Australian Government
Civil Aviation Safety Authority

Civil Aviation Advisory Publication

Effective 3 June 2010

Pilots' responsibility for collision avoidance in the vicinity of non-towered (non-controlled) aerodromes using 'see-and-avoid'

This publication is advisory and provides guidance on how to comply with the *Civil Aviation Regulations 1988 (CAR)*.

Pilots are strongly advised that it is in their best interest to read this advisory publication that support the regulations.

Contents

The relevant regulations and other references

- CAR 161 *Right of way*
- CAR 162 *Rules for prevention of collision*
- CAR 163 *Operating near other aircraft*
- CAR 166 *Definitions for Subdivision 2*
- CAR 166A *General requirements for aircraft on the manoeuvring area or in the vicinity of a non-controlled aerodrome*
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- CAR 166E *Requirements for operating on or in the vicinity of certified, military, registered or designated non-controlled aerodromes*
- CAR 167 *General requirements for aerodrome traffic at controlled aerodromes*
- CAR 243 *Listening watch*
- Civil Aviation Advisory Publication (CAAP) 5.59-1(0) *Teaching and Assessing Single-Pilot Human Factors and Threat and Error Management* (http://casa.gov.au)
- Australian Transport Safety Bureau (ATSB) Aviation Research Report published 1 April 1991 *Limitations of the See-and-Avoid Principle* (http://atsb.gov.au)
- Federal Aviation Administration (FAA) Advisory Circular (AC) 90-48C *Pilots' Role in Collision Avoidance* (http://rgl.faa.gov)
- FAA Advisory Circular (AC) 90-66A *Recommended Standards Traffic Patterns for Aeronautical Operations at Airports without Operating Control Towers* (http://rgl.faa.gov)

To whom this CAAP applies

This CAAP applies to all student, private, commercial, air transport, sport and recreational pilots who operate at, or in the vicinity of, non-towered aerodromes. This includes gliders, ultralights, balloons, and gyroplanes flown on pilot certificates issued by the Australian Ballooning Federation Inc. (ABF), Australian Sport Rotorcraft Association Inc. (ASRA), Hang Gliding Federation of Australia Inc. (HGFA), Gliding Federation of Australia Inc. (GFA), and Recreational Aviation Australia Inc. (RA-Aus).

Why this publication was written

This publication was written to provide advice on the limitations of 'see-and-avoid', and on the use of radio to provide 'alerted see-and-avoid', in order to enhance and maintain separation in a busy air traffic environment. It provides practical advice to pilots on their role in collision avoidance through the see-and-avoid principle to prevent mid-air collisions or airprox events, particularly in the vicinity of non-towered aerodromes.

This publication will support CAAP 166-1(0) *Operations in the vicinity of non-towered aerodromes* when it becomes effective on 3 June 2010.

Status of this CAAP

This is the first CAAP to be written about the see-and-avoid principle as a single subject.

Flying instructors should also refer to CAAP 5.59-1(0) *Teaching and Assessing Single-Pilot Human Factors and Threat and Error Management* from which much of the material for this CAAP was drawn.

For further information

Email the CAR 166 Project Leader at nprm0908os@casa.gov.au.

1. Acronyms

AC	Advisory Circular
ACAS	Airborne Collision Avoidance System
airprox	aircraft proximity
ATC	air traffic control
ATSB	Australian Transport Safety Bureau
CAAP	Civil Aviation Advisory Publication
CAR	Civil Aviation Regulations 1988
CASA	Civil Aviation Safety Authority
FAA	Federal Aviation Administration (of the United States of America)
GA	general aviation
ICAO	International Civil Aviation Organization
QNH	Q code for Nil Height (altimeter subscale setting to obtain elevation or altitude)
TCAS	Traffic Collision Avoidance System (see ACAS)
VHF	very high frequency

2. Definitions

Airmanship *[ICAO Annex 1 to the Convention on International Civil Aviation, Section 1.1 Definitions]**:*** The consistent use of good judgement and well-developed knowledge, skills and attitudes to accompany flight objectives.

