doors. Once implemented, ab-initio trainees will be taught the new procedure, and current tradesman will be educated on the change, eliminating the misunderstanding.

Serviceability

A Special Technical Instruction (STI) STI-ARH-243-Inspection of Upper Fixed Cowling Access Door Locks) was released on 1 March 2017 to all ARH Approved Maintenance Organisations (AMOs) to inspect the access door locks; paying particular attention to the dimensions of the lock hex head screw and the adjacent lock stop (mechanical stop) for wear. This STI gave a non-enduring indication of the serviceability of the fleet.

Analysis by the investigation team and DSTG showed that the serviceability of the upper fixed cowl access door locks is the primary factor that leads to a failure of the cowl. While the mode of unserviceability

can alter, it is highly probable that a serviceable lock and hinge will secure the door and mitigate catastrophic failure of the upper fixed cowl due to aerodynamic forces.

In order to determine the likelihood of failure following the event, STI-ARH-272 was released on 30 August 2018. The STI directs the inspection of upper fixed cowling access door locks and lock stops for correctly operating and adjusted locks with the aim of determining fleet serviceability.

Results from STI-ARH-272 gave a non-enduring indication of the serviceability of the door locks and lock stops at the time of inspection. it did not give an indication of the rate at which upper fixed cowl access door lock and lock stops become unserviceable.

The before-flight and after-flight servicing in the flight-servicing schedule includes inspections to the upper fixed cowl for damage, paying particular attention to the access door hinges for cracks.

At the time of the upper fixed cowl access-door failure, servicing actions only assessed for existing damage to the hinge, locks and lock stops. Analysis shows that an unserviceable lock or lock stop, while displaying no signs of damage, can enable movement in the access door and subsequently lead to failure and separation of the upper fixed cowl.

In order to ascertain the rate at which upper fixed cowl access door lock and lock stops become unserviceable, an enduring regime is required.

STI-ARH-273 Recurring Inspection of Upper Fixed Cowling Access Doors was released on 7 September 2018 to determine the development rate of unserviceability in upper fixed cowl access door locks and lock stops.

Following results from STI-ARH-273 and assessment by the ARH Structures Engineering Team, an



Diagram of the upper fixed cowling right-hand access door and associated hardware.

amendment to the servicing schedule will enable an enduring serviceability check for locks and lock stops.

The investigation determined that the gap surrounding the upper fixed cowl access door does not have a serviceability criteria, and analysis by the investigation team and DSTG indicates that the gap measurement could have an impact on the likelihood of access-door damage following a door lock or lock stop becoming unserviceable.

Aerodynamics

Analysis of the damage demonstrates that the unserviceability of the locks or lock stops is a necessary factor in upper fixed cowl failure. In order for the unserviceability to progress to a failure and separation, aerodynamic forces must be present. The extent of these forces is not fully understood, nor is the relationship between the aerodynamic forces and the gap measurement in a failure.

Army Aviation Test and Evaluation Section was tasked with conducting an aerodynamic assessment of the upper fixed cowl region of the ARH in order

to better understand the aerodynamic loads the access door is subject to. This information should be assessed to determine the viability of any engineering design changes that could be applied to the upper fixed cowl or access doors to further mitigate against catastrophic failure.

Conclusion

The investigation identified several factors that directly contributed to the failure of the upper fixed cowl and there are a number of contributing factors that could lead to further aviation safety occurrences.

Key contributing factors

The incorrect configuration of the internal fire panel – left in the open position due to an error – which resulted in the rigid stop being in the outwards position. This placed pressure on the lower part of the upper fixed cowl right-hand access door and resulted in the failure of the forward lock rivets, allowing movement in the lock. The loose forward lock on the right-hand access door of the upper fixed cowl was the initiator

of vibrations within the door during flight. This caused stresses to the forward hinge that reached a critical point resulting in commencement of cracking around the hinge structure. Subsequent aerodynamic forces (able to now ingress the door) caused the almost total fracture of the upper fixed cowl composite structure above the right-hand access door hinges.

Additional contributing factors

At the time of the event, the flight servicing and data module did not contain the necessary notes and warnings to identify if the rigid stop was left in the outwards position, applying pressure to the access door.

Reaction by Director Aviation Support

Immediately following the damage to the aircraft, the Director Aviation Support and the appropriate agencies began a methodical and appropriate course of action, in parallel to the safety investigation, to ensure the ARH capability could continue to be operated with risk managed within current risk management policy.

AVIATION SAFETY SPOTLIGHT



Amberley fuel spill

By WO Stuart Walters

n 21 February 2018, a C-17 Globemaster was being defueled by a tanker vehicle when, during the defuel, about 2100 litres of aviation fuel overflowed from the tanker, spilling onto the northern apron.

