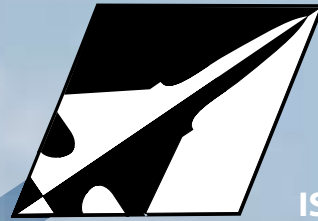




National
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Flight Comment



ISSUE 1, 2010



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Views on Flight Safety

Lieutenant-General André Deschamps, Chief of the Air Staff, Ottawa

As we look back at 2009, we can certainly take great pride that the Air Force has yet again demonstrated its effectiveness and the ability to deliver strategic to tactical effects both at home and abroad. Early in the year, we saw our Air Wing in Afghanistan reach full operating capacity with both the Chinook medium-to-heavy lift helicopters, Griffon helicopters and the Heron unmanned aerial vehicles. Additionally, the tempo in all areas has gone up given the need to support other domestic operations. Our fleets have faced various challenges, usually involving high demand for training and operations while dealing in some cases with low availability of assets.

As we begin 2010, we have already seen the continued demand for Air Force flexibility with OP HESTIA (support to Haiti) while maintaining support to all other operations. I am very proud of the men and women of the Air Force as you face each new task with professionalism and determination. However, this success was not achieved without some cost as we lost a Griffon and three personnel (2 Canadian Forces and one British Army personnel) last summer on operations in Afghanistan.

As we reflect on the challenges of conducting operations under the variety of demanding conditions we currently face (including a decreasing experience level in many occupations), we must keep in mind the importance of our flight safety program. We must guard against the notion that flight safety is only applicable for training and

domestic missions and that “combat flight safety” rules apply when on operations. To dispel any erroneous notions out there, only one system exists and is to be applied, and that is the current flight safety program practiced by all Air Force units.

Clearly, when involved in combat or high risk operations, or in situations that require some deviation from normally accepted and proven practices, it is expected that only those personnel with the appropriate training, accountabilities and authorities will make these decisions. Also, if actions occur that result in exceeding aircraft operating limits or deviating from flight regulations, then personnel are obligated to report these occurrences through their chain of command and the flight safety program to ensure that proper follow-up and lessons learned are conducted.

Our flight safety program was not designed with operational security issues in mind. This was initially a problem as crews were faced with reporting flight safety incidents which, due to the nature of the action or tactics involved, were classified in nature and could not be put into our current unclassified flight safety system. This problem has been addressed through reporting on the Air Force Command and Control Information System (AFCCIS). There also needs to be a realization that these operational security/classified concerns may also exist when training for deployed operations. Until we gain more experience in dealing with this new aspect of flight safety, I encourage Wings and Squadrons to

increase personnel’s awareness regarding the type of information that requires reporting through classified means. Bottom line, if you are in doubt, ask someone in your chain of command or flight safety network to assist.

There is also a potential misperception that that only Air Force personnel are required to comply with the flight safety program. This is incorrect. The flight safety program is a DND program mandated by the Minister of National Defence under the Aeronautics Act and applies to all personnel operating or mandated to support air operations and maintenance. This includes all Canadian Forces personnel, DND civilians and contractors (UAVs, SAR maintenance, etc) who are involved in flight operations.

Ultimately, flight safety is everyone’s business since its core purpose is to avoid the preventable loss of personnel and aircraft. I expect the leadership of the Air Force at all levels to set the example and ensure that those who operate or work around Canadian Forces aircraft understand the important role that they play in this key program.

As we continue with our high operational tempo and begin introducing new fleets in the coming months and years, I will depend upon the support and professionalism of all Air Force personnel to ensure that we continue to provide to the Canadian Forces and the Government of Canada the highly agile and effective airpower they have come to expect. ♦



Flight Comment

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Good Show

For Excellence in Flight Safety

Corporal Sean Finnegan

During the evening of 08 April 2009 at Tyndall Air Force Base Florida, Cpl Finnegan and his co-workers were troubleshooting a snag on a CF188 *Hornet* parked outside on the ramp. While Cpl Finnegan was conducting his checks he heard an allied aircraft taxiing behind the aircraft he was working on. Cpl Finnegan was not comfortable with the situation and he moved towards the tail of the CF188 to have a better look. In the poor visibility conditions, he observed an allied aircraft moving directly towards the CF188. The allied aircraft had experienced a component system failure during taxi which led to the loss of all steering and braking control. Cpl Finnegan took immediate action by yelling at the other technicians working on his aircraft to get out of the way. Within seconds, the allied aircraft collided with the CF188 *Hornet*. As soon as the allied aircraft was immobilized, Cpl Finnegan and his co-workers offered their assistance to the pilot, inquiring about his condition and remained in contact with him until the rescue team arrived to take charge of the scene. Due to Cpl Finnegan's astute observation and his quick reaction to alert personnel of a very dangerous situation, serious injury to himself and his co-workers was averted. Cpl Finnegan's actions are highly commendable and he is clearly deserving of this Good Show award. ♦



Corporal Finnegan is currently serving with 409 Tactical Fighter Squadron, 4 Wing Cold Lake.

Good Show

For Excellence in Flight Safety

Master Corporal Ian Beamer

MCpl Beamer, an aviation technician with 444 Combat Support Squadron, discovered on two separate occasions critical errors in the aircraft maintenance tracking system which had resulted in two CH146 *Griffon* helicopters overflying key maintenance inspections. The first occurrence happened in May 2009 where MCpl Beamer was tasked to complete a statement of work for upcoming maintenance of *Griffon* CH146440's tail rotor ninety degree gearbox. While reviewing the aircraft documentation he noticed major discrepancies between the Automated Data for Aerospace Maintenance (ADAM) database out of sequence inspection record and the CF359 major assembly history record. Upon further inspection he discovered that the Supp Data Code was missing from the ADAM database which was essential to predict the next scheduled inspection. He subsequently determined that *Griffon* CH146440 had over flown the tail rotor gearbox inspection. At the time of the discovery, the aircraft was participating in a Search and Rescue mission and was immediately quarantined. Without further direction, MCpl Beamer took it upon himself to initiate a detailed audit of the remaining squadron aircraft. He identified eight more discrepancies with aircraft CH146440 containing erroneous data that had the probability of escalating into over flown inspections if left unnoticed.

The second discovery happened in July 2009 when MCpl Beamer was tasked to install a new static discharge cable for the aircraft hoist. While reviewing the ADAM database, MCpl Beamer saw that the hoist system inspection was valid for an additional five months; however he knew that the hoist assembly out of sequence inspection is to be completed every 90 days. Realizing the gravity of the situation, MCpl Beamer immediately quarantined the aircraft, informed his supervisors and raised a flight safety incident report.

MCpl Beamer's outstanding attention to details and professionalism while performing his duties was instrumental in preventing potentially catastrophic events. MCpl Beamer is truly deserving of this Good Show award. ♦



Master Corporal Beamer is currently serving with 444 Combat Support Squadron in 5 Wing, Goose Bay.



From the Flight Surgeon

It's Only a Head Cold Why Shouldn't I Fly?

By Gavin Small

This article was originally printed in the Australian Safety Spotlight 04/09 magazine. It is reprinted here with the kind permission of the Australian Directorate of Defence Aviation and Air Force Safety.

The simple answer is because it's dangerous. The routine head cold can, and has, been the cause of many aviation accidents and incidents. Military flying is a demanding task, physically and mentally, and any stressor that adversely affects performance, such as a head cold, is an unnecessary 'weight' for aircrew to take flying with them.

The common cold may lead to any of the following in-flight disabilities:

- Ear block
- Sinus block
- Pressure vertigo

- Other general effects on your flying skill, and
- Unauthorised self-medication

Any aircrew member flying with a cold may experience any or perhaps all of these physiological phenomena, which may be a simple distraction, or can lead to total incapacitation.

Performance effects of a head cold

Ear block. The middle ear is linked to the outside world via the Eustachian tube, a narrow slit to the throat. The function of the tube is to equalise pressure between the middle ear and ambient.

Any blockage, such as would be expected with a cold and the subsequent swelling and inflammation of the tube, would mean that equalisation would be difficult. The problem occurs during descent. If the Eustachian tube is blocked because of swelling, a low-pressure

zone forms in the middle ear and pulls the ear drum inwards, causing a mild hearing loss initially, but progressing to severe, distractive then incapacitating pain. If sufficient pressure differential is attained, the eardrum may actually tear.

A descent from 5000 feet to sea level without equalisation is enough for this tear to occur. Note that a no-flying restriction will follow such an event, and in severe cases the restriction may be permanent.

Sinus block. Anyone who has suffered pressure induced sinus pain will assure you that it is extreme and quite incapacitating. Like the middle ear, the sinus cavities are linked to the world via small slits. The cavities and the slits are lined with mucous membranes. The cause of sinus pain is similar to that of ear pain and occurs on descent if the slits become blocked due to inflammation.



Pressure vertigo. This vertigo, or tumbling/spinning sensation, may occur on ascent or descent, if the pressure in the middle ears is different. It is thought that the differential pressure induces false sensations of movement in the vestibular organs, causing an incapacitating vertigo, due to the differing signals in each ear. The swelling caused by a cold may lead to this differential middle ear pressure. You may not be able to control an aircraft if suffering pressure vertigo.

General performance effects

The fever, and general malaise, induced by a cold or any other illness, will decrease your performance in the air, and your ability to cope with other aviation stressors.

A cold may:

- Decrease your G tolerance
- Increase your susceptibility to decompression sickness
- Decrease your tolerance to fatigue

- Decrease your tolerance to hypoxia
- Decrease your tolerance to cold stress

Self medication

To avoid the prospect of short term grounding, many aircrew suffering a cold may turn to over-the-counter cold remedies. These may cure some symptoms but will not decrease your susceptibility to the above mentioned problems, and can lead to performance problems, particularly visual, in flight.



There is no room for self-medication in military flying. If you need medication, you are not 100 percent fit and should not be flying.

Conclusion

Many people may view the common cold as a routine, nothing-to-worry-about illness. However, in military aviation, the cold can be a severe flight safety risk. The performance decrement caused by a cold will decrease your ability to act as an effective aircrew member, and may lead in severe circumstances, to an overload condition, where the unwell member

is unable to cope with unexpected stressors and the aircraft, and perhaps the lives of those on board may be lost.

It would be an embarrassing epitaph indeed to read:

Here lies Bloggs — he died from a head cold. ♦

A matter of personal readiness...

In any occupational setting, individuals are expected to show up for work ready to perform at optimum levels. This is even more so in aviation.

A breakdown in Personal Readiness can occur when individuals fail to prepare physically and mentally for the task / mission they must perform, which in turn can be detrimental to their performance, lead to errors and impede safety.

Not all Personal Readiness failures occur because rules and regulations have been disregarded or broken. While certain behaviours or conditions may not be governed by any rule or may not be against any existing regulation, individuals must use good judgement when deciding whether they are “fit” to work. A person arriving at work just after over-exercising (e.g. dehydrated after a long-distance run in a hot and humid environment), a person

arriving at work without adequate rest, hung over (e.g. under the influence of residual effects of alcohol despite a bottle-to-work period that was in accordance with regulations) or with impaired vigilance (e.g. from direct, secondary or residual effects of drugs / medication) are examples of Personal Readiness failures. Such individual(s) are not ready to function effectively and at optimum levels in the workplace.

Temporary medical problems in aircrew...

CF aircrew who develop medical problems are initially assessed by the local Flight Surgeon. For minor or temporary medical problems, the local Flight Surgeon has the authority to ground or restrict aircrew for periods up to three months (i.e. assign a temporary A3 or A7 Air Factor) and to reinstate the appropriate Air Factor for aircrew duties once the issue is resolved.

Four basic principles underline the decision-making approach and standards in aviation medicine:

- Flight Safety
- Maintenance of Operational Effectiveness
- Protection of Crewmember Health
- Preservation of Trained Resources

As a simple reminder...

B-GA-100-001/AA-000 National Defence Flying Orders Chapter 9 Safety Requirements

PHYSIOLOGICAL RESTRICTIONS

Illness or Injury

1. An aircrew member shall not fly when feeling unusually fatigued or suffering from any physical or psychological illness or injury (except minor cuts, scrapes, etc.) without the prior approval of a CF medical officer.

Drugs

2. An aircrew member shall take only those drugs (prescribed and over-the-counter), patent medicines and pharmaceutical preparations that are authorized by a medical officer and taken under supervision.

3. Under no circumstances shall an aircrew member be permitted to fly while under the influence of any drug without the flight surgeon's prior approval.

4. Any drug reaction such as sleepiness, nausea, dizziness, weakness, skin rash, etc, shall be reported immediately to a medical officer who will decide whether the member should be temporarily restricted from flying duties.

Queen's Regulations and Orders for the Canadian Forces Volume I – Administrative, Chapter 19, Conduct and Discipline Section 1 – Personal Conduct

19.18 – CONCEALMENT OF DISEASE

An officer or non-commissioned member who is suffering or suspects he is suffering from a disease shall without delay report himself sick.

The Editor's Corner

As we put together this magazine, many of you are involved with operations around the world whether in British Columbia, Afghanistan, or Haiti. The Chief of the Air Staff has reminded us in his Views on Flight Safety article, that the Flight Safety Program remains an integral part of operations for those deployed or at home. For that reason, I think everyone will find something of interest in this issue of Flight Comment.

Our feature article, the 'Limitations of the See-and-Avoid Principle' was recommended by several Aircraft Accident Investigator's who thought this was a timely article with good advice. This article discusses what we commonly refer to as the 'Big Sky theory' and the many physical and physiological limitations that exist for the aircrew. In 2009, there were 43 near miss occurrences reported in the Canadian Forces Flight Safety database, twenty of these (46%) occurred within the training fleets. In fact, the initial investigation report into a recent near miss occurrence involving three CT156 *Harvard II* aircraft can be found in the FTI section of this magazine. Nevertheless, this article should be read by all aircrew, as over half of the occurrences occurred outside of the training environment.

