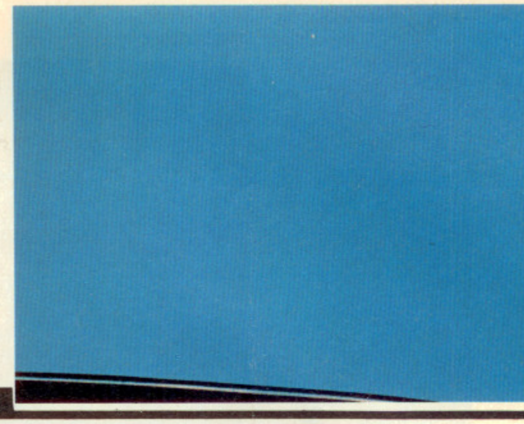
No pilot is invulnerable to an in-flight collision. The most important guard against such mishaps is to know the limitations of the eye and how to effectively scan for other traffic



1 mile

A Project Of The AOPA Air Safety Foundation

How To Avoid A Midair Collision

½ mile

¼ mile

100 feet

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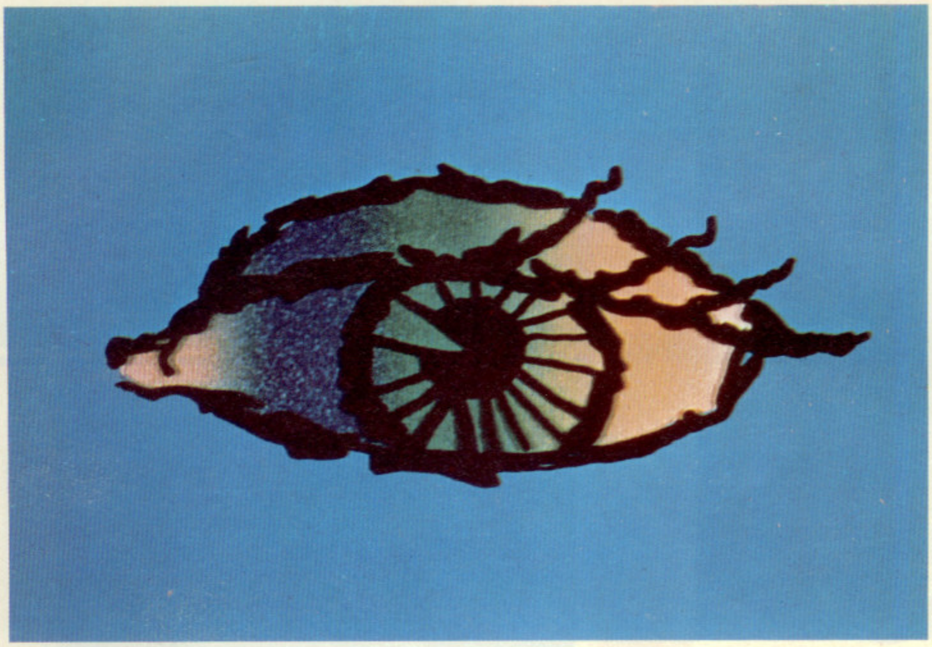


This material has been condensed from the AOPA Air Safety Foundation's Scan Training Program—a uniquely different safety training film that presents, for the first time, a means for the nation's pilots to visually experience the most effective technique for scanning the skies for other traffic. The script for the film and this condensation were written by Dee Mosteller (AOPA 461537), New York City.

By definition and function, the human eye is one of the most important and complex systems in the world. Basically, its job is to accept images from the outside world and transmit them to the brain for recognition and storage. In other words, the organ of vision is our prime means of identifying and relating to what's going on around us.

It has been estimated that 80% of our total information intake is through the eyes. In the air we depend on our eyes to provide most of the basic input necessary for performing a flight—attitude, speed, direction, and proximity to things (like the ground), and opposing air traffic that may constitute a danger of in-flight collision. As air traffic density and aircraft closing speeds increase, the problem of in-flight collision grows proportionately, and so does the importance of the "eyeball system." A basic understanding of the eyes' limitations in target detection is probably the best insurance a pilot can have against running into another airplane and spoiling his whole day.