The fuel spill was contained and noone was injured; however, approximately 50 people were exposed to fuel vapour. There was no damage to aircraft, ground support equipment, or the environment as a result of the spill.

The incident

A scheduled C-17 defuel was being conducted by a tanker vehicle on the northern apron. The tanker had successfully completed its first defuel of the F34 Aviation Turbine Fuel (AVTUR) and returned to collect the remaining fuel.

Monitoring the defuel operation from the tanker's control panel (located centrally on the vehicle's right side) was the tanker operator, and a C-17 maintenance tradesperson, assisting the procedure, was located at the aircraft.

The tanker pumped fuel into compartment 1 until it indicated approximately 7000 litres on the bulk meter. At this point, the tanker operator opened compartment 2 and closed compartment 1. The defuel operation continued until the tanker operator noticed the control panel displaying the over-fill warning light for compartment 4.

Checking the bulk meter, the tanker operator noted it indicated 11,500 litres. Yet, in order to have filled compartment 2, the bulk-meter reading would need to be approximately 14,000 litres. The tanker operator checked compartment 4's volume meter, which was fluctuating between 8000 and 9000 litres.

The tanker operator released his dead-man switch, thereby shutting off tanker 1's pump. However, the aircraft's on-board pumps were also driving fuel transfer. In order to stop the transfer completely, the tanker operator signalled the tradesperson to shut down the aircraft pumps.

Moving to the rear of the tanker, the tanker operator noticed AVTUR flowing from the vapour-recovery system outlet (on the vehicle's left side) and the top tank overflow outlets (at the lower-rear of the vehicle).

The tanker operator returned to the control panel, where he tried to stop the fuel spill by closing compartment 2 and the vapour vent recovery outlet. He then moved to the rear-left of the tanker to see if the spill had ceased and to retrieve the on-board spill kit. The tanker operator saw that AVTUR was continuing to flow from the vapour vent recovery outlet and top tank overflow outlets. The tanker operator moved back to the control panel and switched the system from defuel to refuel mode. He then opened all compartment refuel foot valves in order to equalise AVTUR levels across the tanker compartments. The tanker operator then turned the tanker off using the keyed ignition and began the spill-containment process.

Discovery and initial actions

A maintenance manager, located in the flight-line office, saw fuel flowing from the tanker vapour recovery system and immediately contacted the fire section and informed them of the situation. Members of the squadron proceeded to the aircraft to assist in containing the spill. The group of approximately 10 personnel brought 400-litre spill kits from the flightline, as well as the spill-response trailer.

The tanker operator radioed the Aviation Fuels Section (AVFUELS) dispatcher to report a large fuel spill and request the spill response trailer. The AVFUELS dispatcher called the fire section and notified the officer-incommand of Road Movements Section (RMS). Attempts were also made to contact the base Fuel Quality Control Manager and the base Fuel Quality Control Officer; however, both were unable to be reached.

Containment

The fire section personnel responded immediately to the initial notification of the fuel spill and fire crews were at the incident scene within four minutes. They positioned two fire trucks upwind on the left side of the aircraft. The two fire trucks were equipped with foam extinguishing agent, but were not fitted with gas monitoring equipment. The Airfield Fire Controller (AFC) conducted an assessment and instructed crews to deploy hoses for fire-guard operations in case the spilt fuel ignited.

Absorbent materials (soaker pads and Sphag Sorb2) from the spill-kits were placed on top and around the edges of the spill. However, the soaker



pads were ineffective as they were too light and moved in the prevailing wind.

The AFC contacted the Air Base Command Post (ABCP), to report the fuel spill and requested the Base Aviation Safety Officer (BASO) and Regional Environmental Safety Officer (RESO) be advised of the situation. The AFC also requested the ABCP source additional spill kits and absorbent material from other units, to assist in containment. The ABCP co-ordinated the delivery of a small quantity of absorbent material and additional spill kits.

At the incident site, additional AVFUELS personnel arrived to assist the tanker operator. These personnel brought PPE with them; however, the respiratory equipment had passed its expiry date. A decision was made to wear the respirators as it was deemed better than not wearing them.

The fuel spill spread across the apron, moving towards the drains but was stopped before reaching them, which resulted in pooling beneath the aircraft (between the main and nose

landing gear). Due to the containment material, fuel pooled to a height of about 20 mm.

Aircraft were removed from the vicinity of the spill and the tanker returned to AVFUELS where it was quarantined.

The northern apron has a built-in fuel-containment system but it was not utilised to remove and contain the fuel spill.