Along with the high pace of operations comes one of the dirty dozen human factors: *fatigue*. The Maintainer's Corner features an article reminding technicians of the hazards of working when fatigued, and the responsibility we have as individuals and supervisors to recognize this unsafe condition.

The enclosed poster created by the DFS image technician is a reminder to all of the Danger Areas of various aircraft, please post these within your units!

We hope you find a few articles of interest in this issue. We would like to especially thank those who contributed a Lessons Learned article, we all benefit from your experiences! ♦

Think Safety, Fly Safe!

Captain Kathy Ashton
Editor, *Flight Comment*

Not Speaking Up

Arriving at my first squadron, having recently received my wings, was a truly exciting experience. One of the first pilots I got to know was Mitch*. I had heard that Mitch was an excellent pilot. He had flown in both the military and civilian worlds and at age 35 he had logged over 10,000 hours. Mitch was also the epitome of politeness and friendliness. He had been with the squadron for several years and he was liked and respected by everyone. Whenever I went flying as a co-pilot with Mitch; however, all I saw was a “cowboy”. He certainly was an outstanding pilot, as polite and giving in the cockpit as he was on the ground. Yet Mitch regularly broke the rules – low flying, flying VFR in less than VFR conditions, and routinely pushing the envelope of the aircraft’s performance. I was always confident in Mitch’s flying abilities, but uncomfortable with his lack of regard for rules – rules that were in-place for reasons of flight safety.

The tragedy is that I never said anything to him. How could I? He was a really nice guy, and a very experienced pilot, and always interested in helping me improve my skills as a pilot. I heard some of the other lieutenants talk about Mitch’s flying conduct, but no one would speak up to our squadron supervisors. How could we? Everyone liked and respected Mitch, and as new guys, we certainly didn’t want to rock-the boat. So we hid behind “the code” and kept quiet.

After some months of being with the squadron, Mitch was flying with our flight commander during a trip that resulted in an A category crash. There were no passengers on board and the two miraculously survived with only minor injuries. It was determined during the Board of Inquiry that Mitch was at the controls when the crash occurred. Furthermore, the Board found that his actions and lack of regard for the rules were major cause factors in the aircraft’s loss. The Flight Commander stated that he knew that

“something” was wrong during the final moments prior to impact, but because he felt Mitch “knew” what he was doing”, he was reluctant to speak up.

Who was responsible for the crash, the Flight Commander, Mitch, or me? I guess we all were. The point is that many factors were involved; several windows had to line up over a long period of time in order to finally have the ingredients for a near fatal accident. In the beginning my silence saved me from possible ridicule. In the end, luck saved the crew. Had I spoken up, perhaps things would have been different. ♦

* The name and circumstances have been altered.

This article was originally printed in the Spring 2000 issue of Flight Comment. This is a lessons learned story that we can all benefit from today. All archived issues of Flight Comment can be viewed on the DFS website: www.airforce.forces.gc.ca/dfs.



Photo : Dany Michaud

Photo : MCpl Angela Abbey

Limitations of the See-and-Avoid Principle

This article was originally produced in the 01/2009 issue of Aviation Safety Spotlight. It is reproduced here with the kind permission of the Australian Directorate of Defence Aviation and Air Force Safety.

This research report was first published in April 1991 by the then Bureau of Air Safety Investigations (BASI, now ATSB). The human limitations of being able to identify and react to other aircraft in close proximity are many. We should understand these limitations and apply the techniques suggested to reduce the risk of mid-air collision. Multiple aircraft operating in training or exercise areas have significantly higher risk of mid-air collision. The 'Big Sky Theory' doesn't always work and has a large luck factor involved. Know yours and the aircraft's limitations and fly with these in mind.

The see-and-avoid principle serves a number of important functions in the Australian air-traffic system. However, while it undoubtedly prevents many collisions, the principle is far from reliable. The limitations of the see-and-avoid concept demand attention because increases in air traffic may impose an accelerating level of strain on see-and-avoid and other aspects of the air-traffic system.

Numerous limitations, including those of the human visual system, the demands of cockpit tasks, and various physical and environmental conditions combine to make see-and-avoid an uncertain method of traffic separation. This article provides an overview of the major factors that limit the effectiveness of unalerted see-and-avoid.

Cockpit workload and other factors reduce the time that pilots spend in traffic scans. However, even when pilots are looking out there is no guarantee that other aircraft will be sighted. Most cockpit windscreen configurations severely limit the view available to the pilot. The available view is frequently interrupted by obstructions such as window posts, which totally obscure some parts of the view and make other areas visible to only one eye. Window posts, windscreen crazing and dirt can act as focal traps and cause the pilot to involuntarily focus at a very short distance even when attempting to scan for traffic. Direct glare from the sun and veiling glare reflected from windscreens can effectively mask some areas of the view.

Visual scanning involves moving the eyes in order to bring successive areas of the visual field onto the small area of sharp vision in the centre of the eye. The process is frequently unsystematic and may leave large areas of the field of view unsearched. However, a thorough, systematic search is not a solution as in most cases it would take an impractical amount of time.

The physical limitations of the human eye are such that even the most careful search does not guarantee that traffic will be sighted. A significant proportion of the view may be masked by the blind spot in the eye, the eyes may focus at an inappropriate distance due



Photo : Cpl Jean-François Lauzé

to the effect of obstructions as outlined above or due to empty field myopia, in which, in the absence of visual cues, the eyes focus at a resting distance of around half a metre. An object that is smaller than the eye's acuity threshold is unlikely to be detected and even less likely to be identified as an approaching aircraft.

The pilot's functional visual field contracts under conditions of stress or increased workload. The resulting tunnel vision reduces the chance that an approaching aircraft will be seen in peripheral vision.

The human visual system is better at detecting moving targets than stationary targets, yet in most cases, an aircraft on a collision course appears as a stationary target in the pilot's visual field. The contrast between an aircraft and its background can be significantly reduced by atmospheric effects, even in conditions of good visibility.

An approaching aircraft, in many cases, presents a very small visual angle until a short time before impact. In addition, complex backgrounds such as ground features or clouds hamper the identification of aircraft via a visual effect known as contour interaction. This occurs when background contours interact with the form of the aircraft, producing a less distinct image.

Even when an approaching aircraft has been sighted there is no guarantee that evasive action will be successful. It takes a significant amount of time to recognise and respond to a collision threat and an inappropriate evasive manoeuvre may serve to increase rather than decrease the chance of a collision.

Because of its many limitations, the see-and-avoid concept should not be expected to fulfil a significant role in future air-traffic systems.

Role of see-and-avoid

See-and-avoid serves three functions in Australian airspace:

1. Self-separation of aircraft outside controlled airspace
2. As a separation procedure for VFR aircraft in control zones, where the pilot is instructed to sight and avoid or sight and follow another aircraft as outlined in NOTAM C0511989. This procedure only operates when the pilot can see the traffic and is therefore significantly different to other types of see-and-avoid that may involve unalerted searches for traffic.
3. Last resort separation if other methods fail to prevent a conflict, regardless of the nature of the airspace.

It is important to distinguish between unalerted and alerted see-and-avoid. In alerted see-and-avoid, the pilot of an aircraft in controlled airspace is assisted to sight the traffic and an important backup exists because positive control will be provided if the traffic cannot be sighted. Unalerted see-and-avoid on the other hand, presents a potentially greater safety risk because it relies entirely on the ability of the pilot to sight other aircraft. For these reasons, this article concentrates on unalerted see-and-avoid. However, many of the problems of unalerted see-and-avoid apply equally to alerted see-and-avoid.

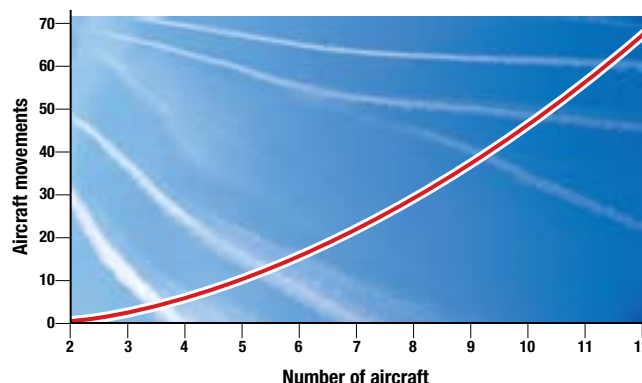


Figure 1 – NUMBER OF POSSIBLE COLLISIONS WITH INCREASING AIR TRAFFIC

Potential for mid-air collisions

There have been relatively few mid-air collisions in Australia. However, there are reasons why the mid-air collision potential demands immediate attention.

At a time when aircraft movements are increasing, the probability of a mid-air collision in a given airspace grows faster than the traffic growth. One of the factors that determines the probability of a collision is the number of possible collision combinations in a particular airspace. The number of possible collision pairs is given by the formula: $P = N \times (N-1)/2$ where N is the number of aircraft operating in a given airspace. For example, with only two aircraft there is only one possible collision pair, with five aircraft there are 10 possible pairs and with ten aircraft there are 45. **Figure 1** illustrates the increase in possible collisions that accompanies increasing traffic density.

Fortunately, the frequency of collisions has not increased as steeply as **figure 1** would suggest because various safety systems have prevented the full expression of the collision potential. Air Traffic Services (ATS), flight rules and visual sighting are three such systems. As well as illustrating the increasing stress placed on the air traffic system by traffic growth, **figure 1** also implies that the cost of traffic separation may follow an inverse 'economy of scale' rule.



Figure 2 – BREAKDOWN OF SEPARATION

In recent years there have been a number of mid-air collisions in Australia and an increase in reported breakdowns of separation (see **figure 2**). The actual number of separation breakdowns may be much higher as it is likely that many separation breakdowns are not officially reported.

See-and-avoid is an important safety system

The see-and-avoid principle is a significant feature of the Australian air traffic system. There is no doubt that safety features such as ATS and see-and-avoid prevent many collisions. It has been estimated that without ATS and in the absence of any ability to see-and avoid there would be 34 times more mid-air collisions en route and 80 times more mid-air in terminal areas (Machol 1979). However, although many collisions are averted by see-and-avoid, the concept is a flawed and unreliable method of collision avoidance.

See-and-avoid is not 100 per cent reliable

See-and-avoid has been described as a maritime concept originally developed for slow moving ships, which is now out of place in an era of high speed aviation (Marthinsen 1989).

There is a growing case against reliance on see-and-avoid. A report released in 1970

concluded that although see-and-avoid was often effective at low closing speeds, it usually failed to avert collisions at higher speeds. It was estimated that see-and-avoid prevents 97 per cent of possible collisions at closing speeds of between 101 and 199 knots but only 47 per cent when the closing speed is greater than 400 knots (Graham and Orr 1970).

A 1975 FAA study concluded that although see-and-avoid was usually effective, the residual collision risk was unacceptable (Graham 1975). Accident investigations here and in the US are increasingly pointing to the limitations of see-and-avoid.

The Americans, having recognised the limitations of the concept, are looking to other methods such as the automated airborne collision avoidance system (TCAS) to ensure traffic separation. TCAS equipment carried on board an aircraft will automatically provide information about any nearby transponder-equipped aircraft that pose a collision threat. It is planned that by the mid 1990s all large civil passenger aircraft operating in the US be fitted with this system.

Perhaps the most damning evidence against see-and-avoid comes from trials carried out by John Andrews in the US, which confirmed that even motivated pilots frequently fail to sight conflicting traffic.

In one of these studies, 24 general aviation pilots flew a Beech Bonanza on a VFR cross-country flight. The pilots believed that they were participating in a study of workload management techniques. In addition to providing various information to a researcher on the progress of the flight,

the pilots under study were required to call out any traffic sighted.

The pilots were not aware that their aircraft would be intercepted several times during the test by a Cessna 421 flying a near-collision course. The interceptions occurred when the Bonanza was established in cruise and the pilot's workload was low; however, the Bonanza pilots sighted the traffic on only 36 out of 64 encounters — or 56 per cent (Andrews 1977, 1984, 1987).

Seeing and avoiding involves a number of steps

See-and-avoid can be considered to involve a number of steps. First, and most obviously, the pilot must look outside the aircraft.

Second, the pilot must search the available visual field and detect objects of interest, most likely in peripheral vision.

Next, the object must be looked at directly to be identified as an aircraft. If the aircraft is identified as a collision threat, the pilot must decide what evasive action to take. Finally, the pilot must make the necessary control movements and allow the aircraft to respond. Not only does the whole process take valuable time, but human factors at various stages in the process can reduce the chance that a threat aircraft will be seen and successfully evaded. These human factors are not errors nor are they signs of poor airmanship. They are limitations of the human visual and information processing system that are present to various degrees in all pilots.

Looking for traffic

Obviously, see-and-avoid can only operate when the pilot is looking outside the cockpit.

According to a US study, private pilots on VFR flights spend about 50 per cent of their time in outside traffic scan (Suzler and Skelton 1976). Airline pilots may possibly scan less than this. In the late 1960s it was estimated

that American airline pilots spent about 20 per cent of their time in outside scan (Orlady 1969). Although this is an old figure it gives a rough idea of the likely amount of scanning by Australian pilots in the 1990s.

The time spent scanning for traffic is likely to vary with traffic density and the pilot's assessment of the collision risk. In addition, factors such as cockpit workload and the ATS environment can influence traffic scanning.

Workload

Many tasks require the pilot to direct attention inside the aircraft. Cockpit workload is likely to be high near airports where traffic is most dense and where an outside scan is particularly crucial. Most of these cockpit tasks are essential; however, some of the workload is less critical and could be performed at other times. It is a common complaint of pilots that air traffic services frequently impose unnecessary tasks in terminal areas.