Profile of Midair Collisions

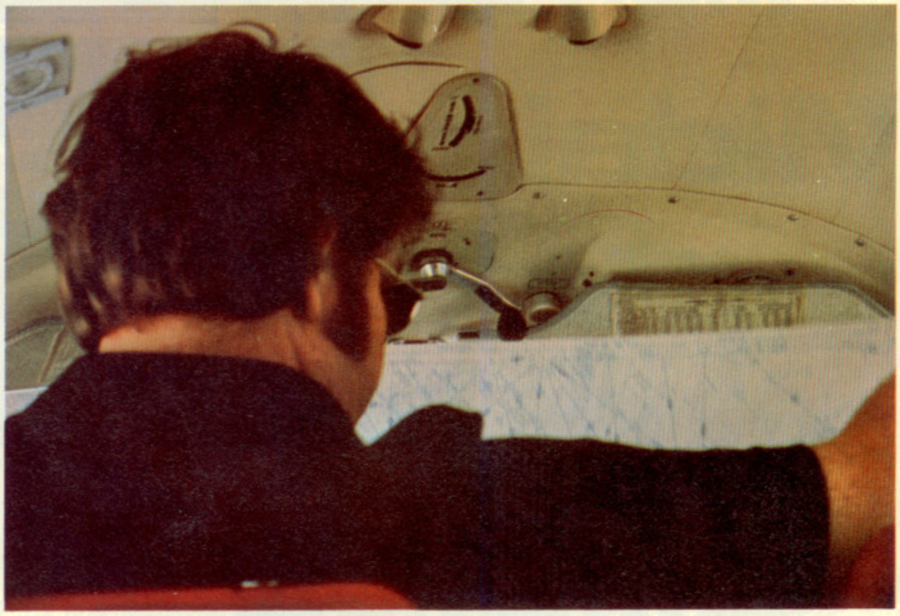
An understanding of the nature of past in-flight collisions is helpful, since the statistics form some definite warning patterns. It may be surprising to some, for example, to know that nearly all collisions occur in daylight hours in VFR weather. Not so surprising, the majority happen within five miles of an airport, in areas of the greatest air traffic concentration, and usually on warm weekend afternoons when more pilots are doing more flying.

Also surprising, perhaps, is the fact that the closing speed (rate at which the two aircraft come together) is relatively slow, usually much slower than the airspeed of either aircraft involved. *This is because the majority of in-flight collisions are the result of a faster aircraft overtaking and hitting a slower plane.*

Statistics on 105 in-flight collisions that occurred from 1964 to 1968 show that 82% were at overtaking convergence angles: 35% were from 0°-10°—almost straight from behind. Only 5% were from a head-on angle.

These numbers, plus the fact that 77% occurred at or below 3,000 feet—49% at or below 500 feet—imply accurately that in-flight collisions generally occur in the traffic pattern and primarily on final approach. Collisions occurring en route generally are at or below 8,000 feet and within 25 miles of an airport.

The pilots involved in such mishaps ranged in experience from first solo to 15,000 hours, and their reasons for flying that day were equally varied. In one case a 19-year-old private pilot flying cross-country, legally VFR, in a Cessna 150 collided with two seasoned airline pilots in a Convair 580 under IFR control. A 7,000-hour commercial pilot on private business in a twin Beech overtook a Cherokee on final with a young flight instructor giving dual to a non-soloed student pilot. Two commercial pilots, each with well over



Not looking out at all, and/or completely blocking your peripheral vision, is an invitation to an in-flight collision.

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 Piper Cubs.

There is no way to say whether the inexperienced pilot or the old, bold pilot is most likely to be involved in an in-flight collision. A beginning pilot has so much to think about he may forget to look around. On the other hand, the older pilot, having sat through many hours of boring flight without spotting any hazardous traffic, may grow complacent and forget to scan. *No pilot is invulnerable.*

Causes of Midairs

What causes in-flight collisions? Undoubtedly, increasing traffic and higher closing speeds represent potential. For instance, a jet and a light twin have a closing speed of about 750 mph. It takes a minimum of 10 seconds, says the FAA, for a pilot to spot traffic, identify it, realize it's a collision threat, react, and have his aircraft respond. But two planes converging at 750 mph will be less than 10 seconds apart when the pilots are first able to detect each other!