Clean up

The clean-up was prolonged due to deficiencies in available spill kits and additional absorbent material. As there was not enough absorbent material, personnel confirmed the availability of sand from a local hardware store; however, it was not purchased due to the timeframe.

Squadron personnel absorbed the remaining fuel with soaker pads and placed the contaminated material in drums for disposal. An airfield sweeper attended the site to pick up any residual absorbent material. Fire crews packed up all firefighting



equipment and returned to fire section.

Over-fill protection

Protection against compartment over-filling is achieved via the installation of optical probes into the top of each compartment. The probes are installed at the Safe Fill Level (SFL) of each compartment. There are two independent, over-fill protection systems on the high capacity tanker (HCT).

The first is vehicle-based and is the primary over-fill protection system. The primary probe is linked to the HCT's programmable logic controller. Gantry, the secondary over-fill

protection system uses a different probe. The gantry system is not used on ADF HCTs as Defence Fuel Installations (DFIs) are not currently configured for its use.

In the event of a primary probe sensing the presence of fuel at the probe-tip (SFL), a red over-fill light illuminates on the control panel. This notifies the operator of a potential compartment over-fill condition. Additionally, the probe sends an electrical signal, which is converted into a pneumatic input to the associated foot valve, causing it to close. Filling of compartments that have not reached the SFL can continue. The HCT over-fill protection system varies from the equivalent commercial vehicles.

Operators do not rely on over-fill warnings to prompt them to change compartments. This is stipulated in the Aviation Defueling Procedures BLI. Instead, operators are required to switch compartments when both of the following criteria are met:

The Bulk Meter reading is:

- 7000 litres (if it is the first compartment being loaded)
- 14,000 litres (for the second compartment loaded)
- 21,000 litres (for the third compartment loaded)
- 28,000 litres (for the fourth compartment loaded)

• The current compartment's volume meter reading is 7000 litres.

Maintenance issue

Six days before the incident, AVFUELS submitted a maintenance request form reporting that the tanker compartment 3 over-fill probe was incorrectly indicating an over-full compartment.

The tanker was removed from service and transferred to maintenance for rectification. Maintenance performed fault finding to determine the electrical continuity of the

AVIATION SAFETY SPOTLIGHT

probe. During this process, the primary and secondary over-fill protection systems were disconnected. Eventually it was determined that the primary probe was unserviceable.

Maintenance did not have a spare probe in stock. As an interim-measure they removed the gantry probe, and fitted it to the primary probe position and the vehicle was returned to service.

After the incident, a rectification report stated that the compartment 3 probe (gantry in primary position) was found to be unserviceable. The probe was replaced, after which the system tested serviceable.

Disconnected plug

A disconnected plug was discovered on compartment 3 during the incident. The investigation analysed information from the vehicle maintenance manual and photos of the electrical plug. The plug for the primary over-fill probe and the secondary probe are identical. It was determined that the disconnected plug was probably that of the primary over-fill probe on compartment 3.

As compartment 4 had unexpectedly filled with fuel during the incident, the compartment 4 foot valve was suspected of being faulty. A field test of the valve confirmed that it was stuck in the open position. The tanker had last been used during the first defuel of the aircraft.

During transfer of fuel from the HCT to the DFI, the operator opens the foot valves using the compartment out buttons. This action opens the foot valve of each compartment in turn, to allow fuel transfer to the DFI.

On completion of the transfer of each compartment, the operator pulls out the compartment out button to close the valve. It is probable that on the incident day, the compartment 4 outlet foot valve became stuck in the open position during the download of compartment 4 to the DFI, immediately before the incident defuel sequence.

The valve was removed and forwarded to the OEM for further investigation. OEM inspection and production testing revealed that the incident foot valve was good and functioning.

Although initial investigation found the compartment 4 outlet foot valve to be stuck in the open position, OEM found the same valve to be serviceable. The most likely explanation is that the valve had an intermittent fault, which had been detected in similar occurrences.



Consequence of stuck foot valve

During a normal defuel process, fuel will flow into the selected compartments via the defuel manifold to the inlet foot valves. When the compartment 4 foot valve failed in the open position, fuel was able to enter compartment 4 via the refuel manifold without going through the bulk meter.

This meant the tanker operator could not have known about the abnormal operation unless he had toggled through the control panel display to the compartment 4 volume meter. Instead, the tanker operator became aware of a problem when the compartment 4 over-fill warning light illuminated. The tanker over-fill protection system varies from equivalent commercial vehicles, in that the commercial vehicles have two vehicle-based overfill protection systems. The secondary on-board overfill protection system is a secondary control that senses a higher level than the SFL in each compartment. This aids the operator in preventing fuel compartment over fills above SFL. This option was not included in the HCT specification.

