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PILOT SKILLS TO MAKE "LOOK-OUT" MORE EFFECTIVE IN VISUAL COLLISION AVOIDANCE

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1. INTRODUCTION

1.1 The practice of "see-and-avoid" is recognized as the primary method that a pilot uses to minimize the risk of collision when flying as an uncontrolled flight in visual meteorological conditions. "See-and-avoid" is directly linked with a pilot's skill at looking about outside the cockpit or flight deck and becoming aware of the surrounding visual environment. Its effectiveness can be greatly improved if the pilot can acquire skills to compensate for the limitations of the human eye. These skills include the application of effective visual scanning, the ability to listen selectively to radio transmissions from ground stations and other aircraft to create a mental picture of the traffic situation, and the development of habit patterns that can be described as "good airmanship".

1.2 This circular aims to make pilots aware of the skills required to make "look-out" more effective and is directed mainly towards those pilots who do most of their flying under visual flight rules (VFR). The skills should be of interest to all pilots, however, regardless of the type of aircraft they fly and the flight rules under which they fly since no pilot is immune to collisions.

1.3 A study of over two hundred reports of mid-air collisions showed that they can occur in all phases of flight and at all altitudes. It may be surprising that nearly all mid-air collisions occur during daylight hours and in excellent visual meteorological conditions. While the majority of mid-air collisions occurred at lower altitudes where most VFR flying is carried out, collisions can and did occur at higher altitudes. Because of the concentration of aircraft in the vicinity of aerodromes, most collisions occurred near aerodromes when one or both aircraft were descending or climbing. Although some aircraft were operating as instrument flight rules (IFR) flights, most were VFR and uncontrolled.

1.4 The pilots involved in the collisions ranged in experience from first solo to 15 000 hours of flight time, and their reasons for flying that day were equally varied. In one case a private pilot flying cross-country, legally VFR, in a single-engine aircraft collided with a turboprop aircraft under IFR control flown by two long-time experienced airline pilots. In another case, a 7 000-hour commercial pilot on private business in a twin-engine aircraft overtook a single-engine aircraft on its final approach piloted by a young flight instructor giving dual instruction to a non-soloed student pilot. Two commercial pilots, each with well over 1 000 hours, collided while ferrying a pair of new single-engine aircraft; and two private pilots with about 200 hours logged between them collided while on local pleasure flights in small single-engine aircraft.

1.5 There is no way to say whether it is the experienced or the inexperienced pilot who is more likely to be involved in a mid-air collision. While a novice pilot has much to think about and so may forget to maintain an adequate look-out, the experienced pilot, having flown through many hours of routine flight without spotting any hazardous traffic, may grow complacent and forget to scan.

1.6 If you learn to use your eyes and maintain vigilance through proper awareness, it will not be difficult for you to avoid mid-air collisions. The results of studies of the mid-air collision problem show that there are certain definite warning patterns.

2. CAUSES OF MID-AIR COLLISIONS

2.1 What contributes to mid-air collisions? Undoubtedly, traffic congestion and aircraft speeds are part of the problem. In the head-on situation, for instance, a jet and a light twin-engine aircraft may have a closing speed of about 1 200 km/h (650 kt). It takes a minimum of 10 seconds for a pilot to spot traffic, identify it, realize it is a collision threat, react, and have the aircraft respond. But two aircraft converging at 1 200 km/h (650 kt) will be less than 10 seconds apart when the pilots are first able to see each other!

2.2 These problems are compounded by the fact that air traffic control and radar facilities are, in some cases, overloaded and limited.

2.3 These factors are all contributory causes, but the reason most often noted in the mid-air collision statistics reads "failure of pilot to see other aircraft" — in other words, failure of the see-and-avoid system. In most cases at least one of the pilots involved could have seen the other in time to avoid the collision if that pilot had been watching properly. Therefore, it could be said that it is really the eye which is the leading contributor to mid-air collisions. Take a look at how its limitations affect your flight.

3. LIMITATIONS OF THE EYE

3.1 The human eye is a very complex system. Its function is to receive images and transmit them to the brain for recognition and storage. It has been estimated that 80 per cent of our total information intake is through the eyes. In other words, the eye is our prime means of identifying what is going on around us.