Airprox *[ICAO Document (DOC) 4444, Chapter 1 Definitions]**:*** A situation in which, in the opinion of a pilot or air traffic services personnel, the distance between aircraft as well as their relative positions and speed have been such that the safety of the aircraft involved may have been compromised.

Error *[CAAP 5.59-1(0)]:* Flight crew actions or inactions that:

- lead to a deviation from crew or organisational intentions or expectations;
- reduce safety margins; and
- increase the probability of adverse operational events on the ground and during flight.

Manage(ment) *[CAAP 5.59-1(0)]* To plan, direct and control an operation or situation.

Non-towered aerodrome: An aerodrome at which air traffic control is not operating. This can be either:

- an aerodrome that is always in Class G airspace;
- an aerodrome with a control tower where no air traffic control (ATC) service is currently provided; or
- an aerodrome which would normally have ATC services provided but such services are presently unavailable.

Safe(ly) *[CAAP 5.59-1(0)]* A manoeuvre or flight is completed without injury to persons, damage to aircraft or breach of aviation safety regulations while meeting the standards specified by the Civil Aviation Safety Authority (CASA).

Threat *[CAAP 5.59-1(0)] (University of Texas/GAPAN definition for multi-crew/LOSA operations)**:***

Events or errors that:

- occur outside the influence of the flight crew;
- increase the operational complexity of the flight; and
- require crew attention and management if safety margins are to be maintained.

Threat *[CAAP 5.59-1(0)] (CASA modified definition for single pilot operations)**:***

A situation or event that has the potential to impact negatively on the safety of a flight, or any influence that promotes opportunity for pilot error(s).

Threat and Error Management (TEM) *[CAAP 5.59-1(0)]:* The process of detecting and responding to threats and errors to ensure that the ensuing outcome is inconsequential, i.e. the outcome is not an error, further error or undesired state.

3. Introduction

3.1 'See-and-avoid', as a means of separation and collision prevention for two or more vehicles, is an ancient principle and one that in the maritime environment predates aviation by many centuries.

3.2 In the early history of aviation, see-and-avoid was the only means for avoiding collision, but as aviation advanced, its limitations have become apparent. Since the early days of flight, additional measures have been sought to reduce the risks of mid-air collision. In parallel with aviation, the maritime industry has adopted, where circumstances have warranted, many of the same means to avoid collisions on the water.

3.3 In modern aviation, see-and-avoid is the last line of defence, but usually not the only mechanism for avoiding a collision or an airprox event.

4. Unalerted see-and-avoid

4.1 Unalerted see-and-avoid is a flight that relies totally on the crew with no other assistance for separation. Unalerted see-and-avoid is only viable in a minority of circumstances when all of the following factors are present to defend against a mid-air collision or airprox event:

- potential horizontal closure rates are slow enough for human reaction;
- potential vertical closure rates are slow enough for human reaction;
- aircraft are of sufficient profile to be seen with the available ambient light, or are made sufficiently conspicuous using artificial lighting;
- aircraft and/or the ground are sufficiently well lit or ambient light provides sufficient contrast; and
- the aircraft structure is such that the pilot's visibility is unhindered in all directions (a near practical impossibility).

4.2 If traffic densities are high enough, humans inevitably fail in their ability to identify and process all the traffic, and thus the risk of collision becomes unacceptably high.

4.3 Improved visual acquisition by pilots alerted to traffic presence (by radio or other means) raises the level of traffic density that can be safely tolerated.

4.4 However, in spite of all its limitations, unalerted see-and-avoid is still a defence against mid-air collisions, and for aircraft without a radio it is the only defence. Good airmanship dictates that all pilots should be looking out and not be solely reliant on radio for traffic separation.

4.5 Unalerted see-and-avoid is an important mechanism for distinguishing aircraft that have a high surface area, particularly if they move slowly. Balloons, airships, powered parachutes and paragliders can generally be seen in most circumstances by pilots of other aircraft of similar speeds. However, pilots of faster aircraft may find (generally with the exception of balloons) these aircraft can be quite difficult to see.