Method of stopping fuel spill caused by faulty foot valve

Standard response during emergency situations in general, is to activate the emergency stop button. Activation of the emergency stop button shuts down the tanker's on-board fuel pump. During the incident, had the tanker operator activated the emergency stop button, it would not have altered the situation as the tanker's fuel pump was already off. To stop the fuel spill after pump shutoff, the tanker operator switched the system from defuel to refuel mode and opened all outlet foot valves in order to equalise fuel across all compartments. While this is not a published response, it had the desired effect of stopping the fuel spill.

Conclusion

The spill of approximately 2100 litres of AVTUR during a C-17 defuel was most likely the result of a stuck foot valve in compartment 4 of the high-capacity tanker. A portion of incoming fuel bypassed the vehicle's bulk meter and entered compartment 4 without the knowledge of the tanker operator. This highlights failure pathways that may not have been considered during the acquisition of the tanker.

The spill clean-up was hampered in three key areas:

- The immediate responders were not aware drains on the northern apron were part of the built-in fuel containment system. Rather than use this purposebuilt system, personnel actively restricted the fuel from entering the containment system.
- The responders used all of the spill material from Aviation Fuel and Fire Sections and the squadron. The Air Base Command Post sourced extra spill kits from the base units; however, there was insufficient material base-wide.
- Conflicting reports of the severity of the spill, and a lack of guidance at the Air Base Command Post meant that communication flow through the chain of command was poor. The Emergency Operations Centre was not activated and critical personnel, such as the Base Aviation Safety Officer was not aware of the incident until 73 minutes later and Regional Environmental Safety Officer 118 minutes later.

During the course of the investigation, a number of deficiencies related to the incident were identified. They include:

- Refueller training does not adequately cover emergency response and Air Force does not have an approved learning management plan.
- Fuel spill categories are complicated and do not describe fuel spills in terms of safety risk. This is potentially confusing for inexperienced personnel and makes it difficult to appropriately categorise fuel spills.
- The base emergency management plan was not well communicated to base users, which led to a lack of compliance.

By MAJ Dave Wade

Tear down

he unmanned ScanEagle was launched from the Beecroft Weapons Range Operating Area when it lost altitude and crashed. likely due to an air navigation (pitot static) system fault. The Remotely Piloted Aircraft (RPA) was located by air asset about 300 m from the launch site and subsequently recovered.

Telemetry

The telemetry was analysed, and a number of key points identified.

As it departed the launcher, the pressure altitude rapidly increased to approximately 6000 ft, while GPS altitude indicated the true altitude of approximately 60 ft. The aircraft automatically turned to the right and reduced throttle setting to achieve 1000 ft pressure altitude, resulting in a ground impact.

The engine remained running throughout the sequence; however, the throttle was automatically reduced.

During the pre-flight checks, a FLT: AC alt lower than GPS Altitude caution (amber message with no audio warning) was present on the screen for approximately eight minutes during the pitot static system check.

Following the pitot static system check completion, the caution selfextinguished. The FLT: AC alt lower than GPS altitude caution (amber) has no aural warning. If the discrepancy is larger the caution becomes a warning (red) and an aural warning is also provided. The selection of aural warnings for cautions and warnings is operator selectable.

The aircraft was torn down in a controlled environment at the squadron by an OEM representative and a squadron maintainer. Fuel samples were taken from both the main fuel tank as well as the refueller equipment. A clear-and-bright test was conducted with nil discrepancies identified. The fuel samples are guarantined and stored at the squadron until the OEM has finalised their report.

The following keys points from the tear down were identified:

- the propeller (spinner) turned freely and compression was felt in the engine
- both the main and header fuel tanks contained sufficient fuel
- there was no evidence of any pre-accident damage to control or aerodynamic surfaces
- identified no physical abnormalities
- the static holes were all clear
- the pitot was found to be blocked with organic matter, which was assessed to be from the impact with the ground.

Operation

During the conduct of the pre-flight checks, the operator was tasked to assist with VHF radio faults. This had the operator away from the screen a number of times during the conduct of pre-flight checks. The operator did not follow the pre-flight checklist in the usual sequence, due to the requirement to stop for VHF checks and the requirement to hand over to the FSR for engine temp checks.

The exercise had two ScanEagles airborne concurrently, which was not the usual operational model. There were two concurrent operations being conducted from a single Connex container.

inspection of the pitot static system

Important findings

The container has two operator consoles divided by the computer systems that run the ScanEagle and mission programs. There were up to seven personnel within the container at any time, either operating or observing and two personnel at the launcher one being in radio comms with the operators.