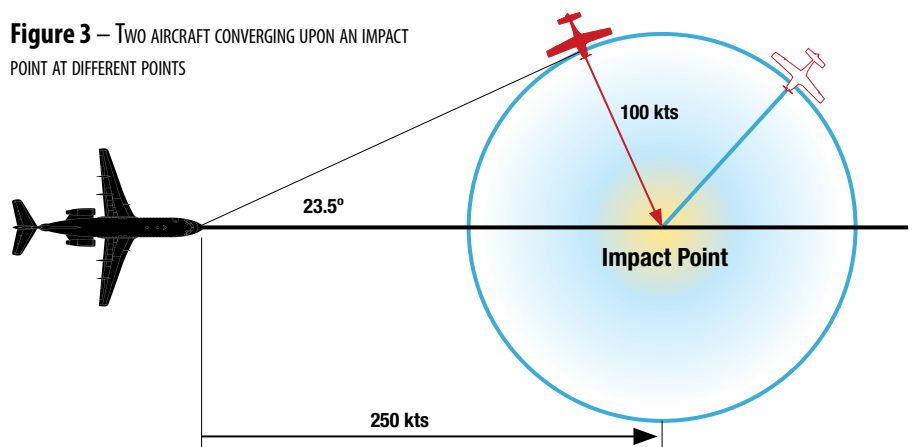
In the case illustrated, two aircraft are converging upon an impact point at different speeds. The jet is travelling two and a half times faster than the light aircraft and at any time prior to the collision, will be two and a half times further away from the collision point than the light aircraft. One result of this is that the faster aircraft will always have a slower aircraft in front of it.

At all times leading up to the collision, any slow aircraft with which the jet may collide will appear at a point relatively close to the centre of the jet's windscreen. From the slower aircraft pilot's of view; however, the jet can approach from any angle, even from a part of the sky not visible in the windscreen.

Crew numbers and workload

The widespread introduction of flightdeck automation has meant that modern airliners are now frequently flown by only two crew-members. However, automation has not reduced the need for pilots to be vigilant for other air traffic and compared

Figure 3 — TWO AIRCRAFT CONVERGING UPON AN IMPACT POINT AT DIFFERENT POINTS



to 20 years ago, the average airliner now has fewer crew looking for more traffic. It has been suggested, sometimes as part of industrial campaigns, that two-crew aircraft have been involved in a disproportionate number of mid-air collisions (Marthinsen 1989). However, it is doubtful that any firm evidence would support this view.

Glass cockpits and workload

A survey (Weiner 1989) suggested that pilots of advanced glass-cockpit airliners were spending more time heads down, particularly at low altitudes as they interact with the flight management computers that were introduced to reduce workload. Yet there are reasons why in some circumstances, the pilot of a fast airliner has a better chance of detecting a conflicting slow aircraft than vice versa (see **figure 3**).

Diffusion of responsibility

Diffusion of responsibility occurs when responsibility for action is divided between several individuals with the result that each assumes that somebody else is taking the necessary action.

Diffusion of responsibility has been a factor in a number of serious aviation accidents, for example the 1972 accident involving an L1011 in the Florida Everglades.

A frequent criticism of the see-and-avoid principle is that pilots flying in controlled airspace relax their traffic scans in the assumption that Air Traffic Control (ATC) will ensure separation.

Yet as the Australian experience shows, mid-air collisions and near collisions can and do occur in controlled airspace. An analysis of U.S. near mid-air collisions (NMACs) showed that the majority of reported NMACs occurred in controlled airspace (Right Safety Digest December 1989).

Diffusion of responsibility has been suggested as a contributing factor in a number of overseas midair collisions, for example the collision of a Cessna 340A and a North American SNJ-4N at Orlando, Florida on 1 May 1987 (NTSB Report 88/02). Pilot complacency when under air traffic control was also identified as a problem by a 1980 NASA report (Billings, Grayson, Hetch and Curry 1980). At present, there is no reliable information on the amount of scanning done by Australian pilots in controlled airspace and outside controlled airspace.

Visual search

The average person has a field of vision of around 190 degrees, although field of vision varies from person to person and is generally greater for females than males (Leibowitz 1973).

The field of vision begins to contract after about age 35. In males, this reduction accelerates markedly after 55 years of age (see **figure 4**). A number of transient physical and psychological conditions can cause the effective field of vision to contract even further. These will be discussed at a later point.

The quality of vision varies across the visual field, largely in accord with the distribution on the retina of the two types of light sensitive

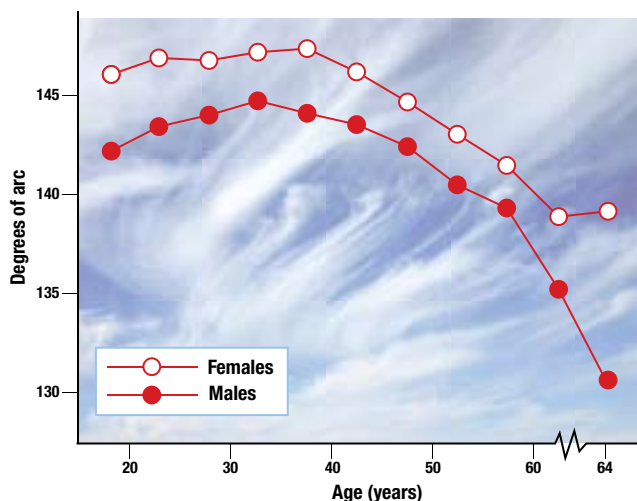


Figure 4 – RIGHT EYE VISUAL FIELD FOR MALES AND FEMALES

cells, rods and cones. Cones provide sharp vision and colour perception in daylight illumination and are concentrated at the fovea, the central part of the retina on which an object appears if it is looked at directly. Rods are situated on the remainder of the retina surrounding the fovea on an area known as the peripheral retina.

Although rods provide a black and white image of the visual field, they continue to operate at low light levels when the cones have ceased to function.

Vision can be considered to consist of two distinct systems, peripheral and foveal vision. Some important differences between the two systems are that colour perception and the detection of slow movement are best at the fovea, while detection of rapid movement is best in the periphery. In daylight, acuity (sharpness of vision) is greatest at the fovea, but with low light levels such as twilight, acuity is fairly equal across the whole retina. At night, acuity is greatest in the peripheral retina.

As **figure 5** shows, acuity in daylight is dramatically reduced away from the direct line of sight, therefore a pilot must look at or near a target to have a good chance of detecting it.

Peripheral and foveal vision perform different functions in the search process. An object will generally be first detected in peripheral vision but must be fixated on the fovea before identification can occur.

Searching for traffic involves moving the point of gaze about the field of view so that successive areas of the scene fall onto the high-acuity area of the retina.

The eye movements in a traffic search occur in rapid jerks called saccades interposed with brief rests called fixations. We only see during the fixations, being effectively 'blind' during the saccades. It is not possible to move the eyes smoothly across a view unless a moving object is being tracked.

Several factors can limit the effectiveness of visual searches.

Obstructions and available field of view

Cockpit visibility

Most aircraft cockpits severely limit the field of view available to the pilot. **Figure 6** illustrates the limited cockpit visibility from a typical general aviation aircraft which because of its relatively slow speed, can be approached from any direction by a faster aircraft (**figure 3**).

Visibility is most restricted on the side of the aircraft furthest away from the pilot and consequently, aircraft approaching from the right will pose a particular threat to a pilot in the left seat.

Obstructions

Obstructions to vision can include window-posts, windscreen bug splatter, sunvisors, wings and front seat occupants. The instrument panel itself may obstruct vision if the pilot's head is significantly lower than the standard eye position specified by the aircraft designers. The effects of obstructions on vision are in most cases self-evident. However there are some less obvious forms of visual interference.

In response to the Zagreb mid-air collision of 1976, Stanley Roscoe investigated the effects of cabin window-posts on the visibility of contrails (Roscoe and Hull 1982). Two significant effects were described: First, an obstruction wider than the distance between the eyes will not only mask some of the view completely, but will result in certain areas of the outside world being visible to only one eye. A target that falls within such a region of monocular visibility is less likely to be detected than a similar target visible to both eyes.

A second undesirable effect of a window-post or similar obstruction is that it can act

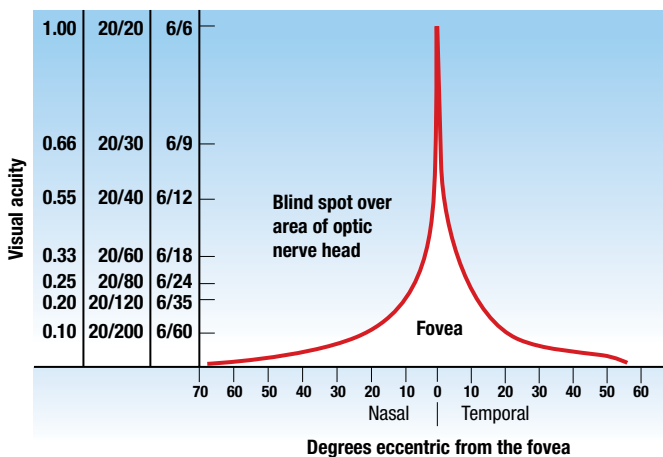


Figure 5 – VARIATION IN VISUAL ACUITY

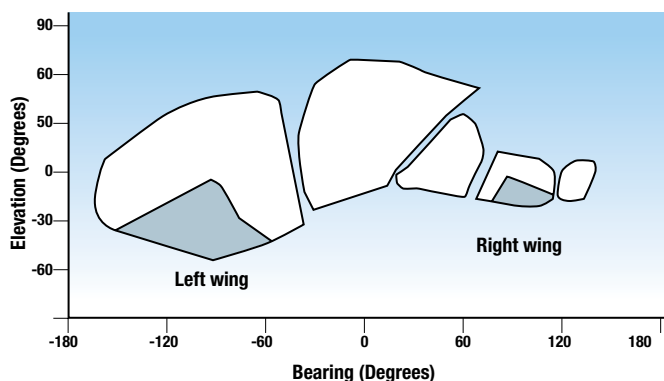


Figure 6 – LIMITED COCKPIT VISIBILITY FROM A
TYPICAL GENERAL AVIATION AIRCRAFT

as a focal trap for the eyes, drawing the point of focus inwards, resulting not only in blurred vision but distorted size and distance perception. This effect is dealt with in more detail in a later section.

The findings of Roscoe and Hull have recently been replicated by Chong and Triggs (1989).

Glare

Glare occurs when unwanted light enters the eye. Glare can come directly from the light source or can take the form of veiling glare, reflected from crazing or dirt on the windscreen.

Direct glare is a particular problem when it occurs close to the target object such as when an aircraft appears near the sun. It has been claimed that glare that is half as intense as the general illumination can produce a 42 per cent reduction in visual effectiveness when it is 40 degrees from the line of sight.

When the glare source is 5 degrees from the line of sight, visual effectiveness is reduced by 84 per cent (Hawkins 1987). In general, older pilots will be more sensitive to glare.

Limitations of visual scan

A traffic scan takes time

The individual eye movements associated with visual search take a small but significant amount of time. At most, the eyes can make about three fixations per second (White 1964); however, when scanning a complex scene pilots will typically spend more time on each fixation.

FAA Advisory Circular 90-48 C recommends scanning the entire visual field outside the cockpit with eye movements of 10 degrees or less to ensure detection of conflicting traffic. The FAA estimates that around one second is required at each fixation. So to scan an area 180 degrees horizontal and

30 degrees vertical could take 54 fixations at one second each = 54 seconds. Not only is this an impracticable task for most pilots, but the scene would have changed before the pilot had finished the scan.

Harris (1979) presents even more pessimistic hypothetical calculations. He estimates that under certain conditions, the search of an area 180 degrees by 30 degrees would require 2700 individual fixations and take around 15 minutes.

Scan coverage

Visual scans tend to be unsystematic, with some areas of the visual field receiving close attention while other areas are neglected. An observer looking for a target is unlikely to scan the scene in a systematic grid fashion (Snyder 1973). Areas of sky near the edges of windscreens are generally scanned less than the sky in the centre (White 1964) and saccades may be too large, leaving large areas of unsearched space between fixation points.

Limitations of vision

Blind spot

The eye has an inbuilt blind-spot at the point where the optic nerve exits the eyeball. Under normal conditions of binocular vision the blind spot is not a problem as the area of the visual field falling on the blind spot of one eye will still be visible to the other eye. However, if the view from one eye is obstructed (for example by a window post), then objects in the blind spot of the remaining eye will be invisible. Bearing in mind that an aircraft on a collision course appears stationary in the visual field, the blind spot could potentially mask a conflicting aircraft.

The blind spot covers a visual angle of 7.5 degrees vertical and 5 degrees horizontal (Westheimer 1986). At a distance of around 40 centimetres the obscured region is about the size of a 20 cent coin.

The obscured area expands to around 18 metres in diameter at a distance of 200 metres, enough to obscure a small plane.

The blind spot in the eye must be considered as a potential, albeit unlikely accident factor. It should be a particular concern in cases where vision is severely limited by obstructions such as window-posts, wings or visors.

Threshold for acuity

There are times when an approaching aircraft will be too small to be seen because it is below the eye's threshold of acuity.

The limits of vision as defined by eye charts are of little assistance in the real world where targets frequently appear in the corner of the eye and where acuity can be reduced by factors such as vibration, fatigue and hypoxia (Welford 1976, Yoder and Moser 1976). Certain types of sunglasses can also significantly reduce acuity (Dully 1990).] There have been attempts to specify how large the retinal image of an aircraft must be before it is identifiable as an aircraft. For example, the NTSB report into a mid-air collision at Salt Lake City suggested a threshold of 12 minutes of arc whereas a figure of between 24 and 36 minutes of arc has been suggested as a realistic threshold in sub-optimal conditions.