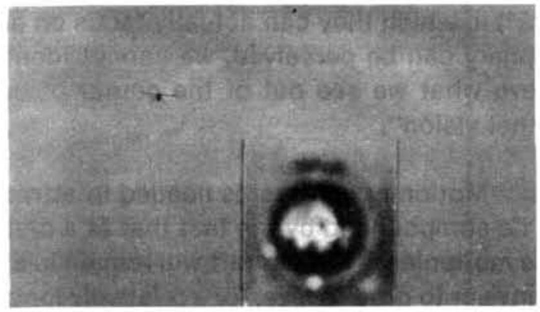
3.2 In the air we depend on our eyes to provide most of the basic input necessary for flying the aircraft, e.g. attitude, speed, direction and proximity to opposing air traffic. As air traffic density and aircraft closing speeds increase, the problem of mid-air collision increases considerably, and so does the importance of effective scanning. A basic understanding of the eyes' limitations in target detection is probably the best insurance a pilot can have against collision.

3.3 The eye, and consequently vision, is vulnerable to many things including dust, fatigue, emotion, germs, fallen eyelashes, age, optical illusions, and the effect of alcohol and certain medications. In flight, vision is influenced by atmospheric conditions, glare, lighting, windshield distortion, aircraft design, cabin temperature, oxygen supply, acceleration forces and so forth.

3.4 Most importantly, the eye is vulnerable to the vagaries of the mind. We can "see" and identify only what the mind permits us to see. A daydreaming pilot staring out into space is probably the prime candidate for a mid-air collision.

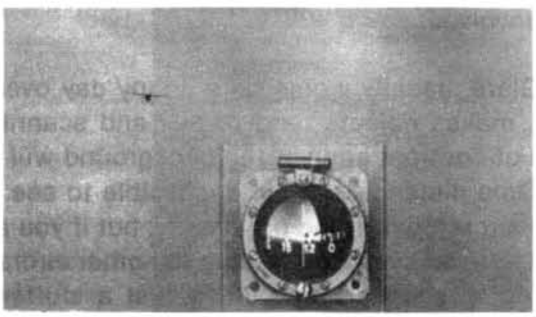
3.5 One inherent problem with the eye is the time required for accommodation or refocusing. Our eyes automatically accommodate for near and far objects, but the change from something up close, like a dark instrument panel two feet away, to a well lighted landmark or aircraft target a mile or so away, takes one to two seconds. That can be a long time when you consider that you need 10 seconds to avoid a mid-air collision. (See Figures 1 and 2.)

Focus point 1 m (compass)

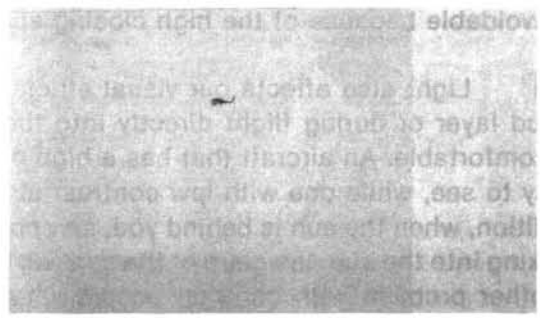


Focus point 500 m (aircraft)

Figure 1. Recognition of an aircraft depending on the eye accommodation



Aircraft head-on,
focus point straight ahead



Aircraft on crossing track,
focus point 45° (right)

Figure 2. Apparent size of light aircraft at 500 m distance

3.6 Another focusing problem usually occurs when there is nothing to specifically focus on, which usually happens at very high altitudes, as well as at lower levels on vague, colourless days above a haze or cloud layer when no distinct horizon is visible. Pilots experience something known as "empty-field myopia", i.e. staring but seeing nothing, not even opposing traffic entering their visual field.

3.7 The effects of what is called "binocular vision" have been studied during investigations of mid-air collisions, with the conclusion that this is also a causal factor. To actually accept what we see, we need to receive cues from both eyes. If an object is visible to only one eye, but hidden from the other by a windshield post or other obstruction, the total image is blurred and not always acceptable to the mind. Therefore, it is essential that pilots move their head when scanning around obstructions. (See Figure 3.)