The exercise was the final activity for the year, with a submarine on task, and was perceived by the team to be a critical task to be achieved. For the three-and-a-half weeks prior to this activity all members were on [Exercise] Autonomous Warrior at Jervis Bay – a period when no simulator or live flying was conducted.

Servicina

Servicing requirements were all up to date and fuel mixtures in use were correct and within use by dates.

Altitude mismatch: The pressure altitude rapidly climbed to approximately 6000 ft while the true (GPS) altitude was approximately 60 ft. This caused the aircraft to automatically reduce its altitude to reach a pressure altitude of 1000 ft, resulting in ground impact. This was determined from the telemetry data and physical tear down. Inspection of the pitot static system during tear down identified no physical abnormalities. The system has been sent to the OEM for further analysis.

Missed caution: During the pre-flight checks, a FLT: AC alt lower than GPS altitude caution (amber message with no audio warning) was present on the screen for approximately eight minutes during the pitot static system check. This caution went unnoticed by all personnel in the connex.

Article sourced from the ASR investigation

Black Hawk main landing gear explosive failure in C-17 cargo bay

By MAJ Darryl Burley

n 18 April 2015, 6 Avn Regt completed a successful strategic lift of a Black Hawk aircraft to RAAF Richmond using a RAAF C-17. During the unloading process, the maintenance crew raised and lowered the Black Hawk Main Landing Gear (MLG) struts to enable suitable clearance for movement inside the C-17. This was completed using a Hydraulic Kneeling Rig (HKR) to generate the required hydraulic pressure.

The left-hand (LH) MLG strut was successfully raised to full extension without incident. Maintenance instructions specified struts to be raised using controlled and momentary one- to two-second actuations of the HKR until full extension was achieved. At full extension, there were no physical or documented indicators to confirm limit reached; instead, common practice was to identify a pitch change in the sound of the HKR hydraulic pump, indicating increased load. This would be considered difficult to hear when conducting the task on a fully functioning airfield.

During extension of the right-hand strut, no pitch change was identified and during the final one- to two-second actuation, the lower stage of the strut separated with such force that the aircraft was propelled upwards with the upper stage of the strut coming to rest facing rearward on the lower stage.

The HKR was immediately shut down and an additional aircraft jack applied to stabilise the aircraft and prevent further movement – reducing the likelihood of the Black Hawk to collapse onto its right-hand side and potentially damage the C-17.

The failure caused a significant volume of hydraulic fluid to be expelled under pressure inside the C-17; spraying the Black Hawk and members of the maintenance team. This was subsequently documented in accordance with WHS policy. Fortunately, there were no injuries sustained and the C-17 was not damaged.





Upper and lower strut sections post separation.



Hydraulic kneeling rig

The HKR is used to provide hydraulic pressure to operate the aircraft landing gear struts during either maintenance or operation without aircraft hydraulic power available. The HKR provides significant hydraulic force, approximately 3000 psi, to pressurise the landing gear struts in order to raise or lower the aircraft. This capability has enabled strategic lift of Black Hawk inside C-130 Hercules and C-17 transport aircraft.

The HKR was introduced into ADF maintenance service in 2013 as a replacement for the obsolete previous model. The procurement process identified that the replacement HKR was in service with US military and compatible with multiple aircraft types including Black Hawk variants. This feature provided confidence in the OTS requirement to demonstrate the ability to interface with Army aircraft with minimal modification or adaptation.

Throughout the procurement process, the focus was on identifying an option that could do the job straight off the shelf rather than determining any potential hazards and likely procedural considerations for use on ADF S-70A-9 Black Hawk aircraft specifically.

Testing and evaluation

After the failed maintenance operation in 2015, Army Aviation Systems Program Office (AASPO) suspended aircraft kneeling, including use of the HKR, and launched an immediate investigation into the incident. This failure was the first known of its type within the ADF fleet and believed to be the first occurrence in the world's Black Hawk fleet.

The investigation team initially conducted a desk-top audit of all maintenance and operating procedures, considering detailed accounts of those involved in the incident. The purpose was to identify any process errors or ambiguities that may have contributed to the

failure. The audit identified that confusion borne through disjointed and potentially ambiguous maintenance documentation was a likely contributor.

Subsequently, AASPO worked with the regiment's maintenance staff to conduct controlled loading activities using the HKR and an amended set of maintenance procedures. During the activity, it became clear that maintenance staff were not aware of all the required loading procedures contained in the maintenance manual.

One of the key likely contributors identified during the audit and subsequent trials was the failure to carry out the documented pre-use checks before commencing kneeling operations – attributed largely to disjointed procedures inside the Black Hawk Maintenance Manual.