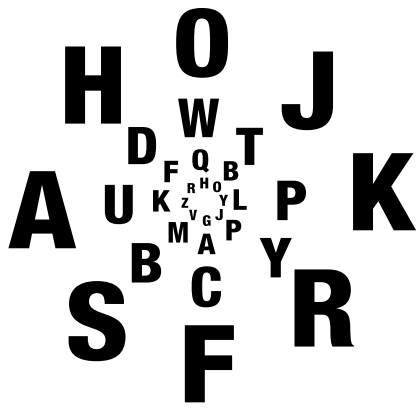


Figure 7 – How VISUAL ACUITY VARIES ACROSS

THE RETINA

Unfortunately it is not possible to state how large a target must be before it becomes visible to a pilot with normal vision because visual acuity varies dramatically across the retina. **Figure 7** illustrates how poor vision can be away from the direct line of sight.

All the letters in the chart should be equally readable when the centre of the chart is fixated (Anstis 1986). It must be remembered that in most cases, an aircraft will be first noticed in peripheral vision.

An effective way to visualise the performance of the eye in a visual detection task is with a visual detection lobe such as **figure 8** which shows the probability of detecting a DC3 at various ranges and at various degrees away from the line of sight (Harris 1973). The figure

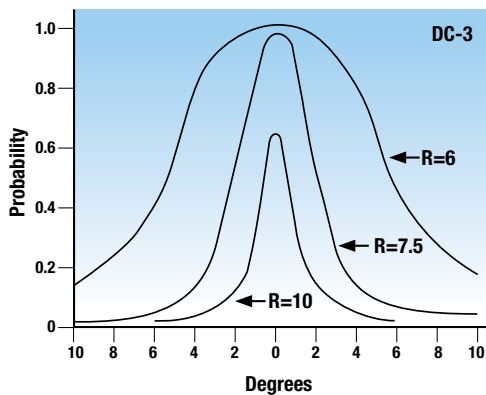


Figure 8 – DETECTING A DC3 AIRCRAFT AT VARIOUS

RANGES AND AT VARIOUS DEGREES AWAY FROM THE LINE OF SIGHT

illustrates that the probability of detection decreases sharply as the aircraft appears further away from the direct line of sight.

Accommodation

Accommodation is the process of focussing on an object. Whereas a camera is focussed by moving the lens, the human eye is brought into focus by muscle movements that change the shape of the eye's lens.

A young person will typically require about one second to accommodate to a stimulus (Westheimer 1986); however, the speed and degree of accommodation decreases with age. The average pilot probably takes several seconds to accommodate to a distant object. Shifting the focus of the eyes, like all muscular processes can be affected by fatigue.

Empty-field myopia

In the absence of visual cues, the eye will focus at a relatively short distance. In the dark the eye focuses at around 50 cm. In an empty field such as blue sky, the eye will focus at around 56 cm (Roscoe and Hull 1982). This effect is known as empty-field myopia and can reduce the chance of identifying a distant object.

Because the natural focus point (or dark focus) is around half a metre away, it requires an effort to focus at greater distances, particularly in the absence of visual cues. However, the ability to accommodate to greater distances can be improved by training (Roscoe and Couchman 1987).

Focal traps

The presence of objects close to the eye's dark focus can result in a phenomenon known as the Mandelbaum effect, in which the eye is involuntarily trapped at its dark focus, making it difficult to see distant objects. Window posts and dirty windscreens are particularly likely to produce the Mandelbaum effect.

Psychological limitations

Alerted search vs unalerted search

A traffic search in the absence of traffic information is less likely to be successful than a search where traffic information has been provided because knowing where to look greatly increases the chance of sighting the traffic (Edwards and Harris 1972). Field trials conducted by John Andrews found that in the absence of a traffic alert, the probability of a pilot sighting a threat aircraft is generally low until a short time before impact. Traffic alerts were found to increase search effectiveness by a factor of eight. A traffic alert from ATS or from a radio listening watch is likely to be similarly effective (Andrews 1977, 1984, 1987).

A mathematical model of visual acquisition developed by Andrews was applied by the NTSB to the Cerritos collision between a DC9 and a Piper PA28. **Figure 9** shows the estimated probability that the pilots in one aircraft could have seen the other aircraft before the collision.

Visual field narrowing

An observer's functional field of vision can vary significantly from one circumstance to another. For example, although a comfortable and alert pilot may be able to easily detect objects in the corner of the eye, the imposition of a moderate workload, fatigue or stress will

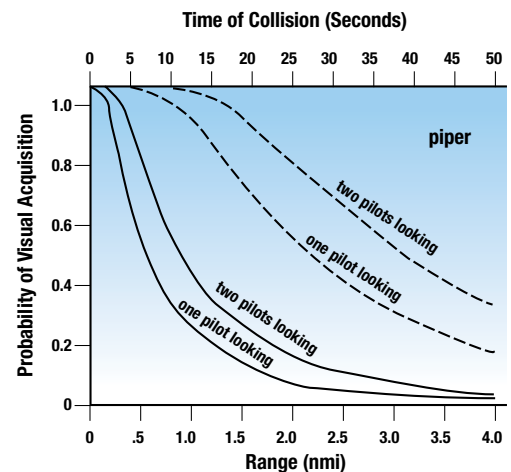


Figure 9 – ESTIMATED PROBABILITY OF VISUAL ACQUISITION

induce tunnel vision. It is as though busy pilots are unknowingly wearing blinkers.

Visual field narrowing has also been observed under conditions of hypoxia and adverse thermal conditions (Leibowitz 1973). However, in aviation, cockpit workload is likely to be the most common cause of visual field narrowing.

Cockpit workload and visual field narrowing

The limited mental processing capacity of the human operator can present problems when there is a requirement to fully attend to two sources of information at the same time. An additional task such as radio work, performed during a traffic scan can reduce the effectiveness of the search, even to the extent of reducing the pilot's eye movements and effectively narrowing the field of view.

A number of researchers have shown that peripheral stimuli are more difficult to detect when attention is focussed on a central task (for example, Leibowitz and Apelle 1969, Gasson and Peters 1965) or an auditory task (for example, Webster and Haslerud 1964).

Experiments conducted at NASA indicated that a concurrent task could reduce pilot eye movements by up to 60 per cent. The most difficult secondary tasks resulted in the greatest restriction of eye movements (Randle and Malmstrom 1982).

Talking, mental calculation and even daydreaming can all occupy mental processing capacity and reduce the effective field of vision.

Target Characteristics

Contrast with background

In determining visibility, the colour of an aircraft is less important than the contrast of the aircraft with its background. Contrast is the difference between the brightness of a target and the brightness of its background and is one of the major determinants of detectability (Andrews 1977, Duntley 1964). The paint scheme that will maximise the contrast of the aircraft with

its background depends of course, upon the luminance of the background. A dark aircraft will be seen best against a light background, such as bright sky, while a light coloured aircraft will be most conspicuous against a dull background such as a forest.

Atmospheric effects

Contrast is reduced when the small particles in haze or fog scatter light. Not only is some light scattered away from the observer but some light from the aircraft is scattered so that it appears to originate from the background, while light from the background is scattered onto the eye's image of the aircraft. Even in conditions of good visibility, contrast can still be severely reduced (Harris 1979).

Figure 10 graphs the amount of contrast reduction when visibility is five nautical miles. The graph illustrates that even at distances less than five miles, contrast can be greatly reduced.

Aircraft paint schemes

From time to time, fluorescent paint has been suggested as a solution to the contrast problem (Federman and Siegel 1973). However, several trials have concluded that fluorescent painted aircraft are not easier to detect than aircraft painted in nonfluorescent colours (Graham 1989).

Trials of aircraft detection carried out in 1961 indicated that in 80 per cent of first detections, the aircraft was darker than its background (Graham 1989). Thus a major problem with bright or fluorescent aircraft is that against a typical, light background, the increased luminance of the aircraft would only serve to reduce contrast.

In summary, particularly poor contrast between an aircraft and its background can be expected when:

- A light coloured aircraft appears against a light background
- A dark aircraft appears against a dark background
- The background luminance is low
- Atmospheric haze is present

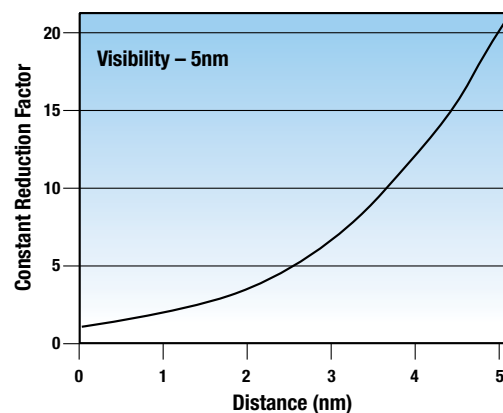


Figure 10 – CONTRAST REDUCTION WITH DISTANCE

Lack of relative motion on collision course

The human visual system is particularly attuned to detecting movement but is less effective at detecting stationary objects. Unfortunately, because of the geometry of collision flight paths, an aircraft on a collision course will usually appear to be a stationary object in the pilot's visual field.

If two aircraft are converging on a point of impact on straight flight paths at constant speeds, then the bearings of each aircraft from the other will remain constant up to the point of collision (see **Figure 11**).

From each pilot's point of view, the converging aircraft will grow in size while remaining fixed at a particular point in his or her windscreen.

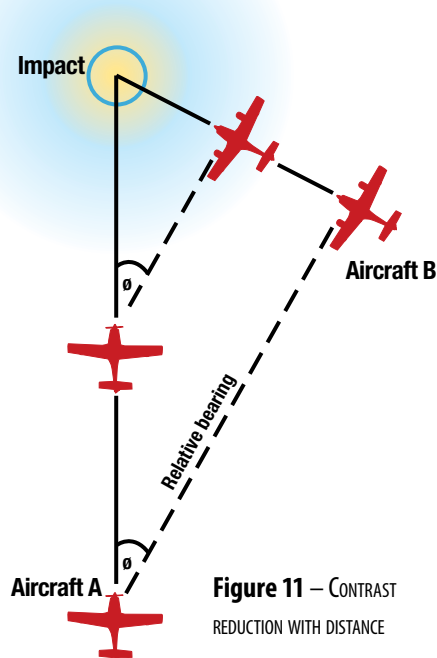
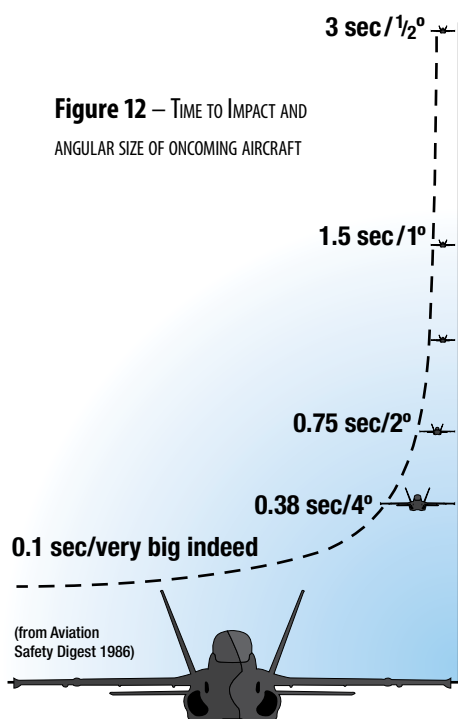


Figure 11 – CONTRAST REDUCTION WITH DISTANCE

Figure 12 — TIME TO IMPACT AND ANGULAR SIZE OF ONCOMING AIRCRAFT



An approaching aircraft presents a small visual angle

An approaching high speed aircraft will present a small visual angle until a short time before impact. **Figure 12** illustrates the case of a GA aircraft approaching a military jet where the closing speed is 600 knots.

Not all situations will be this severe, first because only about one quarter of encounters are likely to be head-on (Flight Safety Digest 1989) and second because many encounters involve slower aircraft.

Given the limitations to visual acuity, the small visual angle of an approaching aircraft may make it impossible for a pilot to detect the aircraft in time to take evasive action. Furthermore, if only the fuselage is used to calculate the visual angle presented by an approaching aircraft, that is wings are considered to be invisible, then the aircraft must approach even closer before it presents a target of a detectable size (Steenblik 1988).

Effects of complex backgrounds

Much of the information on human vision has come from laboratory studies using eye charts or figures set against clear uncluttered backgrounds. Yet a pilot looking out for traffic has a much more difficult task because aircraft usually appear against complex backgrounds of clouds or terrain.

It is likely that an aircraft will be noticed first in peripheral vision but only identified when fixated on the fovea. In such a situation, peripheral vision will pick up objects everywhere, some of which may be conflicting aircraft. The pilot is faced with the complex task of extracting the figure of an aircraft from its background. In other words, the pilot must detect the contour between the aircraft and background.

Contours are very important to the visual system. The eye is particularly attuned to detecting borders between objects and in the absence of contours, the visual system rapidly loses efficiency.

A finding of great importance to the visual detection of aircraft is that target identification is hampered by the close proximity of other objects (Wolford & Chambers 1984).

A major cause of this interference is 'contour interaction' in which the outline of a target interacts with the contours present in the background or in neighbouring objects. Camouflage works of course, because it breaks-up contours and increases contour interaction. Contour interaction is most likely to be a problem at lower altitudes, where aircraft appear against complex backgrounds.

Contour interaction occurs in both foveal and peripheral vision but is a more serious problem in peripheral vision (Bouma 1970, Jacobs 1979). Harris (1979) has highlighted the problem of contour interaction in aviation. **Figures 13 and 14** illustrate the possible consequences of contour interaction on the received image of an aircraft.