3.8 Another inherent eye problem is the narrow field of vision. Although our eyes accept light rays from an arc of nearly 200°, they are limited to a relatively narrow area (approximately 10-15°) in which they can actually focus on and classify an object. Although movement on the periphery can be perceived, we cannot identify what is happening there, and we tend not to believe what we see out of the corner of our eyes. This, aided by the brain, often leads to "tunnel vision".

3.9 Motion or contrast is needed to attract the eyes' attention, and tunnel vision limitation can be compounded by the fact that at a distance an aircraft on a collision course will appear to be motionless. The aircraft will remain in a seemingly stationary position, without appearing to move or to grow in size, for a relatively long time, and then suddenly bloom into a huge mass, almost filling up one of the windows. This is known as the "blossom effect". It is frightening that a large insect smear or dirty spot on the windshield can hide a converging aircraft until it is too close to be avoided.

3.10 In addition to its inherent problems, the eye is also severely limited by environment. Optical properties of the atmosphere alter the appearance of aircraft, particularly on hazy days. "Limited visibility" actually means "limited vision". You may be legally VFR when you have 5 km (3 NM) visibility, but at that distance on a hazy day you may have difficulty in detecting opposing traffic; at that range, even though another aircraft may be visible, a collision may be unavoidable because of the high closing speeds involved.

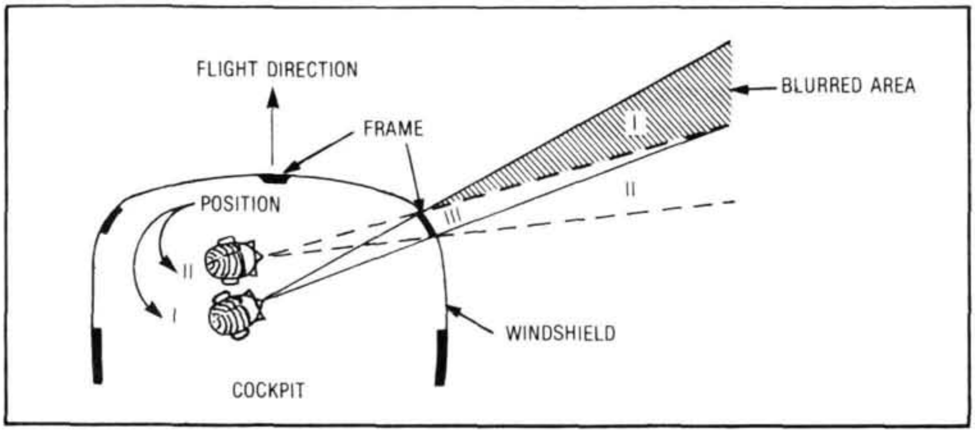
3.11 Light also affects our visual efficiency. Glare, usually worse on a sunny day over a cloud layer or during flight directly into the sun, makes objects hard to see and scanning uncomfortable. An aircraft that has a high degree of contrast against the background will be easy to see, while one with low contrast at the same distance may be impossible to see. In addition, when the sun is behind you, an opposing aircraft will stand out clearly, but if you are looking into the sun, the glare of the sun will usually prevent you from seeing the other aircraft. Another problem with contrast occurs when trying to sight an aircraft against a cluttered background. If the aircraft is between you and terrain that is varicoloured or heavily dotted with buildings, it will blend into the background until the aircraft is quite close.

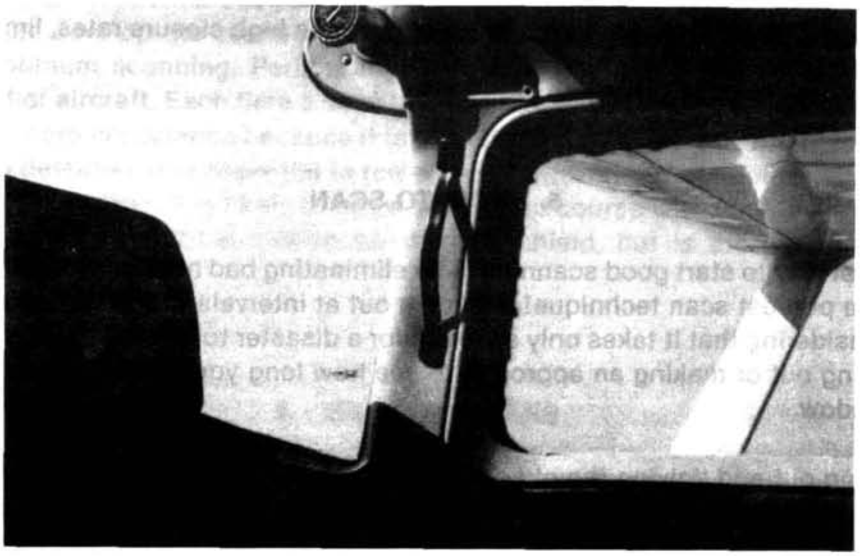
3.12 And, of course, there is the mind, which can distract the pilot to the point of not seeing anything at all, or cause cockpit myopia — staring at one instrument without even "seeing" it.