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

These are all causal factors, but the reason most often noted in the statistics reads: *"Failure of pilot to see other aircraft"*—failure of the see-and-be-seen system. In most cases at least one of the pilots involved could have seen the other in time to avoid contact, *if he had just been using his eyes properly.* So, it's really that complex, vulnerable little organ—the human eye—which is the leading cause of in-flight collisions. Take a look at how their limitations affect your flight:

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Profile of midair collisions

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Limitations of the Eye

The eye, and consequently vision, is vulnerable to just about everything: dust; fatigue; emotion; germs; fallen eyelashes; age; optical illusions; and, the alcoholic content of last night's party. In flight our vision is altered by atmospheric conditions, windshield distortion, too much oxygen or too little, acceleration, glare, heat, lighting, aircraft design and so forth.

Most of all, the eye is vulnerable to the vagaries of the mind. We can "see" and identify only what the mind lets us see. For example, a daydreaming pilot staring out into space sees no approaching traffic and is probably the No. 1 candidate for an in-flight collision.

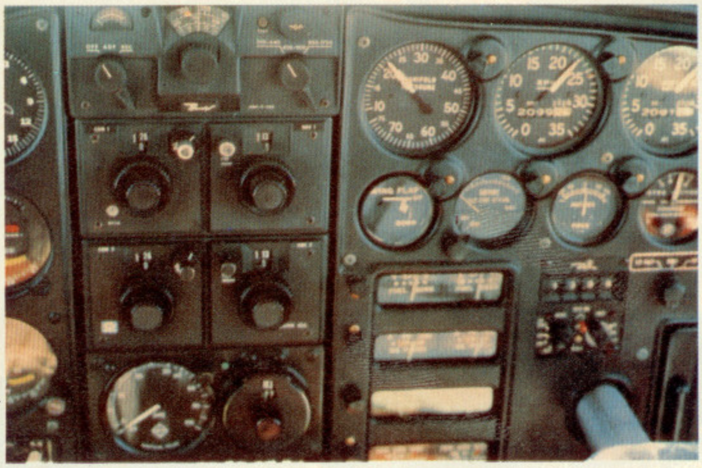
One function of the eye that is a source of constant problems to the pilot (though he is probably never aware of it) is the time required for accommodation. Our eyes automatically accommodate for (or refocus on) near and far objects. But the change from something up close, like a dark panel two feet away, to a well-lighted landmark or aircraft target a mile or so away, takes one to two seconds, or longer, for eye accommodation. That can be a long time when you consider that you need 10 seconds to avoid in-flight collisions.

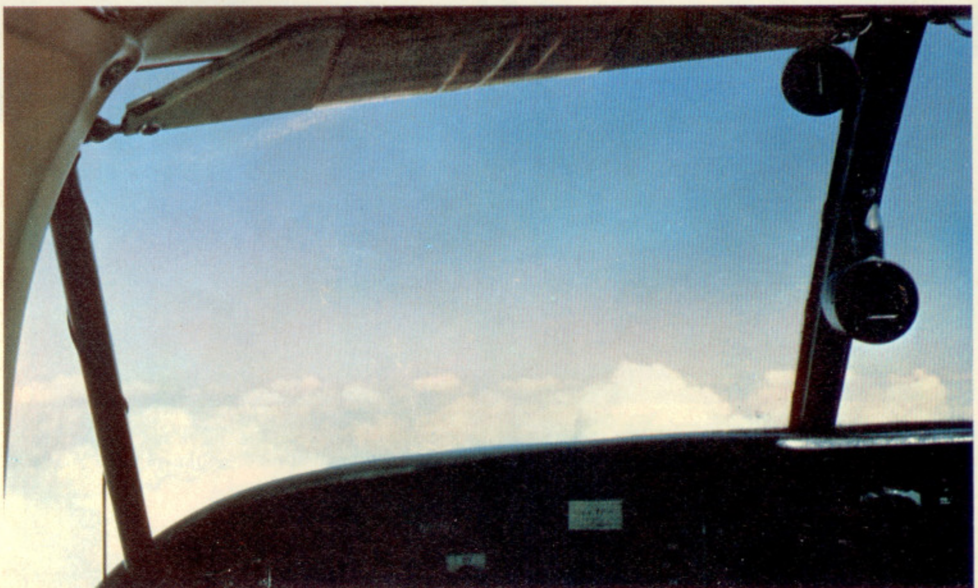
Another focusing problem usually occurs at very high altitudes, but it can happen even at lower levels on vague, colorless days above a haze or cloud layer when no distinct horizon is visible. If there is little or nothing to focus on at infinity, we do not focus at all. We experience something known as "empty-field myopia"; we stare but see nothing, even opposing traffic, if it should enter our visual field.