Anti-Collision Lighting

Effectiveness of lights

There have been frequent suggestions that the fitting of white strobe lights to aircraft can help prevent collisions in daylight. At various times BASI (now ATSB) and the NTSB have each recommended the fitting of white strobe anti-collision lights.

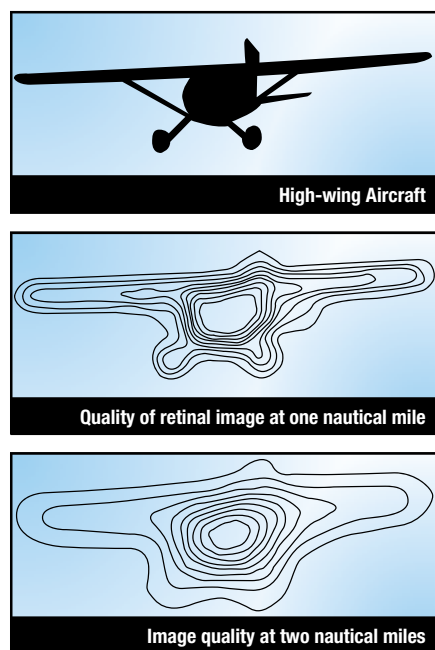


Figure 13 — THE EFFECT OF BACKGROUND CONTOURS ON AIRCRAFT RECOGNITION WITH NO BACKGROUND

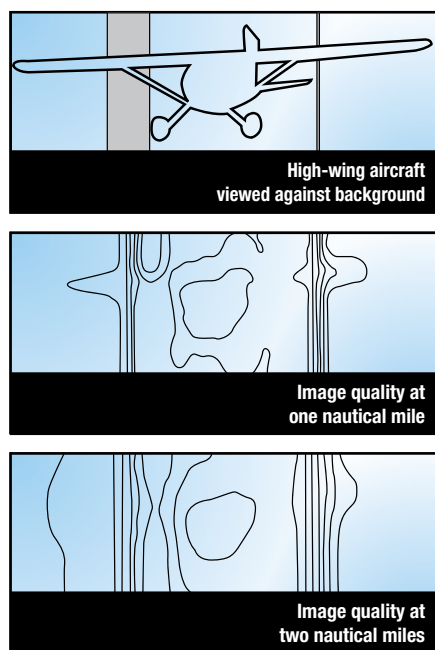


Figure 14 — THE EFFECT OF BACKGROUND CONTOURS ON AIRCRAFT RECOGNITION WITH BACKGROUND CONTOURS

Unfortunately, the available evidence does not support the use of lights in daylight conditions.

The visibility of a light largely depends on the luminance of the background and typical daylight illumination is generally sufficient to overwhelm even powerful strobes. Some typical figures of background luminance are:

Table 1: LUMINANCE OF COMMON BACKGROUNDS

BACKGROUND	CANDELAS* PER SQUARE METRE
SKY	
Clear day	3000.00
Overcast day	300.00
Very dark day	30.00
Twilight	3.00
Clear moonlit night	0.03
GROUND	
Snow, full sunlight	16000.00
On sunny day	300.00
On overcast day (approx.)	30.00 to 100.00

(From IES Lighting Handbook, page 325)

*A candela is approximately equal to a candlepower

In theory, to be visible at three nautical miles on a very dark day, a strobe light must have an effective intensity of around 5000 candelas (see **figure 15**). In full daylight, the strobe must have an effective intensity greater than 100,000 candelas (Harris 1987). Most existing aircraft strobes have effective intensities of between 100 and 400 candelas.

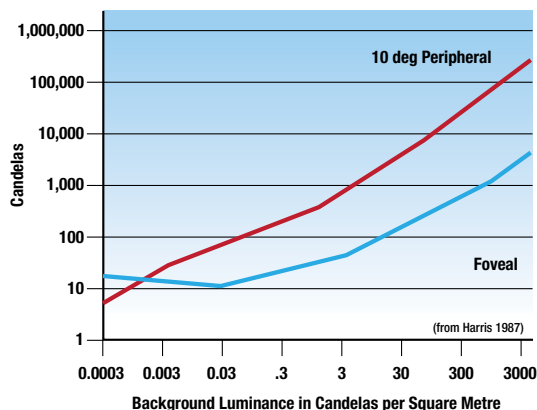


Figure 15 – REQUIRED EFFECTIVE INTENSITY IN CADELAS

Field trials have generally confirmed the ineffectiveness of strobes in daylight.

The following US military trials are outlined in a US Air Force report (Schmidlapp 1977):

- In 1958 the USAF Air Training Command conducted flight tests to compare strobe anticollision lights with rotating beacons. It was concluded that in daylight conditions, no lighting system could be expected to prevent collisions.
- Further tests in 1958 at the USAF Wright-Patterson Base again found that strobe lights were ineffective in daylight.
- A major US Army study was conducted in 1970 in which observers on a hilltop were required to sight approaching helicopters equipped either with strobes of 1800, 2300 or 3300 effective candela or a standard red rotating beacon. It was found that none of the lights were effective against a background of daytime sky, however strobes were helpful when the aircraft was viewed against the ground.
- USAF tests in 1976 found extremely poor performance of strobe lights on aircraft. In all cases, the aircraft was sighted before the strobe. In addition, it was found that after two years service on aircraft, strobe lights were about half as intense as expected.
- Extensive trials in 1977 by the US Air Force Aeronautical Systems Division used strobes fitted on a tower and observers at various distances and viewing angles. The results indicated that in daylight, even a strobe of 36000 candelas was not particularly conspicuous. However, strobes were more visible when the background illumination was less than 30 candelas per square metre, equivalent to a very dark day.

FAA studies have also concluded that there is no support for the use of strobes in daylight. A 1989 FAA study of the effectiveness of see-and-avoid concluded that aircraft colours or lights played no significant role in first directing a pilot's attention to the other aircraft during daytime (Graham 1989).

An earlier FAA study considered that there was 'little hope that lights can be made bright enough to be of any practical value in daylight' (Rowland and Silver 1972). A major FAA review of the aircraft exterior lighting literature concluded that during daytime, the brightest practical light is less conspicuous than the aircraft, unless there is low luminescence of background. (Burnstein and Fisher 1977).

In conclusion, while strobes are not likely to be helpful against bright sky backgrounds, they may make aircraft more visible against terrain or in conditions of low light.

Use of red lights

Until 1985, the then Australian Air Navigation Regulation 181 required aircraft to display a red, flashing, anti-collision light. After 1985, the requirement was changed to allow either a red or white light or both. The use of red warning lights in transport has a long history. Red lights have been used in maritime applications since the days of sail and red became the standard colour for danger on railways. An 1841 convention of British railwaymen decided that white should represent safety, red danger and green caution (Gerathewohl, Morris and Sirkis 1970).

It is likely that the widespread use of red as a warning colour in aviation has come about more because of common practice than any particular advantages of that colour.

White lights superior to red

There are reasons why red is not the best colour for warning lights. Humans are relatively insensitive to red (Leibowitz 1988) particularly in the periphery (Knowles-Middleton and Wyszecki 1960).

About 2 per cent of males suffer from protan colour vision deficiency and are less sensitive to red light than people with normal vision. A protan is likely to perceive a red light as either dark brown, dark green or dark grey (Clarke undated). Any colour involving a filter over the bulb reduces the intensity of the light and field

trials have shown that intensity is the main variable affecting the conspicuity of warning lights (Connors 1975). Given a fixed electrical input, the highest intensities are achieved with an unfiltered white lamu. In a comparison of commercially available warning lights, white strobes were found to be the most conspicuous (Howett 1979). If an aircraft does carry an anti-collision light, then it should be an unfiltered white light rather than a red light.

Evasive Action

The previous pages have dealt with the 'see' phase of see-and-avoid. However, it should not be assumed that successful avoiding action is guaranteed once a threat aircraft has been sighted.

Time required to recognise threat and take evasive action

FAA advisory circular 90-48-C provides military-derived data on the time required for a pilot to recognize an approaching aircraft and execute an evasive manoeuvre. The calculations do not include search times but assume that the target has been detected. The total time to recognizes an approaching aircraft, recognize a collision course, decide on action, execute the control movement and allow the aircraft to respond is estimated to be around 12.5 seconds (see **figure 16**).

Therefore to have a good chance of avoiding a collision, a conflicting aircraft must be detected at least 12.5 seconds prior to the time of impact. However, as individuals differ in their response time, the reaction time for older or less experienced pilots is likely to be greater than 12.5 seconds.

Evasive manoeuvre may increase collision risk

James Harris in his paper *Avoid, the unanalysed partner of see* focuses attention on the avoid side of seeing and avoiding (Harris 1983). He stresses that an incorrect evasive manoeuvre may cause rather than prevent a collision. For example, in a head-on encounter, a bank may

increase the risk of a collision.

Figure 17 illustrates this. In the top diagram, two (stylised) high-wing aircraft are approaching head-on with wings parallel. There is a limited number of ways in which the aircraft can collide if they maintain a wings-level attitude, and the area in which the two aircraft can contact or the 'collision cross-section' is relatively small.

However, if the pilots bank shortly before impact, as in the lower diagram, so that the aircraft approach each other with wings perpendicular, then there is a much larger collision cross section and consequently, a higher probability of a collision. This is not to suggest that banks are always inappropriate evasive manoeuvres, but that in some cases, evasive action can be unsuccessful or even counterproductive. At least one foreign airline accident has been attributed to an unnecessary evasive manoeuvre (Civil Aeronautics Board 1966).

Conclusions

The see-and-avoid principle in the absence of traffic alerts is subject to serious limitations. It is likely that the historically small number of mid-air collisions has been in a large part due to low traffic density and chance as much as the successful operation of see-and-avoid.

Unalerted see-and-avoid has a limited place as a last resort means of traffic separation at low closing speeds but is not sufficiently reliable to warrant a greater role in the air traffic system.

BASI considers that see-and-avoid is completely unsuitable as a primary traffic separation method for scheduled services.

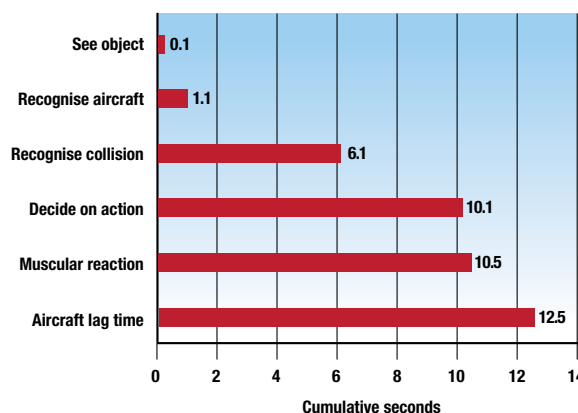


Figure 16 — TIME TO REACT TO COLLISION THREAT
FROM FAA AS ADVISORY CIRCULAR CADELAS

Many of the limitations of see-and-avoid are associated with physical limits to human perception, however there is some scope to improve the effectiveness of see-and-avoid in other areas.

Although strobes cannot increase the visibility of an aircraft against bright sky, it is likely that high intensity white strobes would increase the conspicuity of aircraft against a dark sky or ground. There is no evidence that low intensity red rotating beacons are effective as anti-collision lights in daytime.

Pilots and ATS personnel should be made aware of the limitations of the see-and-avoid procedure, particularly the psychological factors which can reduce a pilot's effective visual field.

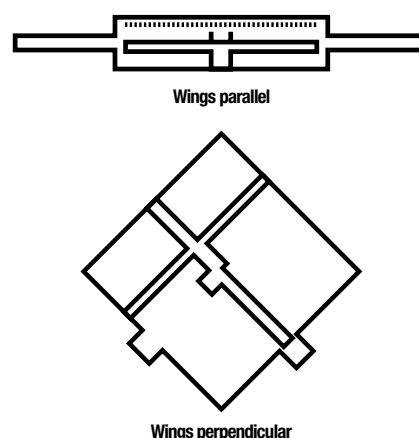


Figure 17 — COLLISION CROSS-SECTION



Pilots may be trained to scan more effectively and to accommodate to an appropriate distance when searching for traffic. Simply ensuring that the windscreen is clean and uncrazed will greatly increase the chance of sighting traffic.

There are important questions about the operation of see-and-avoid which can be answered by future research. These include the question of how frequently pilots scan for traffic and whether they scan significantly less in controlled airspace due to an over-reliance on ATS. The traffic scan training received by student pilots should be assessed. The visibility from aircraft should also be examined, with particular reference to windows and cabin obstructions.

The most effective response to the many flaws of see-and-avoid is to minimise the reliance on see-and-avoid in airspace. ♦

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Fatigue: A Technician's Breaking Point

By Major Sylvain Giguère, Directorate of Flight Safety, Ottawa

In aircraft maintenance, fatigue refers to “the tendency of metals to break under repeated cyclic loading at a stress considerably less than the tensile strength in a static test”. The traditional definition of fatigue, i.e., tiredness, is still to this day taboo. To a certain extent, the maintenance culture regards fatigue as a weakness rather than an inevitable outcome of intense and prolonged work periods. This might explain why, if you were to review Canadian Forces (CF) flight safety occurrences, you would find that fatigue is not cited as a cause; however, there is evidence that fatigue may be a contributor.

Fatigue is a real threat to effective operations. For example, in 2009, there was fuel spill experienced by a CC130 Hercules deployed at Kandahar Airfield (KAF). It occurred during a fuel transfer from external to internal fuel tanks. The maintenance

personnel planned to use the dump valves to speed up the fuel transfer process. For the majority of CC130 aircraft, the switches for these valves are covered and witness wired closed. The configuration of the occurrence aircraft is slightly different as it is an “H” model with air-to-air refueling capability. Thus, the maintenance technicians broke the witness wire and opened the valve while operating the fuel dump pump. These actions resulted in a fuel spill. The investigation report identifies the cause as a skill-based error by the technician due to not recognizing the difference in aircraft configuration. Interestingly, the investigation report also indicates that the technicians’ mental state (“reduced attention-stress”) was a factor in the occurrence. The crew had just arrived in theatre, been immediately sent to KAF, and reported to be fatigued due to local conditions and limited acclimatization period.