3.13 As can be seen, visual perception is affected by many factors. Pilots, like others, tend to overestimate their visual abilities and to misunderstand their eyes' limitations. Since a major cause of mid-air collisions is the failure to adhere to the practice of see-and-avoid, it can be concluded that the best way to avoid collisions is to learn how to use your eyes for an efficient scan.

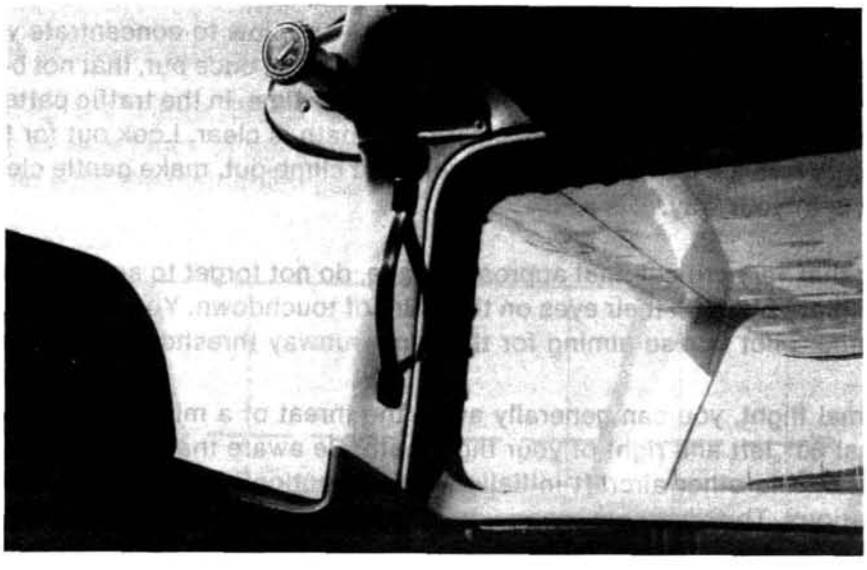
4. VISUAL SCANNING TECHNIQUE

4.1 To avoid collisions you must scan effectively from the moment the aircraft moves until it comes to a stop at the end of the flight. Collision threats are present on the surface, at low altitudes in the vicinity of aerodromes, and at cruising levels.





Aircraft is visible in the lower right hand windshield with the left eye



Aircraft is not visible with the right eye as it is obscured by the windshield post.

Figure 3. Effect of binocular vision

4.2 Before take-off, scan the airspace and the runway visually and with airborne radar if available, to ensure that there are no aircraft or other objects in the take-off area. Assess the traffic situation from radio reports. After take-off, scan to ensure that no aerodrome traffic will be an obstacle to your safe departure.

4.3 Before and during the turn to departure heading, focus particular attention in the direction of the turn.

4.4 During climb and descent, listen to radio exchanges between the controller and other aircraft and form a mental image of the traffic situation and positions of aircraft on opposing and intersecting headings, anticipating further developments. Scan with particular care in the area of airway (route) intersections. You should remain constantly alert to all traffic within your normal field of vision, as well as periodically scanning the entire visual field outside the aircraft to ensure detection of conflicting traffic. Remember that the performance capabilities of many aircraft, in both speed and rates of climb/descent, result in high closure rates, limiting the time available for detection, decision, and evasive action.

5. HOW TO SCAN

5.1 The best way to start good scanning is by eliminating bad habits. Naturally, not looking out at all is the poorest scan technique! Glancing out at intervals of five minutes or so is also poor when considering that it takes only seconds for a disaster to happen. Check the next time you are climbing out or making an approach to see how long you actually go without looking out of the window.