AASPO staff requested the assistance of Defence Science and Technology Group (DSTG) scientists to carry out maintenance OT&E on the MLG struts to better identify and understand the actual mode and circumstances of failure.

DSTG conducted extensive testing on the Black Hawk MLG struts and the testing confirmed the method of failure and, equally as important, the pressure applied at the point of failure. Consequently, AASPO was able to establish never previously documented, specific operating limits to ensure continued safe operation.

The DSTG testing regime confirmed that failure of the MLG strut occurred at 3000 psi. DSTG replicated the unloaded aircraft (weight) conditions common during strategic lift operations. Further testing identified that with increased aircraft mass. Black Hawk struts could withstand increased pressure application; therefore confirming that safe maintenance kneeling practice should specifically consider aircraft load (weight) versus applied hydraulic pressure limits for kneeling application.

At the completion of the rigorous testing regime, revised Black Hawk/ HKR procedures were developed and successfully validated through testing as a result of direct collaboration between the operating unit and AASPO.

Findinas

The findings of the testing and investigation are outlined below.

- **1.** The presentation of kneeling operating procedures in the maintenance documentation was inadequate and disjointed. Processes were identified at two separate locations in the publications without any clear linkages identified, allowing for critical processes to be not followed.
- **2.** The OEM Maintenance and Operation documentation provided with the HKR did not include specific limits for Black Hawk maintenance operations. Further investigation confirmed that Sikorsky had not established any form of operating limitations for MLG strut pressurisation and as such there was no indication of pressure limits to be applied to MLG struts. DSTG testing confirmed failure consistently occurred at 3000 psi and subsequent testing identified that all replacement rigs in service were operating at pressures in excess of 4000 psi at the time of the failure, which meant they would have satisfied the pre-use pressure check but could still have led to failure.
- **3.** During Introduction-Into-Service (IIS), the initial operating procedures were developed entirely using the OEM operation and maintenance documentation without physical inspection of the unit or testing of its capability or functions. A lack of understanding or identification of operating limitations could reasonably be considered to have significantly limited suitability considerations.
- 4. No initial IIS testing was carried out by AASPO. However, a test plan was developed using OEM documentation and previous operational processes

and provided to regiment maintenance staff to carry out on behalf of AASPO. This plan was conceived with limited practical knowledge of the rig and its operational capability and consisted of a simple list of tasks/questions with a portion for answers to be submitted. This test plan did not clearly indicate the two separate areas of the *Black* Hawk Maintenance Manual which contained relevant processes and as such did not confirm suitability of preuse checks which included bleeding any air from hydraulic lines. It is highly likely, supported by investigation findings, that air was present in the lines attached to the aircraft during the failure incident and as a result would have introduced air into the struts.

- **5.** It was identified during the investigation that modifications were carried out to the rig during IIS testing and changes made to the operating procedures to make it work, but were not clearly communicated to SPO staff. In addition, failure to carry out the required pre-use checks during the testing due to maintenancemanual inadeguacies and test-plan failings, allowed modifications to be insufficiently confirmed and as a result provided clear opportunity for a failure to occur.
- 6. During the process of testing and confirming interim maintenance procedures and establishing operating limits, it became clear that certain legacy maintenance actions were not suitable for continued practice. An example of this was the established practice of de-activating the HKG pump only once a change in pitch noise was identified, which would traditionally indicate a strut has achieved full extension. It was identified that with the replacement HKR, no pitch change was evident, likely due to a higher performing with greater capability. As a result, it was identified that there were no other means of confirming maximum strut extension had been

achieved, which was identified as the



primary cause of this particular failure event. AASPO in conjunction with DSTG testing established and defined clear operational parameters to confirm maximum extension is achieved.

7. As part of the IIS of the replacement rig, there were several modifications and adjustments made to the rigs that were not adequately captured in maintenance or logistic documentation. Alternative battery packs were installed after being acquired by regiment staff and were not captured within maintenance documentation. Hose fittings were acquired by both AASPO and the regiment, which were not sufficiently captured in maintenance documentation, and the fitment of the hoses from legacy units, while directed by AASPO, were not suitably captured in maintenance documentation.

Lessons learnt

The following is a summary of lessons learnt from this incident and steps taken to ensure these issues are not encountered again with IIS of new or replacement equipment.

Funding constraints and priorities

While acknowledging funding limitations are in no way uncommon, not carrying out specific tasks to ensure safe operation and integration of equipment upon IIS on the basis of financial constraints is simply not appropriate. WHS obligations to ensure that equipment is introduced with suitable and safe operating parameters and procedures are paramount to the ongoing safety of personnel.