The effects of what is called "binocular vision" have been studied seriously by the National Transportation Safety Board (NTSB) during investigations of in-flight 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 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.

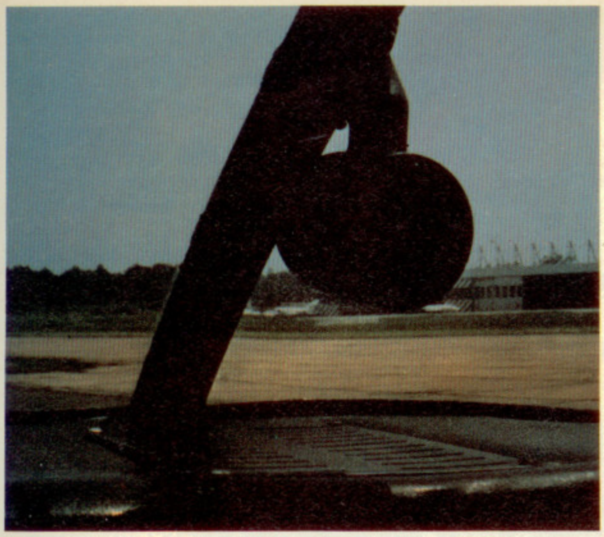
Another inherent eye problem is that of narrow field of vision. Although our eyes accept light rays from an arc of nearly 200°, they are limited to a relatively narrow area (approximately 10-15°) in which they can actually focus on and classify an object. Though we can perceive movement in the periphery, we cannot identify what is happening out 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."

This limitation is compounded by the fact that at a distance an aircraft on a collision course with you will appear to be motionless. It will remain in a seemingly stationary position, without appearing either to move or to grow in size for a relatively long time, and then suddenly bloom into a huge mass filling one of your windows. This is known as "blossom effect." Since we need motion or contrast to attract our eyes' attention, this becomes a frightening factor when you real-





It takes from one to two seconds, or longer, for the eye to refocus from a close object, such as a dark panel, to a far object. When visibility is less than ideal, it can take longer. To avoid an in-flight collision, a pilot needs a minimum average of 10 seconds after identifying the threat.



Right-eye view of the tower.

Blurred view of the tower.

Left-eye view of the tower.

View of an aircraft with sun glancing off it from behind.

ize that a large bug smear or dirty spot on the windshield can hide a converging plane until he's too close to be avoided.

In addition to the built-in problems, the eye is also severely limited by environment. Optical properties of the atmosphere alter the appearance of traffic, particularly on hazy days. "Limited visibility" actually means "limited vision." You may be legally VFR when you have three miles, but at that distance on a hazy day, opposing traffic is not easy to detect. At a range closer than three miles—even though detectable—he may not be avoidable.

Lighting also affects our vision stimuli. Glare, usually worse on a sunny day over a cloud deck or during flight directly into the sun, makes objects hard to see and scanning uncomfortable. Also, an object that is well lighted will have a high degree of contrast and will be easy to detect, while one with low contrast at the same distance may be impossible to see. For instance, when the sun is behind you, an opposing aircraft will stand out clearly, but when you're looking into the sun and your traffic is "backlighted," it's a different story.

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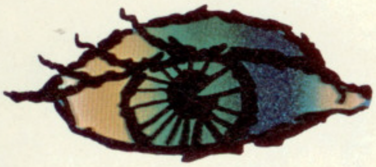
Aircraft are more difficult to see when the background terrain is a cluttered city area.



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Another contrast problem area is trying to find an airplane over a cluttered background. If it is between you and terrain that is vari-colored or heavily dotted with buildings, it will blend into the background until it is quite close.

And, of course, there is the mind, which can distract us to the point of not seeing anything at all, or lull us into cockpit myopia—staring at one instrument without even "seeing" it. How often have you filed IFR on a CAVU day, settled back at your assigned altitude with autopilot on, and then never looked outside, feeling secure that "Big Daddy Radar" will protect you from all harm? Don't you believe it. Remember, our radar system has its limitations too! It's fine to depend on instruments, but not to the exclusion of the see-and-be-seen system, especially on days when there are pilots not under radar surveillance or control flying around in the same sky. And don't forget, our Air Traffic Control (ATC) system is definitely not infallible, even when it comes to providing radar separation between aircraft flying on IFR flight plans.