4.6 Gliders and aircraft conducting aerobatics can sometimes be observed more easily because of their constantly changing profile direction, attitude and altitude. These aircraft generally do not remain on a fixed course for a long time, providing the human eye the opportunity to more easily obtain a fix than is the case where speed and direction remain constant.

However, glider and aerobatic pilots should be aware that pilots of other aircraft may find their aircraft difficult to spot. This is especially the case if they are unaware of the glider or aerobatic activity.

5. Alerted see-and-avoid

5.1 As aviation developed, increasing performance, traffic density and flight in non-visual conditions caused limitations of see-and-avoid to surface. The need to enhance a pilot's situational awareness has led to the principle of 'alerted see-and-avoid'.

5.2 The primary tool of alerted see-and-avoid that is common across aviation—from sport and recreational to air transport—is radio communication. Radio allows for the communication of information (in this instance traffic information) to the pilot from the ground (e.g. air traffic control) or from other aircraft.

5.3 For this reason, very high frequency (VHF) radio carriage will become mandatory at and in the vicinity of all registered, certified and military aerodromes (and additional aerodromes as designated by CASA according to risk) from 3 June 2010. These aerodromes will be identified/published in the En Route Supplement Australia (ERSA) and/or by Notice to Airmen (NOTAM).

5.4 Other tools of alerted see-and-avoid include:

- ACAS—Airborne Collision Avoidance System;

  Note: ACAS (and Traffic Collision Avoidance System (TCAS)) relies on transponder information from other aircraft for its pilot alerting and collision avoidance function.

- PCAS—Portable Collision Avoidance System;
- ADS-B—Automatic Dependent Surveillance Broadcast;
- FLARM—flight alarm, a low-cost collision avoidance system originally designed for gliders; and
- Ground-based radar (with traffic information being relayed back to pilots via radio).

5.5 Due to their design, packaging, power requirements or cost, not all the tools listed above are suitable in all circumstances. All, however, provide significant safety gains in the aviation environments for which they are designed.

6. Effective lookout

6.1 Lookout is the principle method of implementing see-and-avoid. Effective lookout means seeing what is 'out there' and assessing the information that is received before making an appropriate decision.

6.2 Vision is the primary source of information for a pilot. Whether it is aircraft attitude, position, physical hazards or other traffic, what a pilot sees is processed by the brain and used to build up situational awareness. In this context, lookout must not be thought of as just scanning the skies to locate other traffic; it also involves the internal and external environment of the aircraft. Vision is used inside an aircraft to interpret flight instruments, flight controls and aircraft systems, and externally to observe and interpret weather, terrain, aircraft attitude and position.

6.3 The multitude of factors that can adversely affect vision and lookout includes the amount of ambient light, window posts, the cleanliness and crazing of windscreens, and other physiological and psychological concerns. Failure to address these issues could result in limitations to effective lookout.

6.4 Workload mismanagement can lead to excessive 'head in the cockpit' with less time spent looking outside the aircraft during busy periods. Pilots need to move their head to see beyond window posts and any other obstructions such as pilots or passengers in the adjacent seat/s.

7. Seeing and interpreting

7.1 Not only is seeing important, but accurately interpreting what is seen is equally vital. The concept of see-and-avoid is far from reliable *[ATSB]*. By employing an effective scanning technique and understanding how to enhance visual detection of other traffic, a pilot is more likely to reduce the likelihood of collision. Size and contrast are the two primary factors that determine the likelihood of detecting other aircraft, size being the more important factor. As general aviation (GA), sport and recreational aeroplanes and rotorcraft are usually small or have low visual profiles in certain circumstances, the problem of detecting those aircraft is exacerbated.

7.2 AC 90-48C published by the FAA details a scanning technique that involves eye movements in sectors of 10 degrees, of one-second duration per sector. However, scanning a 180 degree horizontal and 30 degree vertical sector would take a minimum of 54 seconds. US military research found that it takes a pilot 12.5 seconds to avoid a collision after target detection. Therefore, it can be deduced that considerable time gaps exist where traffic may not be detected during a normal scan period. Such a structured and disciplined scan technique may also be difficult to achieve. Pilots must develop an effective scan that provides maximum opportunity to see traffic. Passengers in small aircraft may also be utilised to help improve lookout.