Most will agree that, with the increasing number of operations, our personnel resources are being stretched. To produce the required air assets to support operations, maintenance personnel either work longer hours or alternatively may be tempted to omit checklists and use shortcuts in order to hasten the completion of the task. From a flight safety perspective, both situations are worrisome. Working longer hours will sooner or later lead to fatigue with its accompanying degradation of alertness and performance. Using unapproved shortcuts versus following accepted procedures is a greater concern because it compromises safety and may degrade the component’s life and aircraft performance. It is clear that adequate manning is the solution to the shortage of personnel; however, when faced with a shortage, we have to manage the situation. This requires an understanding of what fatigue is and how to deal with it.



Photo: MCpl Robert Bottrill



Photo - Cpl Bernard LeBlanc

The primary sources of fatigue are insufficient sleep (significantly less than the optimal quota of sleep over an extended period), extended wakefulness (long duty days, sustained operations), and changing schedules. The effects of fatigue are similar to those of alcohol. Go without sleep for 17 hours and your performance will mirror someone with 0.05 blood alcohol content (BAC). Stay awake for 24 hours and you can expect to perform at a level similar to a 0.10 BAC. It is said that generally, we are lousy judges of our own fatigue levels. Thus, we must actively look for and recognize the objective indicators of fatigue in ourselves and other team members. If you recognize the effects of fatigue in yourself or others, don't keep it a secret. Assertiveness is safety and peace of mind. Keep your eyes open for:

- **Impaired judgment.** If you begin to notice faulty judgment and stupid mistakes popping up more than once, fatigue may be a player.
- **Delayed decisions.** Fatigue greatly impacts cognitive and decision-making abilities. Decisions may be delayed and reactions slowed.

- **Loss of short-term memory and recall.** Fatigue impacts short-term memory more than long-term memory.
- **Shortened attention span.** Difficulty experienced with activity requiring concentration.
- **Shortcuts and procedure deviations.** Quick solutions may be counterproductive and downright dangerous.

In the civilian realm, the National Transportation Safety Board (NTSB) has shown concerns about the effects of fatigue. In 1990, it included the reduction of accidents and incidents caused by human fatigue in the Aviation Industry to their "Most Wanted List". In response, the Federal Aviation Administration (FAA) completed a number of studies into the maintenance working environment, fatigue, and maintenance error/accidents. The FAA studies confirmed that fatigue was affecting the maintenance community. To alleviate the impact, the FAA implemented education and training sessions on fatigue management for aircraft maintenance personnel. A similar initiative was undertaken by the Canadian Forces with the implementation of Human

Performance in Military Aviation (HPMA) training. This is a worthwhile initiative that provides the maintenance community with knowledge and countermeasures specifically intended to deal with fatigue in the aircraft maintenance environment. Below are some possible preventive measures:

- Avoid sleep debt. If you did not get the appropriate amount of sleep during the night, make this a priority over other activities. Try to maintain the same sleep schedule and try to get an average of 8 hours (or as necessary) per night.
- Carefully plan your work activities. Proper timing of work activities can be of paramount importance to decreasing the effects of fatigue.
- Optimize sleeping quarters. Sleep mask and ear plugs can improve conditions if suitable accommodations are unavailable.
- Avoid alcohol and caffeine before bed as it may disrupt sleep.
- Assign an adequate number of qualified maintenance personnel to tasks and avoid disruption of on-going tasks.
- Recognize when personnel are fatigued and transfer some tasks to a more alert crew member.

The FAA is currently not considering the establishment of duty time limits for aircraft maintenance personnel, despite NTSB seeking a regulation to this effect. There are also no duty-time limits for CF aircraft maintenance personnel. Notwithstanding the lack of duty-time limits, all of us have a duty to preserve airworthiness and ensure safety. Thus, all of us individually have a responsibility to plan and use rest periods properly in order

to minimize incurring fatigue. We also have a duty of not letting ourselves go beyond safe practices and set aside our values as professionals in this very specialized field of aircraft maintenance. Remember: Safety is no Accident! ♦

Further Reading:

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Photo: Cpl Bernard LeBlanc



BOMB *garden*

By Warrant Officer Dave Norris,
413 Transport and Rescue
Squadron, 14 Wing Greenwood

We were off for our great adventure. The Squadron was to deploy to Aviano Italy for six months on a NATO tour. Both the air and ground crews had trained long and hard and we were ready to go. Many of the folks had never been on a tour, but we were all looking forward to it.

We arrived in theatre and started to settle in when the tour turned into an Operation. Our tempo increased, more aircraft were deployed and the bombing started. We were flying night and day, working twelve hours on and twelve hours off. The month of April was the wettest I had ever seen. We could only use one hardened aircraft shelter (HAS) as it seemed all of NATO's fighters had arrived on the same base.

As the numbers of aircraft increased, so did the amount of ordnance. We were using the GBU 12 laser guided bomb (LGB) but found it

was limited, so we reverted back to the old MK 82, a 500 pound iron bomb. It seemed at one point that the loaders had "dropped" or down loaded more bombs than the pilots. There was a requirement for quick turn around times, so it was decided to keep as much ordnance in the dispersal area as we could, both GBU 12 and MK 82 bombs.

While this was going on, it was decided to introduce a new weapon into the theatre, the GBU 10, a 2000 pound LGB. As the GBU 10 is a much larger weapon, more Net Explosives Quantity (NEQ) was introduced into the equation. We had bombs on trailers, on pallets in the grass and on the hardstand plus all the weapons loaded on the aircraft. We met all our timings, flew lots of missions and kept the Operation running day and night. It was quite a sight, but was it right?

Whenever live weapons were in use at our home base, we used the Wing Armament Orders as guidance. These orders detailed the designated load areas, aircraft spacing and the amount of ordnance that could be on sight at a given time.

So why did procedures change while we were operating in Aviano?

You have to remember this was two years after the air trades amalgamation (1997), the first deployment for many and the over-whelming attitude was that we were on Operations. Many thought that during Operations the rules changed, but they don't. Air Weapons Safety is there for a reason and much study has gone into Quantity Distance tables (QD) stating how much ordnance can be on sight at one time.

After much discussion a plan was set in place, limits were established for the NEQ in our area. We could not change our aircraft spacing, so this was also factored into the plan. The only HAS available became the personnel shelter and an explosives free area. This was also our shelter during thunderstorms. The potential for an explosives mishap was greatly reduced.

Whether you are at home or deployed, Air Weapons Safety goes with you. ♦



How Far Do You Push?

**By Captain Gary Hartzenberg,
435 Transport and Rescue Squadron,
17 Wing Winnipeg**

There's a saying familiar to those in the aviation community: "it's better to be on the ground wishing you were flying, than to be flying wishing you were on the ground."

It was a Friday night, the beginning of a weekend standby period with the *Hercules* Search and Rescue (SAR) Squadron. My thoughts were beginning to turn to my warm and inviting bed when the pager suddenly went off. After a quick call to Operations, I learned we would be heading westward towards the mountains for a confirmed helicopter crash. A review of the weather for that night told us to expect gusty winds and overcast layers around the mountain tops, not ideal for a night search in high terrain.

After a three hour transit, we were on scene and sure enough, the weather was not going to allow us to do a visual search. We contacted Rescue Coordination Center (RCC) and were informed that a ground party was en-route to the crash

site and we were to remain on scene and provide the ground party with night illumination by dropping flares over the site.

As day broke we were getting low on fuel and we proceeded to the nearest airport. By this time, the weather had lifted enough to allow an air ambulance helicopter to get into the crash site. We were now to proceed back on scene and fly top cover for the helicopter. On the transit back to the crash site, we began to ponder the inevitable question: can we press on home or do we stop short and go to ground in a hotel. We discussed all the advantages of landing at our home base: it was a familiar aerodrome for landing at the end of a long crew day, the aircraft could be turned over to a fresh crew to hold standby and we would be able to sleep in our own beds. Those of us on the flight deck were confident that we could make it back to base if we were released in a reasonable amount of time. After an hour of top cover duties, it looked as if we were going to have to settle for that hotel and we began to make plans to stop short. At precisely that instance we were informed that the survivors had been picked up and we were cleared off scene.

After we levelled off en-route back home, I could feel my head begin to nod and droop and I could see the same happening across the flight deck. Never has so much coffee been ingested by so few in such a short space of time. We arrived back home at about the same time as the weather system that had most likely contributed to the crash the night before, and we now had to land in rain showers and winds gusting to 50 knots. As we bumped along during the instrument approach on descent, I remember thinking: I'd rather be on the ground right now. As it turned out the Aircraft Captain made a flawless landing and we taxied back to the ramp. By the time we shut down the engines, we were pushing a 15 hour crew day. We accomplished the mission well within the legal limitations and without incident, but I can't help but wonder what would have happened if the weather been any worse or the transit any longer. Would we have pushed as hard to get home? I'd like to think that the desire to get home and the perceived pressure of maintaining the SAR coverage would not have overridden our good judgement. ♦



Photo: WO Serge Peters

Decision to Land

By Major Dennis Scharf, Central Flying School, 17 Wing Winnipeg

A number of years ago I had the opportunity to provide my contribution to the Canadian Forces as a Multi-engine Qualified Flying Instructor but first I had to complete the King Air conversion training. I was becoming very familiar with the aircraft and some of the smaller aerodromes in the area, developing a skill set and an increased self confidence, contributing to a fairly quick conversion to the familiar King Air. During this upgrade process to achieve aircraft captain status, our flying program was briefly delayed due to some of the winter storms that frequently pass through southern Manitoba. We were just finishing up the required daytime training items and now ready for the night sequences, which included a number of circuits and a short cross-country to practice navigation and circuit joining procedures.

The storm had dumped around four inches of snow by mid-afternoon and the airport snow removal team was doing a great job of getting rid of the white stuff by nightfall. As we arrived on duty all systems were a go. Weather and NOTAM's checked, performance figures reviewed and confirmed, aircraft walk around and all appropriate briefings

completed. It looked like we were going to have a successful and productive night despite what Mother Nature had thrown our way. Attempts were made to contact the airport operators of our planned route but these attempts were unsuccessful due to the time of day. We set off and completed the majority of our training requirements including circuit work and IFR approaches and decided to finish off the remaining items during our "Round Robin" cross-country flight. Everything was going great at the first couple of aerodromes but when we arrived at our last airport we triggered the ARCAL lighting but the runway lights looked awfully fuzzy from 1500 feet above ground level (AGL). I elected to make a low level observation pass to look at the runway conditions before deciding to get the remaining performance landing and take-off exercise in before returning home. As we passed over the length of the runway at 300 feet AGL the conditions appeared favourable with a blanket of snow and some drifts apparent from the shadows. As I discussed the situation with my instructor, the plan was to attempt the landing but if it did not look good on short final either pilot could call the overshoot. Perhaps my presentation and self confidence may have played a role in his acceptance of my decision to "give it a try". The approach for a maximum

effort landing was good right until we touched down then it was quite apparent that there was a lot more snow than we had first assumed. I kept the aircraft moving up and down the runway a number of times until we had sufficiently packed the snow enough to ensure we would not get stuck.

I discussed the situation with my instructor, who was as surprised as me, and elected to do a survey of the runway on foot prior to attempting any take-off. I paced off the usable portion of the runway then returned to the aircraft to reference the performance charts. We then proceeded with a lengthy discussion of all the possible implications and milestone decisions that would be made during the takeoff to ensure legal compliance and safety including having the instructor (Aircraft Commander) in the left seat. Long story short, a successful takeoff ensued with all requirements for the mission being met but we both returned with a valuable learning experience, leaving work that night much wiser. I can truthfully say that the Human Factors training we had previously received contributed to the safe team work and decision making process, despite the mess we had put ourselves in. ♦



STAYING GROUNDED

By Captain Jody Hanson, Air Traffic Controller, 8 Wing Trenton

It was the end of a successful spring BOXTOP. I was a CC130 *Hercules* navigator on one of the flying crews and it had been a good deployment. It was the morning of the last day, and my crew and I were all tired from the festivities that had taken place the night before at the final buffet supper. We knew we had to fly the next morning, so we had respected the 12 hour “bottle to throttle” rule, but it was still a late night for everyone.

Our flight was the last scheduled Canadian departure out of Thule that morning with a load of passengers all itching to get home after 3 weeks away. As we were flight planning, we watched the two other *Hercules* aircraft and an CC150 *Polaris* depart the airfield one by one. We were anxious for our turn to depart the runway and we were talking about each other’s

plans for the days off following the deployment. Finally it was our turn to walk out to the aircraft and start our pre-flight checks. Since we were the last aircraft and we had a full passenger load, I knew that I would be the crewman going out in front of the aircraft when it came time for the start. So as we approached the aircraft from the rear, I surveyed the ground around the aircraft to make mental notes about the chock status, FOD, etc. I saw nothing out of the ordinary, made a mental note and continued into the airplane to do my own pre-flight checks.

When it came time for the start, I was making my way out to the front of the aircraft when a Danish airfield technician approached me with something in his hand. He had the grounding wire! He was walking by and had noticed that it was still attached to the aircraft and grounding pin! Neither I nor any of my crewmates had noticed the wire. If the technician had not seen it, we would have

started, taxied and potentially taken off with an extremely long wire still externally connected to the back of the aircraft, flopping dangerously in the air. The possible complications from that are extremely scary!