As you can see, visual perception is affected by many factors. It all boils down to the fact that pilots, like anyone else, tend to overestimate their visual abilities and to misunderstand their eyes' limitations. Since the No. 1 cause of in-flight collisions is the failure to properly adhere to the see-and-be-seen concept, we can conclude that the best way to avoid them is to learn how to use our eyes in an efficient external scan.

How To Scan

So, you want to know what *is* the perfect scan? There is none, or at least there is no one scan that is best for all pilots. The most important thing is for each pilot to develop a scan that is both comfortable and workable for him . . . in his own airplane.

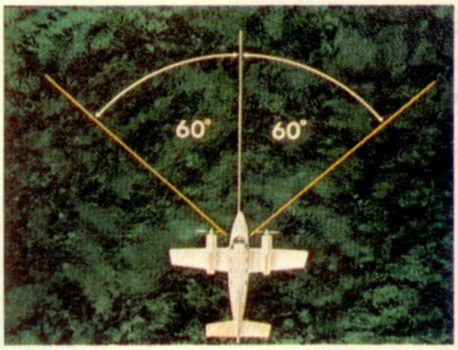
The best way to start is by getting rid of bad habits. Naturally, not looking out at all is the poorest scan technique, but glancing out at intervals of five minutes or so is also poor when you remember that it only takes seconds for a disaster to happen. Check yourself the next time you're climbing out, making an approach, or just bouncing along over a long cross-country route. See how long you go without looking out the window.

Glancing out and giving it 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 (even though it may be great for meditation).

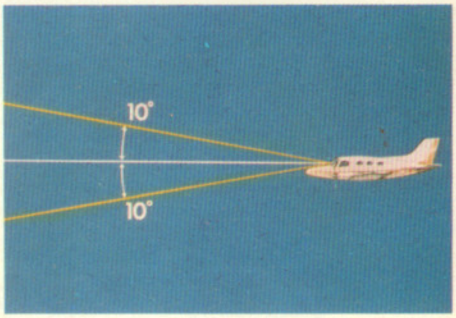
So much for the bad habits. Learn how to scan properly; first, by knowing where to concentrate your search. It would be preferable, naturally, to look everywhere constantly but, that not being practical, concentrate on the areas most critical to you at any given time. In the traffic pattern especially, clear yourself before every turn, and always watch for traffic making an improper entry into the pattern. On descent and climbout, make gentle S-turns to see if anyone is in your way. (Make clearing turns, too, before attempting maneuvers, such as pylons and S-turns about a road.)

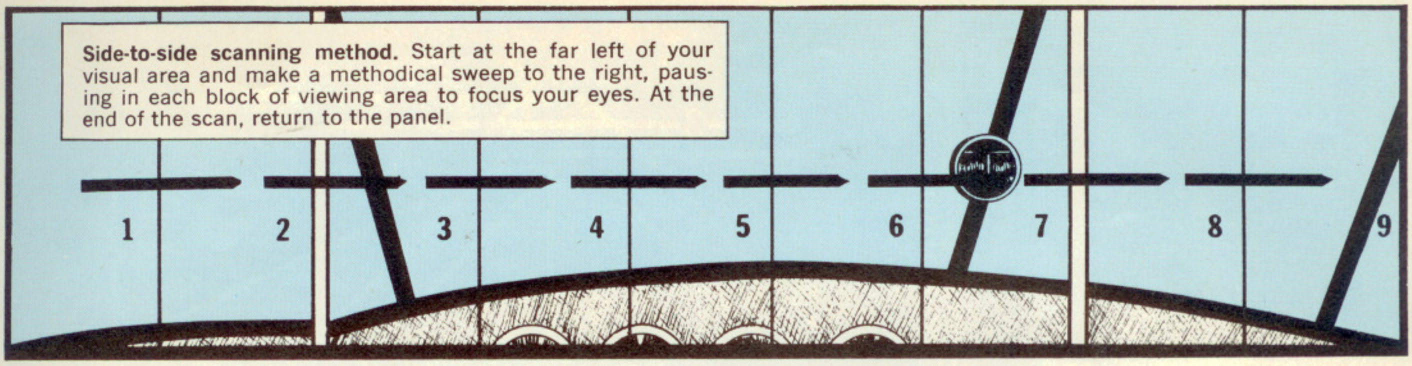
During that very critical final approach stage, don't forget to look behind and below, at least once; and avoid tunnel vision. Pilots often rivet their eyes to the point of touchdown. (You may never arrive at it if another pilot is aiming for the same numbers at the same time.)