5.2 Glancing out and "giving the old once-around" without stopping to focus on anything is practically useless; so is staring out into one spot for long periods of time.

5.3 There is no one technique that is best for all pilots. The most important thing is for each pilot to develop a scan that is both comfortable and workable.

5.4 Learn how to scan properly by knowing where and how to concentrate your search. It would be desirable, naturally, to be able to look everywhere at once but, that not being possible, concentrate on the areas most critical to you at any given time. In the traffic pattern especially, always look out before you turn and make sure your path is clear. Look out for traffic making an improper entry into the circuit. During descent and climb-out, make gentle clearing turns to see if anyone is in your way.

5.5 During that very critical final approach stage, do not forget to scan all around to avoid tunnel vision. Pilots often fix their eyes on the point of touchdown. You may never arrive at the runway if another pilot is also aiming for the same runway threshold at that time.

5.6 In normal flight, you can generally avoid the threat of a mid-air collision by scanning an area at least 60° left and right of your flight path. Be aware that constant angle collisions often occur when the other aircraft initially appears motionless at about your 10 o'clock or 2 o'clock positions. This does not mean you should forget the rest of the area you can see. You should also scan at least 10° above and below the projected flight path of your aircraft. This will allow you to spot any aircraft that is at an altitude that might prove hazardous to you, whether it is level with you, climbing from below or descending from above.

5.7 The probability of spotting a potential collision threat increases with the time spent looking outside. Certain techniques may be used to increase the effectiveness of the scan. To be most effective, the gaze should be shifted and refocused at regular intervals. Most pilots do this in the process of scanning the instrument panel but it is also important to focus outside the cockpit or flight deck to set up the visual system for effective target acquisition. Pilots should also realize that their eyes may require several seconds to refocus when switching views between items in the cockpit and distant objects. Proper scanning requires the constant sharing of attention with other piloting tasks, thus it is easily degraded by such conditions as fatigue, boredom, illness, anxiety or preoccupation.

5.8 Effective scanning is accomplished by a series of short, regularly-spaced eye movements that bring successive areas of the sky into the central visual field. Each movement should not exceed 10°, and each area should be observed for at least one second to enable detection. Although horizontal back-and-forth eye movements seem preferred by most pilots, each pilot should develop the scanning pattern that is most comfortable and then adhere to it to assure optimum scanning. Peripheral vision can be most useful in spotting collision threats from other aircraft. Each time a scan is stopped and the eyes are refocused, peripheral vision takes on more importance because it is through this element that the presence of other aircraft is often detected. It is essential to remember, however, that if another aircraft appears to have no relative motion, it is likely to be on a collision course with you. If the other aircraft shows no horizontal or vertical motion on the windshield, but is increasing in size, take immediate evasive action.

6. SCAN PATTERNS

6.1 Two scanning patterns described below have proved to be very effective for pilots and involve the "block" system of scanning. This system is based on the premise that traffic detection can be made only through a series of eye fixations at different points in space. In application, the viewing area (windshield) is divided into segments, and the pilot methodically scans for traffic in each block of airspace in sequential order.

Side-to-side scanning method

Start at the far left of your visual area and make a methodical sweep to the right, pausing very briefly in each block of the viewing area to focus your eyes. At the end of the scan, return to and scan the instrument panel and then repeat the external scan. (See Figure 4.)