Lesson – The IIS of any new or replacement equipment must be planned and budgeted prior to the decision to purchase and must consider all IIS and confirmatory testing, including any travel associated with those tasks. Hazard assessment There were many statements made regarding WHS considerations and hazard identification throughout the supporting documentation and decision-making records. A key omission; however, was that there was no evidence of a specific hazard assessment having been conducted

at any time within the procurement or engineering processes.

It is essential that staff introducing equipment consider very clearly not just whether a replacement item fulfils the form, fit and function of the legacy item but whether it can potentially exceed them. In the case of the replacement kneeling rig, no clear consideration was given to what impact, if any, a replacement unit may have on components if its pressureproduction capability was in excess of the legacy unit.

The replacement rig met all previous form, fit and function requirements of the legacy rig and as such could carry out the required tasks with minimal adaptation. Additionally, it was noted that the fittings being supplied with the new unit would need to be adapted utilising the legacy unit hoses to ensure suitable connection to the aircraft struts. However, it was not considered during the IIS testing or subsequent operation, that this change did not allow the hoses to be connected to the rig for the purposes of bleeding prior to operation.

As a result, the full pre-use requirements were never appropriately met prior to the incident failure.

Lesson – IAW SSPP and CASG FG all logistic processes must include a specific System Safety Hazard Assessment to fully consider all possible impacts of the IIS of new equipment, for example, the full array of what, where, when, why and how questions must be asked and answered. System Safety Hazard Assessments must be conducted to identify and treat all potential failure modes. This must be done IOT establish a suitable and defensible SFARP position and must be completed in order to develop a suitable ILSP for any equipment being introduced into Defence.

Operation and loading procedures In order to ensure that equipment is able to be operated in a safe and controlled manner, suitable operating procedures must be provided and validated as part of declaration of compliance/design-approval processes prior to IIS. Staff carrying out the IIS must develop, document and validate all operating procedures and parameters during introduction and before service release.

All procedures must be clear and all references to subsequent procedures and applications must be clear and unambiguous. Additionally, consideration must be given to whether current procedures remain suitable and adequate. These designapproval and acceptance activities must be recorded and appropriately authorised within an approved EMS to ensure compliance with WHS Act requirements regardless of the source of the procedures or equipment. The organisation authorising the equipment for use in the ADF are accountable under the WHS Act.

Lesson – Legacy procedures may not necessarily be suitable for the operation of improved equipment and independent consideration must be given to developing adequate procedures upon introduction.

Staff should strive to identify any opportunity to improve current processes to ensure suitability with updated and often improved equipment. Documenting of this process and subsequent outcomes of that investigation must be carried out to ensure due process is followed. **Pre-introduction inspection** Staff carrying out the IIS activity were not resourced to inspect, verify and validate the functions and capabilities of the replacement HKR. The first unit was delivered directly to the operational unit and financial constraints prohibited SPO staff travelling to the unit for initial testing.

Visual inspection and operational testing provides a key opportunity for staff developing operating procedures to carry out initial testing independently to confirm functional and physical difference between legacy and replacement units. This informs further development and refinement of operational procedures and parameters prior to exposure of increased risk through operation on an aircraft.

Lesson – Initial visual and operational independent testing is fundamental to design and integration verification and is conducted to ensure that operational procedures and parameters are established and confirmed prior to connection to an aircraft thereby reducing potential risk to personnel and equipment.

Alternative testing plan AASPO Engineering Management System outlines a requirement for a test director to be a member awarded specific engineering authority by the chief engineer of the appropriate aircraft platform. This responsibility cannot be delegated to any member that does not have the requisite authorities afforded them. This ensures that staff developing the operational procedures and documentation for IIS of equipment are following the requirements of the specific safety management system under which the item is to be managed.

Ensuring the testing is conducted and controlled by the personnel developing the processes and procedures ensures that each step of each process is followed thereby ratifying the overall procedures and processes developed.

It also allows for adaptation by the developer of the procedures depending on feedback provided by operational staff and ensures accuracy and relevance of all processes developed through utilisation of relevant SMEs.

An abbreviated, short-answer test plan may significantly limit opportunity for adaptation and may not specifically confirm all aspects of the processes and procedures developed.

Lesson - Suitably qualified and authorised staff must conduct IIS testing and verification under the Management System facilitating IIS. Suitably authorised personnel provide a mechanism to ensure that sufficient testing is carried out to validate all processes developed.



Management Plan and ILSP Clear processes exist within the ADF and must be used to ensure that IIS is managed as a defined project to ensure appropriate staff with relevant experience in procurement and IIS control the introduction activity.

This will include engineering and hazard assessments and must be conducted under a methodical project management structure to ensure control and delivery of the required outcomes.