In normal flight, you can generally avoid the threat of an in-flight collision by scanning an area 60° to the left and to the

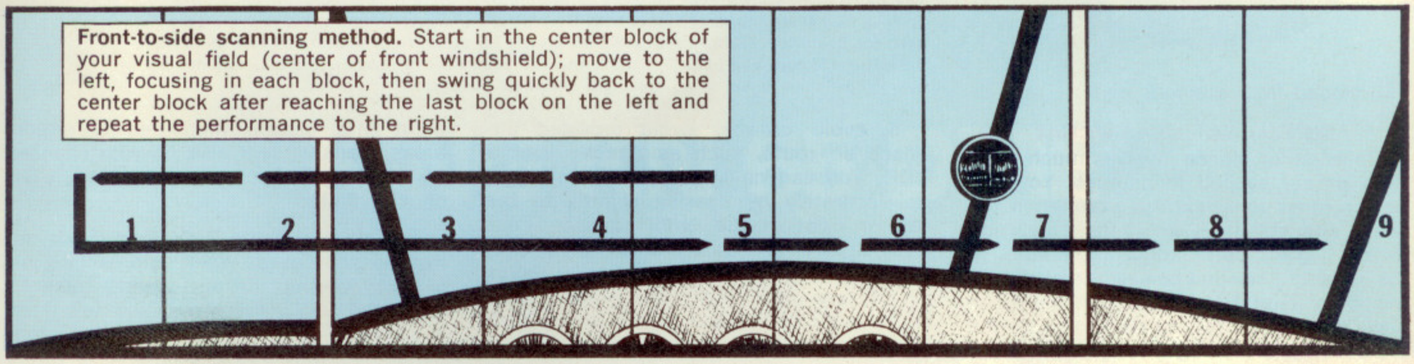


You can generally avoid the threat of an in-flight collision by vertically scanning 60 degrees to the left and right and horizontally scanning 10 degrees up and down.





Two scanning methods that have proved to be the most effective for pilots involve the "block" system of scanning, which is based on the theory 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.



right of your center visual area. This doesn't mean you should forget the rest of the area you can see from your side windows every few scans. Horizontally, the statisticians say, you will be safe if you scan 10° up and down from your flight vector. This will allow you to spot any aircraft that is at an altitude that might prove hazardous to your own flight path, whether it's level with you, below and climbing, or above and descending.

The slower your plane, the greater your vulnerability; hence, the greater scan area required.

But don't forget that your eyes are subject to optical illusions and can play some nasty tricks on you. At one mile, for example, an aircraft flying below your altitude will appear to be above you. As it nears, it will seem to descend and go through your level, yet, all the while it will be straight and level below you. One in-flight collision occurred when the pilot of the higher flying airplane experienced this illusion and dove his plane right into the path of the craft flying below.

Though you may not have much time to avoid another aircraft in your vicinity, use your head when making defensive moves. Even if you must maneuver to avoid a real in-flight collision, consider all the facts. If you miss the other aircraft but stall at a low altitude, the results may be the same for you.

Scan Patterns

Your best defense against in-flight collisions is an efficient scan pattern. Two basic scans that have proved best for most pilots are called the "block" system. This type of scan is based on the theory that traffic detection can be made only through a series of eye fixations at different points in space. Each of these fixes becomes the focal point of your field of vision (a block 10-to-15° wide). By fixating every 10-to-15°, you should be able to detect any contrasting or moving object in each block. This gives you nine-to-12 "blocks" in your scan area, each requiring a minimum of one to two seconds for accommodation and detection.

One method of block scan is the "side-to-side" motion. Start at the far left of your visual area and make a methodical sweep to the right, pausing in each block to focus. At the end of the scan, return to the panel.