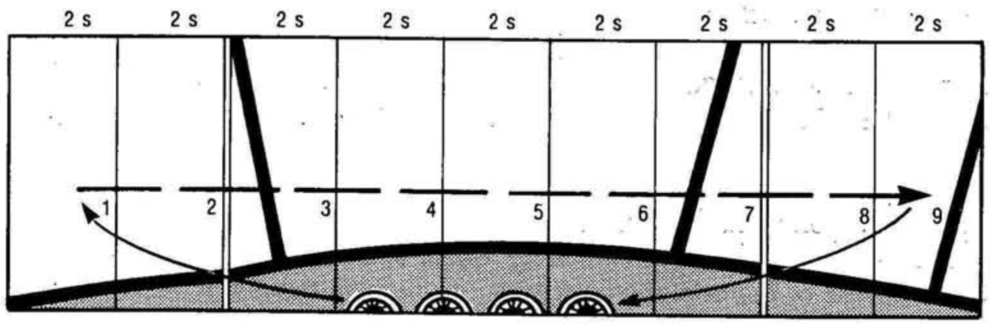


Figure 4. Side-to-side scanning method

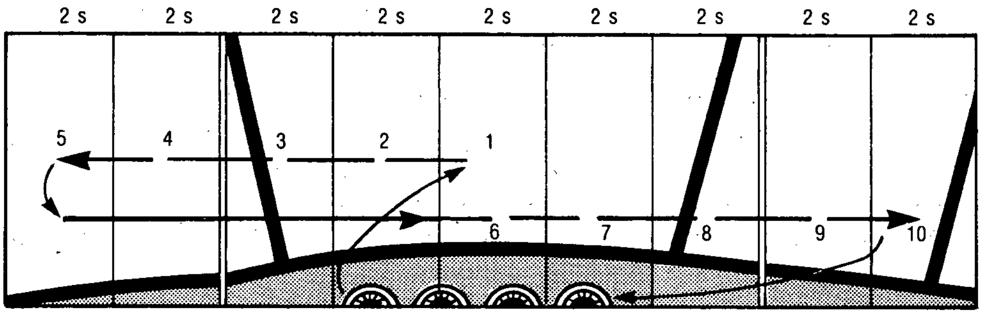


Figure 5. Front-to-side scanning method

Front-to-side scanning method

Start in the centre block of your visual field (centre of front windshield); move to the left, focusing very briefly in each block, then swing quickly back to the centre block after reaching the last block on the left and repeat the performance to the right. Then after scanning the instrument panel, repeat the external scan. (See Figure 5.)

6.2 There are other methods of scanning, of course, some of which may be as effective as the two described above. Unless some series of fixations is made, however, there is little likelihood that you will be able to detect all targets in your scan area. When the head is in motion, vision is blurred and the mind will not register targets as such.

7. THE TIME-SHARING PLAN

7.1 External scanning is just part of the pilot's total visual work. To achieve maximum efficiency in flight, a pilot also has to establish a good internal scan and learn to give each scan its proper share of time. The amount of time spent scanning outside the cockpit in relation to what is spent inside depends, to some extent, on the work-load inside the cockpit and the density of traffic outside. Generally, the external scan will take about three to four times as long as the look at the instrument panel.

7.2 During an experimental scan training course, using military pilots whose experience ranged from 350 hours to over 4 000 hours of flight time, it was discovered that the average time needed to maintain a steady state of flight was three seconds for the instrument panel scan and 18 to 20 seconds for the outside scan.

7.3 An efficient instrument scan is good practice, even when flying VFR. The ability to scan the panel quickly permits more time to be allotted to exterior scanning, thus improving collision avoidance.

7.4 Developing an efficient time-sharing plan takes a lot of work and practice, but it is just as important as developing good landing techniques. The best way is to start on the ground, in your own aeroplane or the one you usually fly, and then use your scans in actual practice at every opportunity.

7.5 During flight, if one crew member is occupied with essential work inside the cockpit, another crew member, if available, must expand his scan to include both his own sector of observation and that of the other crew member; in other words the second crew member must scan ahead and to both sides of the aircraft.

8. COLLISION AVOIDANCE CHECKLIST

8.1 Collision avoidance involves much more than proper scanning techniques. You can be the most conscientious scanner in the world and still have an in-flight collision if you neglect other important factors in the "see-and-avoid" technique. It might be helpful to use a collision avoidance checklist as routinely as you do the pre-take off and landing lists. Such a checklist might include the following items:

Check yourself

Start with a check of your own conditions. Your eyesight, and consequently your safety, depend on your mental and physical condition. If you are distracted before a flight, you should think twice about flying under such circumstances. Absentmindedness and distraction are the main enemies of concentrated attention during flight.

Plan ahead

To minimize the time spent "head down" in the cockpit, plan your flight ahead of time. Have charts folded in proper sequence and within handy reach. Keep your cockpit free of clutter. Be familiar with headings, frequencies, distances, etc. ahead of time so that you spend minimum time with your head down in your charts. Some pilots record these things on a flight log before take-off. Check your maps, NOTAM, etc. in advance for such potential hazards as restricted areas, military low-level routes, intensive training areas and other high-density areas.