7.3 Pilots should remain mindful that certain circumstances will make it difficult for their aircraft to be seen. An aircraft (a small one in particular) will often be rendered difficult to see by the patterns in the surface of the earth when viewed from above, and particularly when over urban areas. Conversely, an aircraft when viewed from below can potentially be much more easily sighted against a uniformly overcast cloud background or blue sky. All pilots would be aware of the difficulty seeing aircraft that have the sun directly behind them.

7.4 Pilots should also be aware that two aircraft converging on a point have the potential to remain fixed in one or both pilots' field of view, i.e. their relative position (in the windscreen) won't change until moments before impact.

8. Traffic separation by radio

8.1 Accurate provision and interpretation of traffic information for the purposes of separation to or from another aircraft is an essential pilot skill. Four commonly used ways of providing and interpreting traffic information by radio communication for the purpose of airborne separation are practised at non-towered aerodromes. All methods have their advantages depending upon circumstances.

- Separation by 'clock code'—Pilots maintain traffic separation by reference to the central axis and numbers of an analogue clock face. Particular care must be given to identifying which aircraft is the central axis of the clock. *You are at my 2 o'clock and low* has the opposite meaning to *I am at your 2 o'clock and low.* The weakness of this method of separation is that it requires at least one pilot to have seen, identified and made contact with the other aircraft.
- Separation by ground reference—Pilots maintain separation by radio by either identifying that each is in different places relative to a ground feature(s), or by agreeing to remain on different sides of a readily identifiable ground feature such as a runway extended centreline, road, town or railway line. The advantage of this method of separation is that it does not require either aircraft to have actually seen each other (although this is desirable). The weakness of this method of separation is that ground features could be misidentified. The uncertainty or confusion can lead to distracting from the effort of retaining separation through see-and-avoid.

  Pilots who offer indistinct local landmarks as separation reference points to other pilots (where they cannot be certain of mutual understanding) may be offering information of limited use.
- Separation by altitude reference—Pilots maintain separation by radio by identifying that each is at a different altitude or by one aircraft descending/climbing to another level. Provided that both aircraft altimeters are set to the correct subscale reference (QNH) for the locality, this method should provide separation for both aircraft regardless of visual contact.
- Separation by navigational or avionic reference—Pilots maintain separation by identifying that each is in a different place relative to a known navigational point or line (radial), or separated by distance from a fixed point (e.g. global positioning system (GPS) or VHF omni-directional radio range (VOR)). This method of separation does not require either aircraft to have actually seen each other (although this is desirable). The weakness of this method of separation is that differing avionic equipment or pilot navigational skill can lead to incorrect assumptions being made about the usability of the separation information offered.

  Pilots who offer instrument flight rules (IFR) reference points as separations to gliders, ultralights or small GA aircraft may not be offering information that is readily usable.

9. Alerted search

9.1 An alerted search is visual scanning when air traffic information has been provided and a pilot knows where to look. Air traffic services or other pilots could provide this information. Transponders are detected by aircraft fitted with ACAS (TCAS) allowing them to 'see' other aircraft and take evasive action if necessary.

The effectiveness of a search for other traffic is eight times greater under alerted circumstances than when just unalerted *[ATSB]***.**

9.2 Technology can assist lookout and pilots should not disregard the benefits that the engagement of an autopilot can provide to visual scanning.

9.3 As threats are external to the aircraft, an effective lookout must be maintained. The pilot must:

- consistently look outside the aircraft;
- search the available visual field to detect threats that will probably appear in the peripheral vision;
- shift vision directly to the threat and, if identified as a collision risk, decide on what effective evasive action to take; and
- manoeuvre the aircraft to avoid collision or an airprox event.