The second form is the "front-to-side" version. Start with a fixation in the center block of your visual field (approximately the center of the front windshield in front of the pilot). Move your eyes to the left, focusing in each block, swing quickly back to the center block, and repeat the performance to the right.

There are other methods of scanning, of course, some of which may be as effective for you as the two preceding types. *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.

The Time-Sharing Plan

External scanning is just part of the pilot's total eyeball job. To achieve maximum efficiency in flight, one has to establish a good internal (panel) scan as well and learn to give each its proper share of time. The amount of time one spends eyeballing outside the cockpit in relation to what is spent inside depends, to some extent, on the workload inside the cockpit and the density of traffic outside. Generally, the external scan will take about three to four times as long as a look-around the instrument panel.

McDonnell Douglas recently conducted an experimental scan training course, using military pilots ranging in experience from 350 to over 4,000 hours. They discovered that the average time needed to maintain a flight situation status quo was three seconds for panel scan and 17 seconds for outside. (Since military pilots are most likely flying a more consistent schedule than you or I, we'll allow you six or seven seconds on the panel!)

Panel Scan

An efficient instrument scan is good practice, even if you limit your flying to VFR conditions, and being able to quickly scan the panel gives one a better chance of doing an effective job outside as well. The following panel scan system is taught by FAA and AOPA Air Safety Foundation to instrument students. (See next page.)

Start with the attitude indicator. It will show changes in attitude affecting the two most critical areas of flight—heading and altitude. Move to the directional gyro for heading; to altimeter; airspeed indicator; rate of climb; and turn and bank. It is a good idea to skim over the attitude indicator each time you move on to a new instrument as this is your chief control instrument. Include your VOR and engine instruments every third scan or so, or as the flight situation dictates.

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 airplane or the one you usually fly, and then use your scans in actual practice every chance you get.

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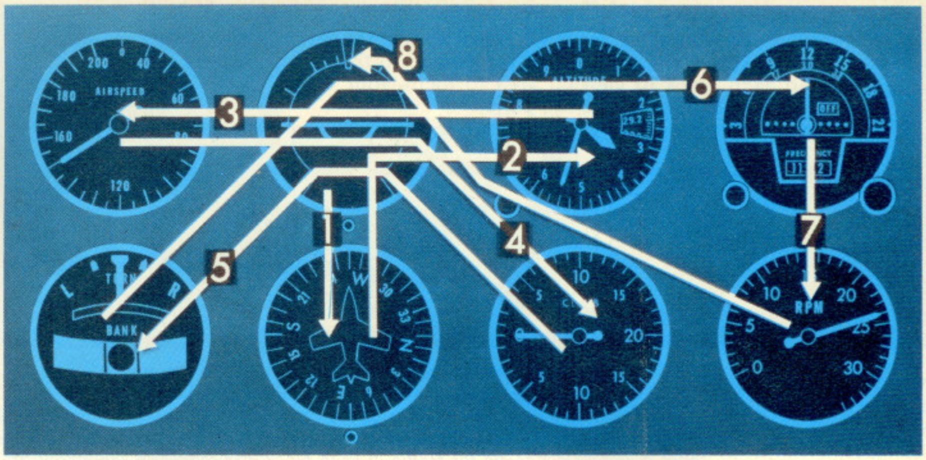
Collision Avoidance Checklist

1. Check Yourself
2. Plan Ahead
3. Clean Windows
4. Adhere to S.O.P.'s
5. Avoid Crowds
6. Compensate for Design
7. Equip for Safety
8. Talk and Listen
9. SCAN!



The panel scan shown here involves skimming over the attitude indicator each time your scan moves on to a new instrument. (1) Start with the attitude indicator, then move to the directional gyro for heading; (2) move on to the altimeter; (3) airspeed indicator; (4) rate-of-climb indicator; (5) turn-and-bank indicator. Include your VOR (6) and engine instruments (7) every third scan or so, or as the flight situation dictates.

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Collision Avoidance Checklist

Collision avoidance involves much more than proper eyeball 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 overall see-and-be-seen picture. It might be helpful to use a collision avoidance checklist as religiously as you do the pretakeoff and landing lists. Such a checklist might include the following nine items.

1. Check yourself. Start with a check of your own condition. Your eyesight, and consequently your safety, depend on your mental and physical condition.