Clean windows

During the pre-flight walk-around, make sure your windshield is clean. If possible, keep all windows clear of obstructions such as opaque sun visors and curtains.

Adhere to procedures

Follow established operating procedures and regulations, such as correct levels and proper pattern practices. You can get into trouble, for instance, by "sneaking" out of your proper level as cumulus clouds begin to tower higher and higher below you, or by skimming along the tops of clouds without observing proper cloud clearance. Some typical situations involving in-flight mishaps around airports include: entering a right-hand pattern at an airport with left-hand traffic or entering downwind so far ahead of the traffic pattern that you may interfere with traffic taking off and heading out in your direction. In most in-flight collisions at least one of the pilots involved was not where he was supposed to be.

Avoid crowded airspace

Avoid crowded airspace, such as over a VOR, while en route. Aircraft can be holding over navigation aids even in good weather. If you cannot avoid aerodromes en route, fly over them well above circuit height. Military aerodromes, in particular, should be avoided as they usually have a very high concentration of fast-moving jet traffic operating in the vicinity.

Compensate for blind spots

Compensate for your aircraft's design limitations. All aircraft have blind spots; know where they are in yours. For example, a high-wing aircraft that has a wing down in a turn blocks the view of the area you are turning into. A low wing blocks the area beneath you. One of the most critical potential mid-air collision situations exists when a faster low-wing aircraft is overtaking and descending on to a high-wing aircraft on final approach.

Equip to be seen

Your aircraft lights can help avoid collisions. High intensity strobe lights, which can be installed at relatively low cost, increase your contrast and conspicuity considerably by day and even more by night. In areas of high traffic density, strobe lights are often the first indication another pilot receives of your presence. Transponders allow radar controllers to identify your aircraft in relation to other traffic and provide you with traffic information. The carriage of transponders is now mandatory in certain areas, even when operating VFR. Although it is not always mandatory, the carriage of a transponder in areas where it can be used will increase your chance of receiving traffic information from the radar controller.

Talk and listen

Use your ears as well as your eyes by taking advantage of all the information that you receive over the radio. Pilots reporting their position to the aerodrome controller are also reporting to you. Approaching an aerodrome, call the tower/flight information unit when you are 30 km (15 NM) from the airport, or such other distance or time prescribed by the ATS authority, and report your position, altitude and intentions. When flying in areas where there are no air traffic services, switch to the special frequency established for mutual exchange of information. Even though you can determine the position of another aircraft from a radio report, however, do not stop scanning the rest of the airspace as there may be other aircraft in your vicinity.

Make use of information

Since detecting a small aircraft at a distance is not the easiest thing to do, make use of any hints you get over the radio. Your job is much easier when an air traffic controller tells you that traffic is "three miles at one o'clock". Once that particular traffic is sighted, do not forget the rest of the sky. If the traffic seems to be moving on the windshield, you're most probably not on a collision course, so continue your scan but watch the traffic from time to time. If it does not appear to have motion you should watch it very carefully and get out of its way if necessary.

Use all available eyes

If you normally fly with a co-pilot, you will have established crew prócedures which ensure that an effective scan is maintained at all times. But if you do not, obtain the assistance of suitably qualified persons on board the aircraft to look out for traffic of which you have been made aware and monitor the movement of other aircraft which you have already sighted. Remember, however, that the responsibility for avoiding collision is yours and you must maintain your vigilance at all times.

Scan

The most important part of your checklist is, of course, to keep looking out at where you are going and to watch for other traffic. Make use of your scan constantly.

8.2 If you adhere to good airmanship, keep yourself and your aircraft in good condition, and develop an effective scan time-sharing system, you will have the basic tools for avoiding a mid-air collision. And as you learn to use your eyes properly, you will benefit in other ways. Remember, despite their limitations, your eyes provide you with colour, beauty, shape, motion and excitement. As you train them to spot minuscule targets in the sky, you will also learn to see many other important "little" things you may now be missing, both on the ground and in the air. If you use the brain behind the eyes, you will be around to enjoy these benefits of vision for a long time.

— END —

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The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for world-wide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

Regional Supplementary Procedures (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

Technical Manuals provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

Air Navigation Plans detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

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