Most likely due to self-induced fatigue and a sense of “get-home-itis,” I had not properly carried out the checks required of a start crewman. Lesson learned – if you know you’re tired and maybe feeling a little complacent, that is the time to make the extra effort to ensure your mind is fully in the game. Better to arrive late than never. ♦

From the Investigator

TYPE: CC115 *Buffalo* (115465)

LOCATION: Kelowna Airport, British Columbia

DATE: 26 November 2009

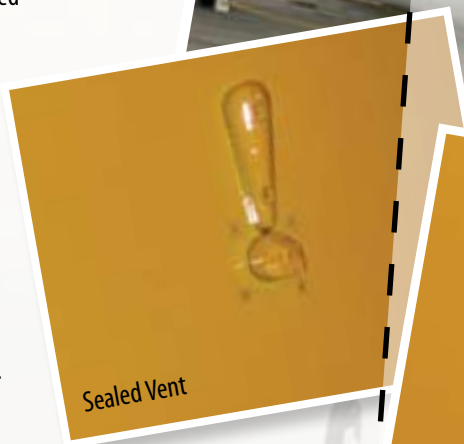
The occurrence aircraft was undergoing a complete maintenance overhaul (referred to as a periodic inspection) at a civilian contractor's facility. As part of this procedure, the aircraft exterior was to be completely stripped and repainted; which was being completed in parallel with the overhaul of mechanical systems.

During refinishing, adhesive backed metal aluminum tape was used to seal the fuel tank vents, as per normal procedures. But in this case, the repainting task was only partially completed and the tape had not yet been removed, when the aircraft was scheduled for a fuel leak check as part of a parallel maintenance routine.

The Crew Chief had reviewed the Canadian Forces Technical Order (CFTO) pertaining to the fuel system and other systems, prior to commencing the leak check, which required the pressure refueling of all tanks. The outer wing fuel tanks were filled without incident, but as the inner wing fuel tanks gauges were indicating approximately 3700 lbs of the total 4160 lbs capacity, a bang was heard, and shortly thereafter, fuel was seen pouring from the right inner-wing fuel tank trailing edge, near the retracted wing flaps. The fuel spill was contained with absorbent material but the aircraft sustained

very serious damage to the center wing box assembly. There were no injuries.

The focus of the investigation will be on the practicality and applicability of CC115 CFTO procedures with respect to simultaneous maintenance work processes. The maintenance procedures for other fleets will also be comparatively assessed. ♦



From the Investigator

TYPE: CT156 *Harvard II* (156101)

LOCATION: 25 nautical miles south of Moose Jaw, Saskatchewan

DATE: 13 August 2009

The incident involved three CT156 *Harvard II* training aircraft. The first aircraft was on a Clearhood dual mission with the student in the front seat. The two other aircraft were a formation, with "lead" having a crew of two and flown by an instructor in the front seat. Number 2 was a dual flight with the student in the front seat. Both missions were properly briefed and dispatched and had selected airspace that was laterally and vertically separated, but adjacent, with the formation in the western airspace and the single ship in the eastern.

The clearhood mission was recovering from a landing attitude stall when a "non threat" aircraft was spotted off the aircraft's nose. The student manoeuvred to setup for a final turn stall heading west near the western edge of their airspace, while the instructor wrote down the details of the traffic conflict. Just as the instructor was finishing the note, the student called "traffic" for a different aircraft. The instructor looked up and first saw an aircraft off the nose and left and in a climbing right hand turn away from their position and then a second aircraft, co-altitude and closing quickly. The instructor immediately took control of the aircraft and pushed the aircraft nose over, then, assessing that they were still on a collision course, quickly rolled the aircraft inverted and pulled five plus "g" to complete the miss. The wing of the other aircraft was seen to flash by and the aircrew assessed the miss distance as being less than 100 feet. The instructor terminated the mission and returned to base.

The formation mission entered their planned area and proceeded with their planned mission. Upon completion of the fluid manoeuvring part of the mission the lead called "terminate" and initiated a slight climb and a left turn back towards the middle of the area as during manoeuvring he had flown near the eastern edge of his airspace. Number 2 was in a "fighting wing" position on the right side of the formation. The student in number two saw traffic and initiated a full power climbing turn to the right, as the traffic looked as if would transit between the formation members. The instructor in number two took control, reversed the turn and saw the conflict aircraft slicing down and away from lead. Lead had not seen the conflicting traffic and neither aircraft in the formation realized how close the miss was. The mission was then completed without further incident.

The investigation is focusing on multiple contributing factors, including but not limited to airspace management and flight operations procedures. 2CFFTS has enhanced the role of the operations desk in assigning airspace. Other preventive measures recommended include further segregating 15 Wing airspace and pursuing an electronic based collision avoidance system for 15 Wing aircraft. ♦



Epilogue

TYPE: CC130 *Hercules* (130319)

LOCATION: Camp Mirage

DATE: 24 June 2009



The incident occurred in the evening at Camp Mirage while a maintenance crew was changing a propeller on a *Hercules* aircraft. The technician at the center of the occurrence was assigned to complete the required Level A and independent checks. As the evening work progressed, the technician's physical state gradually worsened such that he had trouble walking and using the maintenance stands. Supervisors observed his behaviour, expressed their concern and asked if he was fit to continue. The technician stated that he was fine. At one time during the work the technician climbed a maintenance ladder where his footing gave way and he fell three feet to the ground. The member was diagnosed with a serious injury.

The investigation revealed that the member sustained injuries on at least three occasions in the weeks preceding the occurrence. The technician was repeatedly offered medical attention which he always declined, stating that he was fine. On two occasions prior to the occurrence he was ordered by his supervisors to report for medical attention, orders that were willfully disregarded. This was a direct transgression of Queens Regulation and Orders 19.18 "Concealment of Disease", which states: *an officer or non-commissioned member who is suffering or suspects he is suffering from a disease shall without delay report himself sick.* Furthermore, this disregard for orders to seek medical attention was not enforced nor clarified by supervisors. Supervisors allowed

the member to continue to work without restriction knowing that he had not sought medical attention.

As a result of this occurrence the local In-Briefing was reviewed to ensure incoming personnel were aware of their responsibilities such that if they felt ill in some way; they were obliged by the Queens Regulations and Orders to report to a medical facility. In addition, all supervisors were reminded of their responsibility to direct individuals to medical attention when they observed conditions requiring medical attention and to do so in a clear unequivocal manner. To capitalize on the Flight Safety mantra "of learn from the mistakes of others – you will not live long enough to make them all yourself"; this occurrence was made available to the directing staff of the Intermediate Air Force Environmental Qualification course for use as a case study about Air Force supervisory personnel, workplace safety and supervisory responsibilities. ♦

Epilogue

TYPE: CC130 Hercules (130325)

LOCATION: Baker's Island, Trenton Ontario

DATE: 13 May 2009

Freefall parachutist training was being conducted in the late afternoon from a CC130 Hercules aircraft for a stick of four Search and Rescue Technicians (SAR Techs). The destination drop zone (DZ) was the well known gravel surface of the so called 'Pea Bowl' at Baker's Island. Streamers were dropped to assess the wind before the drop and a windsock was located at the DZ. The surface wind was assessed to be from the southeast at 12 to 14 knots, well below the maximum allowable wind speed for parachute training of 25 knots. The Jumper at the center of the occurrence was the third free-fall parachutist to leave the aircraft. In descent, he established a standard downwind pattern to the DZ to permit an into-wind approach and landing. After turning onto base leg, he recognized that the effect of the wind on his movement over the ground was greater than expected. He immediately turned towards the DZ but assessed he was going to land short. The area immediately below him was unsuitable for landing due to obstacles. With some last minute manoeuvring between tall trees, he landed on the sloped, paved road surface that circles Baker's Island and sustained a serious injury.

The investigation focussed on the Jumper's assessment of the wind; low level canopy handling characteristics and the effect of low level winds over confining terrain on the actual landing area. Flying in turbulent air is discussed in the Parachutist Manual (B-GL-322-005/FP-001 Chapter 12 Section 5 paragraph 62 (page 266-267) and in the

Standard Manoeuvre Manual 60-130-2605 (Chapter 4 Section 4, Parachuting Techniques). A warning in paragraph 13 states: 'Gust induced stall or momentary deflation of the canopy is possible due to turbulence and gusts'. A stall will increase the parachutist's rate of descent resulting in injury. It was determined that the area downwind of the original large DZ was composed of obstructions that limited the Jumper's choice of alternate landing zones. The combination of wind direction and its speed over steep terrain features with tall trees was conducive to the production of mechanical turbulence (rotors and eddies). As the Jumper began his final maneuvering to avoid obstacles, he attempted to apply full braking to flare the parachute immediately before landing. The application of full brakes to reduce forward speed in turbulent air likely resulted in a near stalled condition, causing the canopy to lose lift. The Jumper's focus on selecting, assessing and then flying to a less desirable landing zone, together with the distractions of handling the canopy in turbulence resulted in a final rate of descent exceeding the jumper's ability to react and to adopt a proper parachute landing fall.

This occurrence is being widely circulated in the SAR Tech community to emphasize the importance of assessing the wind for ground track and turbulence; early selection of an alternate landing area and the importance of using the parachute landing fall to absorb energy. ♦



Epilogue

TYPE: CF188 *Hornet* (188730)

LOCATION: Bagotville Quebec

DATE: 5 March 2009

A maintenance contractor Periodic Augmentation Team (PAT) conducted a ground run on the Bagotville ramp, to operate the hydraulic system of *Hornet* CF188730. The aircraft was towed outside of the hangar and the Auxiliary Power Unit (APU) was started. After less than two minutes of operation, one of the technicians outside the cockpit observed smoke from the APU area, and requested an emergency shut-down. The technician in the cockpit had heard a voice alert for bleed air, and decided that he would shutdown if he heard it again. Coincident with the discovery of smoke, the ground run operator heard the voice alert for the second time and immediately shut-down the APU, before the aircraft engines were started.

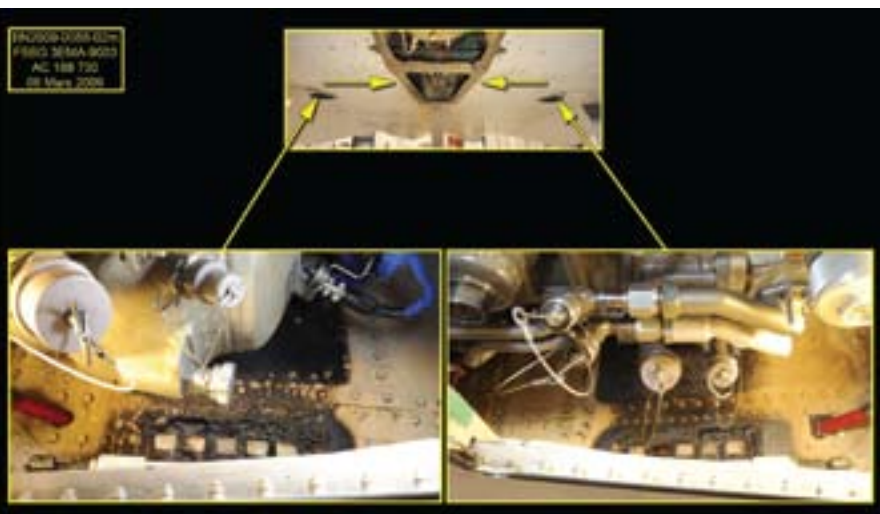
The heat from the APU caused serious damage to the surrounding structure, consistent with C Category Ground Accident criteria.

The investigation revealed that the run-up was being carried-out to lower the leading edge flaps in order to make a repair. Consideration by the PAT was given to using the hydraulic cart to pressurize the hydraulic system. Based on the assumption that a run-up takes about the same amount of time as using a hydraulic maintenance stand, this option was discarded in favour of the run-up. Although time is a factor, an assessment of the risk associated with each option available was not considered. This is part of the basic concepts of Human Performance in Military Aviation (HPMA) which recommends the use of the "AIPA" model. AIPA is a closed loop process that represents the decision making model: Awareness, Implications, Plan, and Act. At the second step, Implication, the individual going through the process will assess all possible choices and their associated risk. In the case of this accident, time was the only factor considered but the reality is that there is much less risk on the equipment and personnel when using a hydraulic test stand.

The investigation also revealed that although the written emergency procedure covers this scenario properly, the ground run simulator did not have this particular scenario in their library.

As a result of this investigation, the following preventive measures were taken or recommended:

- A status board was added in the maintenance bay to clearly show if the aircraft is safe for various maintenance tasks: A/C safeties, Flight control, Landing Gear cycles, Environmental Control System (ECS), Electrical power, and Run-up. Only the floor supervisor can change the status to 'green'.
- Provide HPMA training to contractors working at the wing.
- As a proactive measure, the team will make a review of operations/safety after every periodic.
- New scenarios will be developed for the simulator, to include emergencies while the APU is running on its own. ♦



Epilogue

TYPE: CF188 *Hornet* (188931)

LOCATION: Hickam Air Force Base, Hawaii

DATE: 07 July 2008



At approximately 2135 Zulu on 7 July 2008, Dagger 33's right engine flamed out after landing at Hickam Air Force Base, located at Honolulu International Airport. Dagger 33 was a CF18 Hornet aircraft returning to base as the wingman with a USAF F15 Eagle aircraft, Mytai 17. Just prior to landing Mytai 17 and Dagger 33 were told to overshoot and go around. When Mytai 17 asked Dagger 33 about his fuel state, Dagger 33 stated a fuel quantity about 500 lbs greater than it actually was and said he was almost at the minimum fuel state. During an extended traffic pattern back to the runway, Dagger 33 did not inform Mytai 17 or ATC that he was actually going to land with less than emergency fuel, 1200 lbs. On second final approach Dagger 33 shut down the left engine and proceeded to land with about 640 lbs total

fuel. The right engine flamed out on the taxiway with approximately 500 lbs of fuel indicating. Post occurrence investigation determined that the Fuel Quantity Gauging system and the Fuel Quantity Indicating system were both functioning normally. It is unknown why Dagger 33 would not accurately report the aircraft's fuel state when queried by Mytai 17 and then not take the necessary action to ensure the aircraft landed with more than 1200 lbs of fuel. It is possible that in this occurrence the pilot was reluctant to declare an emergency, thinking that when ATC was advised of the "min fuel" state he would receive enough sequencing priority to land above emergency fuel, but that priority never came and he inadvertently crossed a line that locked him into this particular outcome.