2. Plan ahead. 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 even jot these things down on a flight log before takeoff. Check your maps and the special general and area notices in AIM in advance for restricted areas, oil burner routes, intensive student jet training areas and other high density spots.

3. Clean windows. During the walkaround, make sure your windshield is clean. If possible, keep all windows clear of obstructions, like solid sun visors and curtains.

4. Adhere to S.O.P.'s. Stick to Standard Operating Procedures and observe the regulations of flight, such as correct altitudes and proper pattern practices. You can get into big trouble, for instance, by "sneaking" out of your proper altitude as cumulous clouds begin to tower higher and higher below you, or by skimming along the tops of clouds without observing proper separation. Some typical situations involving in-flight mishaps around airports include: entering a right-hand pattern at an airport with left-hand traffic; 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.

5. Avoid crowds. Avoid crowded airspace en route, such as directly over a VOR. You can navigate on VFR days just as accurately by passing slightly to the left or right of the omni stations. Pass over airports at a safe altitude, being particularly careful within a 25-mile radius of military airports and busy civil fields. Military airports usually have a very high concentration of fast-moving jet traffic in the vicinity and a pattern that extends to 2,500 feet above the surface. Jets in climbout may be going as fast as 500 mph.

6. Compensate for design. Compensate for your aircraft's design limitations. All planes have blind spots; know where they are in your aircraft. For example, a high-wing aircraft that has a wing down in a turn blocks the area you are turning into. A low wing blocks the area beneath you. And one of the most critical midair potential situations is a faster low-wing plane overtaking and descending on a high wing on final approach.

7. Equip for safety. Your airplane can, in fact, help avoid collisions. Certain equipment that was once priced way above the lightplane owner's reach, now is available at reasonable cost to all aviation segments. High intensity strobe lights increase your contrast by as much as 10 times day or night and can be installed for about $100 apiece. In areas of high density, use your strobes or your rotating beacon constantly, even during daylight hours. The cost is pennies an hour—small price to pay for conspicuity.

Transponders, available in quick installation kits for under $1,000, significantly increase your safety by allowing radar controllers to keep your traffic away from you and vice versa. Now mandatory for flight into certain high density airport areas, transponders also up your chances of receiving radar traffic advisories, even on VFR flights.

8. Talk and listen. Use your radios, as well as your eyes. When approaching an airport, whether or not you're going to land, call in 15 miles out and tell them your position, heading, altitude and intentions. And find out what the local traffic situation is. At an airport with radar service, call the approach control frequency and let them know where you are and what you are going to do. At uncontrolled fields, call airport traffic advisory service on 123.6 MHz, or other FSS frequency, or Unicom on 122.8 MHz.

Since detecting a tiny aircraft at a distance is not the easiest thing to do, make use of any hints you get over the radio. A pilot reporting his position to a tower is also reporting to you. And your job is much easier when an air traffic controller tells you your traffic is "three miles at one o'clock." Once you have that particular traffic, by the way, *don't forget the rest of the sky.* If your traffic seems to be moving, you're not on a collision course, so continue your scan and watch it from time to time. If it doesn't appear to have motion, however, we suggest you watch it very carefully, and get out of its way, if necessary.

9. Scan! The most important part of your checklist, of course, is to keep looking where you're going and to watch for traffic. Make use of your scan constantly.

Basically, if you adhere to good airmanship, keep yourself and your plane in good condition, and develop an effective scan time-sharing system, you'll have no trouble avoiding in-flight collisions. And as you learn to use your eyes properly, you'll benefit in other ways. Remember, despite their limitations, your eyes provide you with color, beauty, shape, motion and excitement. As you train them to spot minute targets in the sky, you'll also learn to see many other important "little" things you may now be missing, both on the ground and in the air. If you couple your eyes with your brain, you'll be around to enjoy these benefits of vision for a long time. □

The AOPA Scan Training Program was developed by Bray Studios, New York, N.Y., under a grant from the AOPA Air Safety Foundation. It was developed with the assistance of the National Transportation Safety Board, the Federal Aviation Administration, the National Aeronautics and Space Administration, and a number of private companies and individuals who share AOPA's interest in furthering aviation education and flying safety. Additional information on the safety training film, which is shown at free safety seminars throughout the country, can be obtained by contacting: AOPA Air Safety Foundation, P.O. Box 5800, Washington, D.C. 20014.