9.4 Pilots must realise that this process takes time; and human deficiencies can reduce the chances of a threat being detected and avoided. The factors affecting lookout may not be errors or poor airmanship, but limitations of the human visual and information processing systems which are present to various degrees in all humans.

9.5 There are two main elements to effective traffic avoidance. Firstly, to see an 'object', and secondly, to react accordingly to what has been seen. An object could range from looking like a speck in the windscreen that is actually an aircraft at long range, to a large feature. The next step would be to determine if the object is a threat, and then take avoiding action.

10. What is situational awareness?

10.1 Simply defined, situational awareness is *knowing what is going on around you, and being able to predict what could happen.* Colloquially, this can be described as 'street smart'.

10.2 A more comprehensive and technical definition is *the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of the status in the near future.*[1]

10.3 The first definition is generic, applies to life in general, and to most occupations. The second definition is more specific to aviation and is often assigned three levels:

- Level 1: Perception of the current environment;
- Level 2: Interpretation of the immediate situation; and
- Level 3: Anticipation of the future environment.

10.4 Monitoring and gathering information from both within the cockpit and outside the aircraft, and the processing on all three levels, is required to build and maintain comprehensive situational awareness.

11. Interaction with other aircraft at, or in the vicinity of, a non-towered aerodrome

11.1 Rules of the air regarding right of way and rules for prevention of collisions should always be respected *[CARs 161 and 162]*. Pilots of powered aircraft should not normally seek right of way from non-powered aircraft, although the offer of right of way may come if conditions are favourable.

11.2 So as not to impede commercial aviation, pilots flying recreational or sport aircraft for their own enjoyment, or pilots flying GA aircraft for their own leisure, should consider giving way to aircraft being used for 'commerce' provided that the inconvenience to their own operation is not great and it can be done safely. Operators of commercial flights should never expect a give way offer to be assumed or automatic. Any offer to give way must be explicit and its acceptance acknowledged.

11.3 Operators of commercial flights should also not assume that a sport or recreational aircraft is being operated for purely non-commercial reasons. Hundreds of individuals Australia-wide derive their income conducting flying training in sport or recreational aircraft.

11.4 Although the conduct of a non-standard circuit join (such as a straight-in approach) may have operational and economic advantages, pilots should be aware that any variations to the recommended circuit join may carry increased collision risks. When varying any standard procedure, it is essential that situational awareness is assessed and maintained.

[1] M. R. Endsley (1988)

11.5 Pilots should be mindful that transmission of information by radio does not guarantee receipt and complete understanding of that information. Many of the worst aviation accidents in history have their genesis in misunderstanding of radio calls, over-transmissions, or poor language/phraseology which undermined the value of the information being transmitted.

11.6 Without understanding and confirmation of the transmitted information, the potential for alerted see-and-avoid is reduced to the less safe situation of unalerted see-and-avoid.

11.7 There are practical limits on how much voice traffic a VHF frequency can efficiently carry. Excessively long radio broadcasts or broadcasts that do not add value to situational awareness have the potential to block transmissions being made by other pilots. Radio communications should be to the point, clear, accurate, and necessary. An unnecessary radio transmission that over-transmits another transmission is as hazardous as making no transmission at all.

11.8 Under no circumstances should a pilot attempt to direct other traffic. Direction of air traffic (as opposed to alerting, requesting or advising) is an ATC function and should not be performed by pilots in flight or on the ground. Pilots who seek to direct other pilots as a pseudo air traffic controller, either innocently or to obtain expedited traffic movement, are acting beyond common courtesy and are potentially operating outside the law. Such actions may expose pilots to liability if their direction results in an undesirable outcome.

Example of appropriate request or advice: "Alpha Bravo Charlie, could you maintain five thousand? We will maintain six thousand until we have passed you."

11.9 Pilots are expected to operate in a courteous and professional manner at all times. Aviation safety relies upon a cooperative approach between all pilots, particularly on and in the vicinity of aerodromes in times of busy traffic.

Note: CAAP 166-1(0) is effective from 3 June 2010 and provides more details on straight in approaches and joining the circuit on the base leg.

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