Conclusion

IIS of any equipment must be conducted as a deliberate planned activity to ensure delivery of equipment that is safe and fit or purpose. The required logistic and engineering processes were in place in the lead up to this occurrence. They must be followed in all instances regardless of whether items being procured are a novel system or simply an OTS replacement for an ageing obsolete system used for a long period of time.

Processes must be followed and appropriately recorded to ensure that any decisions are clear, justified, reasonable and defensible. In this instance, convergence of apparently benign factors contributed to significant damage, loss of capability and ultimately a lucky escape from a serious workplace accident.

SNAPS -

Everybody has an opinion and we want yours.

Your thoughts and opinions change the way your unit thinks about safety.







YOUR UNIT ... YOUR VOICE



29 APR TO 17 MAY 2019

For further information visit the DFSB website

2019 Courses

COURSE AIM: ASO (I) Aviation Safety Officer (Initial) Course

To graduate Unit ASOs. Maintenance ASOs and Flight Senior Maintenance Sailors.

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

COURSE AIM:

To graduate Base, Wing, Regiment, Fleet, Group and Command ASOs.

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

PREREQUISITES:

A solid background

in Crew/Maintenance

Resource Management

NTS Aviation Non-

Technical Skills

Trainer

ASO (A)

Aviation Safety

Course

Officer (Advanced)

COURSE AIM: To graduate students with the knowledge and skills to deliver nontechnical skills training.

AIIC Aviation Incident **Investigator Course**

and/or Human Factors. COURSE AIM: PREREQUISITES: To develop members Any personnel who are

with the skills to involved with Defence conduct aviation aviation. There is no incident-level restriction on rank. investigations in defence civilians and support of their ASOs. contractor staff are also welcome to attend.

DATES	LOCATION	
19 to 28 Feb	Nowra	
26 Mar to 04 Apr	Canberra	
30 Apr to 09 May	Canberra	
30 Jul to 08 Aug	Canberra	
18 to 22 Mar	Canberra	
20 to 24 May	Canberra	
TBA Jun-Jul	TBA	
TBA Sep-Oct	TBA	
27 Aug to 05 Sep	Canberra	
15 to 24 Oct	Canberra	
12 to 21 Nov	Canberra	
09 to 13 Sep	Canberra	
	DATES 19 to 28 Feb 26 Mar to 04 Apr 30 Apr to 09 May 30 Jul to 08 Aug 18 to 22 Mar 20 to 24 May TBA Jun-Jul TBA Sep-Oct 27 Aug to 05 Sep 15 to 24 Oct 12 to 21 Nov 09 to 13 Sep	DATESLOCATION19 to 28 FebNowra26 Mar to 04 AprCanberra30 Apr to 09 MayCanberra30 Jul to 08 AugCanberra30 Jul to 08 AugCanberra18 to 22 MarCanberra20 to 24 MayCanberraTBA Jun-JulTBATBA Sep-OctTBA27 Aug to 05 SepCanberra15 to 24 OctCanberra12 to 21 NovCanberra09 to 13 SepCanberra

Jodated 7 Feb 2019



COURSE DESCRIPTION:

The course provides theory and practical exercises in the broad topics of the Defence Aviation Safety Management System, risk management, human factors, the Defence Safety Analysis Model, safety event investigation and reporting.

COURSE DESCRIPTION:

The course provides theory and practical exercises in the broad topics of the Defence Aviation Safety Management System, human factors and risk management, and base/unit emergency response. Includes participation in a practical emergency response component.

COURSE DESCRIPTION:

The course provides the theoretical background of aviation nontechnical 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.

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 Defence Aviation Safety Analysis Model; aviation safety event investigation and reporting. Interested personnel should contact their ASO.

NOMINATIONS CLOSE
18 Jan
1 Mar
29 Mar
28 Jun
22 Feb
11 Apr
TBA
TBA
26 Jul
13 Sep
11 Oct
05 Aug

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: ASDC Aviation Safety, Aviation Branch, HQ FORCOMD.

For further details regarding the above courses visit the **DFSB Aviation Safety Assurance** and Training intranet site or email DFSB.setcourses@defence.gov.au



DECLARE ALL DANGEROUS GOODS





Always check with movements staff or flight crew

Failure to declare Dangerous Goods is an <u>offence</u> under the Defence Force Discipline Act











Dangerous goods are a risk to health, safety, property or the environment. These include obvious things, such as: explosives, radioactive materials, flammable liquids, dangerous or volatile chemicals, strong acids, compressed gases, poisons and aerosols. Everyday items that can cause problems include toiletries, aerosols, tools and lithium batteries. **REMEMBER – IF IN DOUBT, ASK!**