Numerous changes to the CF18 Aircraft Operating Instructions and the CF18 How to Fly manual were recommended that included guidance for ancillary selection and throttle management during low fuel situations and a statement that highlights when total fuel is less than 500 lbs, engine operation is not assured.

It was recommended that all CF18 pilots receive a briefing with emphasis on using proper radio terminology, the fact that a declaration of minimum fuel does not guarantee sequencing priority and that the pilot must declare emergency fuel if sequencing priority is required. ♦

Epilogue

TYPE: **CH146 Griffon (146437)**

LOCATION: **Calgary, Alberta**

DATE: **3 November 2007**

Griffon helicopter CH146437 was used as a static display aircraft for a job fair activity organised by the Calgary recruiting center and held at HMCS Tecumseh in downtown Calgary. The event involved personnel from several units including, but not limited to, the recruiting center and 14 Service Battalion, both from Calgary, and 408 Tactical Helicopter Squadron (THS) from CFB Edmonton. The occurrence happened as displays were being dismantled at the end of the day's events when a Medium Logistic Vehicle Wheeled (MLVW) was being driven out of the building to be parked in the vehicle compound located a few hundred feet and at the eleven o'clock position from the doorway of the building. Two people were taking care of moving the vehicle, the driver and his passenger. The passenger acted as a ground guide while the vehicle was driven in close proximity to obstacles inside the building. The ground guide boarded the vehicle just prior to exiting the building. The MLVW drove between the aircraft (on its left) and a Heavy Logistic Vehicle Wheeled (HLVW) (on its right). As the vehicle turned left, it hit the trailing edge of the aircraft's forward non-folded main rotor blade with the canvas support beams of the cargo area. Neither the driver nor the passenger noticed that the MLVW had contacted the rotor blades until someone went to the vehicle and informed them of the incident.

The investigation revealed that all the preparation for the static display was done over the phone and that no prior reconnaissance by 408 THS personnel was conducted. The original intent was to have the helicopter display located inside the building at HMCS Tecumseh. The crew arrived on location the day prior to the event; only to find that the helicopter would not fit through the door with the mission kit installed (FLIR, Night Sun, and two door guns). The decision was then made to leave the helicopter outside near the doorway so that people inside the building could see it. A security perimeter (using no parking signs) was present around the helicopter for some time during the day; however, the signs were removed at some point before the incident. The investigation could not determine when or why the signs were removed. The investigation concluded that poor knowledge of orders applicable to security in vicinity of air displays contributed to this occurrence.

Preventive measures from this occurrence include:

- Better direction provided to air display directors (ADD) via the tasking message vehicle, to ensure proper knowledge of ADD duties and responsibilities
- Highlighting the fact, on the MLVW drivers course, that visual acuity while driving the MLVW is greatly reduced due to the ergonomics of the vehicle ♦



Epilogue

TYPE: CT155 *Hawk* (155204)

LOCATION: South of Cold Lake, Alberta

DATE: 19 October 2009

The incident occurred during a routine Air to Surface Tactics training mission being flown at low altitude within the borders of the Cold Lake low flying area. The aircraft was being flown from the front seat by a student fighter pilot with an experienced instructor occupying the rear seat. During the simulated transmission of a tactical report the aircraft experienced an uncommanded nose-down pitch change. At the time, the aircraft was flying straight and level at 426 knots and 385 feet above ground level. The aircraft quickly nosed over to approximately four degrees nose down attitude with a peak negative “g” of -0.6. The student pilot initially thought that the instructor had made a stick input to indicate to him that he should be flying lower (the instructor did not do this). The instructor initially thought that the student may have become incapacitated and had fallen on the controls. The aircraft lost about 100 feet before both pilots initiated recovery action by pulling back on the stick.

The instructor estimated it required a 40 to 50 lb pull force to raise the nose above the horizon but he reported stick pressure became normal during the final portion of the recovery and, following a controllability check, the aircraft landed uneventfully at Cold Lake.

The investigation determined that the aircraft experienced a tailplane nose-down trim run-away. A thorough technical investigation was unable to find any fault with the trim system and the aircraft ground checked and test flew



serviceable. The pilots were confident they had not made an inadvertent trim input.

Based on a simulator trial and, as stated in the Aircraft Operating Instructions, an uncommanded full trim input can be easily countered by the pilots. However, both pilots were startled and neither pilot considered that it could have been a tail plane trim run-away situation. The altitude loss was exacerbated by the student's delayed response and confusion regarding why the stick was moving forward on its own. Previous exposure / training to a run-away trim emergency in a controlled

environment would improve the aircrew's familiarity with the symptoms and likely result in a quicker response. Additionally, such practice would build pilot confidence in their ability to safely control the aircraft during an extreme out-of-trim condition.

The investigation recommended that prior to participation in a low level training phase pilots complete a full runaway nose-down trim exercise in the simulator. It was also recommended that a "Tail Plane Run-away Trim" procedure be added to the Hawk critical emergency checklist. ♦

Epilogue

TYPE: CU170 *Heron* (170251)

LOCATION: Kandahar, Afghanistan

DATE: 5 January 2009

At dusk *Heron* CU170251 was being towed eastbound on Foxtrot taxiway (Kandahar) by a small, 4 wheel-drive, 2 passenger, Kawasaki mule utility vehicle. Both headlights and an amber strobe light were illuminated on the mule while the *Heron's* navigation, strobe and taxi lights were on. Four ground crew members were riding in the mule, two in the vehicle seats and two sitting facing backwards on the hatch of the mule's cargo bed. Concurrently, a Security Forces (SF) vehicle (pickup truck) was travelling westbound towards the setting sun along Foxtrot's Motor Transit Route (MTR). The MTR consists of two lanes on the south side of Foxtrot's taxiway centerline and operates much like a two lane road.

When the collision became apparent, the front seat passenger on board the mule attempted to get the SF vehicle driver's attention. The driver of the SF vehicle heard yelling and looked towards the mule. Moments later, the SF vehicle collided with the right wing of the *Heron*. Upon impact, the *Heron* turned violently to the right, the right wing rode up the truck's windshield and along its roof and the left wing approached, but did not contact the two ground crew personnel sitting in the back of the mule. The *Heron* sustained significant damage to the right wing and the SF vehicle windshield was shattered. No one was hurt in the incident.

The investigation revealed that the SF driver saw the aircraft in tow only after the impact

and the mule driver did not attempt any avoidance manoeuvres as he had right of way over the ground vehicle. Foxtrot taxiway and the MTR are not under positive control from the control tower and are only under procedural control with its authorized use and Right of Way procedures detailed in Flight Line Driving SOP. SF personnel are permitted onto the MTR for the conduct of their security tasks, however in this instance they were using the MTR as a shortcut to transport personnel. Some SF supervisors were aware of the use of the MTR as a shortcut but had not implemented measures to prevent such activity.

Since this occurrence preventive measures have been put in place to prevent future incidents. They include the following:

- dissemination of a *Heron* information package to all unit flight line driving instructors to detail the aircraft characteristics
- prohibition of ground crew from riding in the back of the mule for personal safety reasons
- reduction of Foxtrot taxiway operations to essential requirements only
- when use of Foxtrot taxiway cannot be avoided, the *Heron* is towed slightly north of the taxiway centerline, limiting the wing overhang over the MTR
- additional light sources have been implemented on both the UAV and tow vehicle during night towing operations

- vehicle traffic on the MTR has been further restricted by the closure of some access points
- infractions to Flight Line Driving SOPs are now briefed to COMKAF Command Staff at their daily briefings ♦



For Professionalism

For commendable performance in flight safety

Second Lieutenant Jeremy Waller

While awaiting his primary flight training, 2Lt Waller was posted to 404 Squadron in Greenwood, NS. In July 2008, he was a passenger onboard an *Aurora* aircraft that was departing Bagotville, Quebec for a return flight to Greenwood. On climb out from Bagotville, 2Lt Waller brought an abnormality to the attention of the flight deck crew. While sitting in the port forward observer's seat, he noticed that something appeared out of the ordinary on one of the engines. Two inboard engine cowling fasteners on the number one engine were not properly secured. In recalling his passenger briefing that he should bring anything that appeared abnormal to the attention of a crew

member, he proceeded to alert the flight deck crew of the situation. After doing so, the crew elected to return to Bagotville as a precautionary measure. Left unreported, the risk of the engine cowling opening during flight posed a serious threat in damaging the aircraft and would have placed the crew in an emergency situation. 2Lt Waller's outstanding observational skills, situational awareness and professionalism for an on-the-job training pilot is worthy of praise. His airmanship is to be commended and his actions make him very deserving of this For Professionalism award. ♦

Second Lieutenant Waller is currently serving with 404 Long Range Patrol and Training Squadron, 14 Wing Greenwood.



Captain Andy Robbins

During a maintenance investigation of a roll spoiler failure in a CT142 Dash-8 aircraft, it was determined that the spoiler cable tensions were not within limits. Further investigation revealed that the technicians at the unit did not believe that checking the spoiler cable tension during periodic inspections was required as per the direction on the periodic task cards. Capt Robbins, an Air Maintenance Officer did not believe this was correct. He discovered that the specific wording to check spoiler cable tensions had been changed in the periodic task cards. The functional phase task cards included the CFTO as a reference and the CFTO contained a note to ensure correct rigging before starting the functional check. Capt Robbins did not think that the direction in the periodic task cards was clear and he questioned whether other flight control cable tensions were being

checked during inspections. To confirm his suspicions, the rudder cable tension was checked on another aircraft and was found to be well out-of-limits. This resulted in the entire CT142 Dash-8 fleet being declared unserviceable and all control cables were inspected and adjusted. In addition, Capt Robbins believed this check more logically belonged in the survey phase when panels are removed and the systems are accessible. He diligently staffed periodic task card amendments to include specific direction to check cable tensions during the survey phase.

Using his extensive technical experience on the CT142 aircraft, Capt Robbins was able to identify the root cause of a problem that affected the entire fleet and he developed corrective measures to maintenance procedures to ensure the safety of the CT142 flight control system. His efforts are truly deserving of this For Professionalism award. ♦



Captain Robbins is currently serving with 402 Squadron, 17 Wing Winnipeg.

For Professionalism

For commendable performance in flight safety

Corporal David Walbourne

On the 30 September 2008, Cpl David Walbourne, an aviation technician with 413 Squadron, was performing a Before Flight check on a CC130 *Hercules* aircraft. The inspection was taking place later in the day which necessitated the use of a flashlight. During a visual inspection of the aircraft's exterior from the ground, his attention was drawn to a small section of bare metal located on the underside of the left hand horizontal stabilizer approximately 15 feet above him. Suspecting a possible sheared rivet on the elevator trim tab, he obtained a maintenance stand to allow for a more detailed inspection and discovered that one rivet visible from the ground was sheared, plus three additional rivets were sheared and several more were compromised. Upon discovering more damage than initially suspected, he expanded his search in an effort to determine the cause of the damaged rivets and after further investigation

discovered a broken lobe at the elevator trim tab hinge point. He immediately informed his supervisor of the situation and requested an Aircraft Structures technician to assess the damage and probability of repair. During subsequent removal of the elevator trim tab, a four inch crack was discovered along the hinge section resulting in a complete replacement of the elevator trim tab. Cpl Walbourne's outstanding professionalism, sound decision making and remarkable troubleshooting techniques prevented a serious failure of the secondary flight control which could have compromised flight characteristics with potentially catastrophic results.

An excellent role model and asset of 413 Squadron's maintenance organization; he is to be commended for his extraordinary attention to detail and willingness to look beyond normal maintenance requirements and is deserving of this For Professionalism award. ♦



Corporal Walbourne is currently serving with 413 Transport and Rescue Squadron, 14 Wing Greenwood.

Mr Rick Steeves

On 03 March 2009, Mr. Rick Steeves, a Bombardier servicing technician and apprentice technician at the NATO Flying Training in Canada (NFTC) school, was assigned to carry out a Thru Flight Inspection on a CT156 *Harvard II* aircraft. While inspecting the rear cockpit, Mr. Steeves noticed a piece of FOD under the rear ejection seat. Although the Thru Flight Inspection does not call for a FOD check, nor is there a FOD check called for in the AFMO Process 6102, CT156 *Harvard II* Servicing Activities, Mr. Steeves took it upon himself to check under the ejection seats during inspection. Not knowing what the FOD was, Mr. Steeves ensured that the aircraft was placed unserviceable and immediately took the metal piece into the hangar to see if anyone could

identify the FOD. An investigation determined that the FOD was the indent lever bolt of the Power Control Lever (PCL) that the tensioning spring is attached to. Both PCLs in the aircraft were inspected and it was determined that the metal piece was from the forward PCL. The tensioning spring was still attached by one end but the other end was dangling. Mr. Steeves' find initiated an inspection of all spares in supply and a cursory check of *Harvard II* aircraft revealing no other missing pieces from any of the installed PCLs. If this condition had gone undetected and the aircraft was sent flying, the FOD could have potentially jammed flight control cables and/or the PCL could have jammed during flight due to the tensioning spring dangling down. For the outstanding performance of his duties, Mr. Steeves is awarded the Flight Safety For Professionalism award. ♦



Mr Steeves currently works for Bombardier NATO Flying Training in Canada, 15 Wing Moose Jaw.