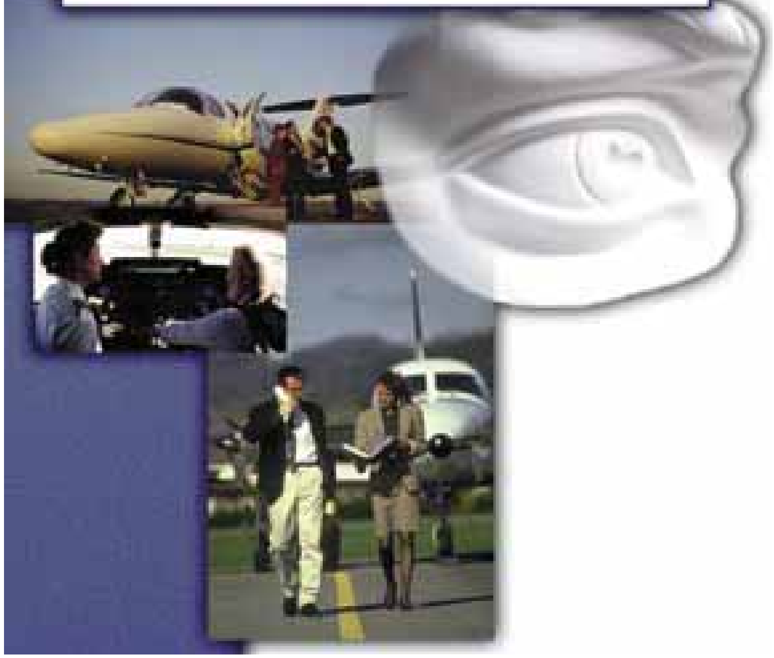
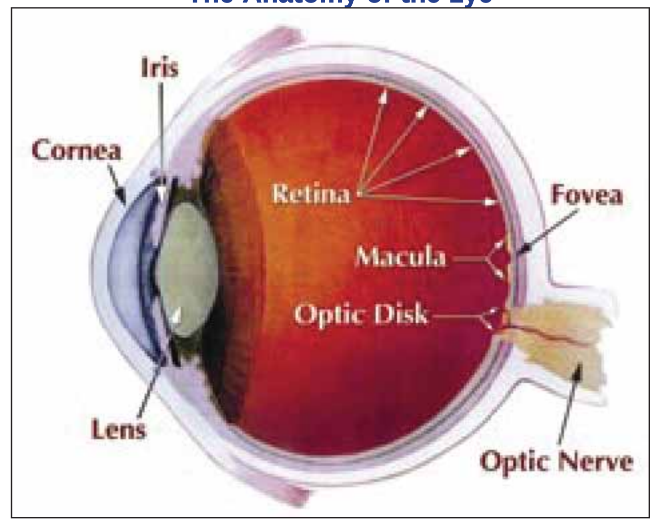
Federal Aviation Administration

Pilot Vision



Vision is a pilot's most important sense to obtain reference information during flight. Most pilots are familiar with the optical aspects of the eye. Before we start flying, we know whether we have normal uncorrected vision, whether we are farsighted or nearsighted, or have other visual problems. Most of us who have prescription lenses—contacts or eyeglasses—have learned to carry an extra set of glasses with us when we fly, just as a backup. But, vision in flight is far more than a lesson in optics. Seeing involves the transmission of light energy (images) from the exterior surface of the cornea to the interior surface of the retina (inside the eye) and the transference of these signals to the brain.

The Anatomy of the Eye

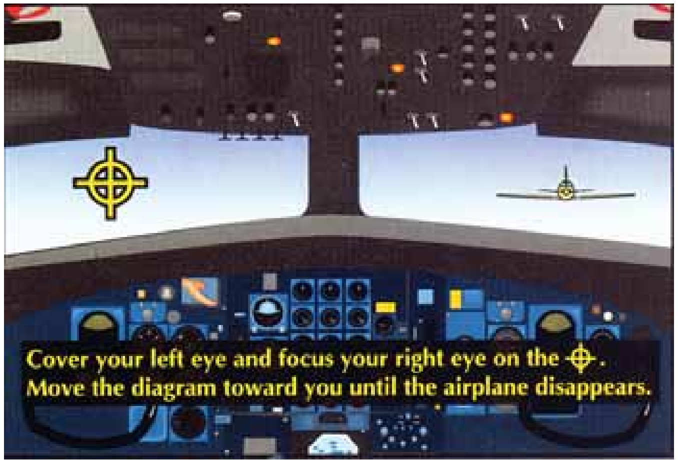


- Light from an object enters the eye through the cornea and then continues through the pupil.
- The opening (dilation) and closing (constriction) of the pupil is controlled by the iris, which is the colored part of the eye. The function of the pupil is similar to that of the diaphragm of a photographic camera: to control the amount of light.
- The lens is located behind the pupil and its function is to focus light on the surface of the retina.
- The retina is the inner layer of the eyeball that contains photosensitive cells called rods and cones. The function of the retina is similar to that of the film in a photographic camera: to record an image.
- The cones are located in higher concentrations than rods in the central area of the retina known as the macula, that measures about 4.5 mm in diameter. The exact center of the macula has a very small depression called the fovea that contains cones only. The cones are used for day or high-intensity light vision. They are involved with central vision to detect detail, perceive color, and identify far-away objects.
- The rods are located mainly in the periphery of the retina — an area that is about 10,000 times more sensitive to light than the fovea. Rods are used for low-light intensity or night vision and are involved with peripheral vision to detect position references including objects (fixed and moving) in shades of grey, but cannot be used to detect detail or to perceive color.

• Light energy (an image) enters the eyes and is transformed by the cones and rods into electrical signals that are carried by the optic nerve to the posterior area of the brain (occipital lobes). This part of the brain interprets the electrical signals and creates a mental image of the actual object that was seen by the person.

The Anatomical Blind Spot

The area where the optic nerve connects to the retina in the back of each eye is known as the optic disk. There is a total absence of cones and rods in this area, and, consequently, each eye is completely blind in this spot. Under normal binocular vision conditions this is not a problem, because an object cannot be in the blind spot of both eyes at the same time. On the other hand, where the field of vision of one eye is obstructed by an object (windshield post), a visual target (another aircraft) could fall in the blind spot of the other eye and remain undetected.

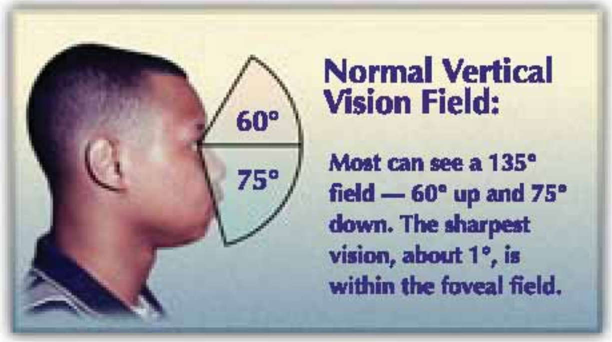


The Night Blind Spot

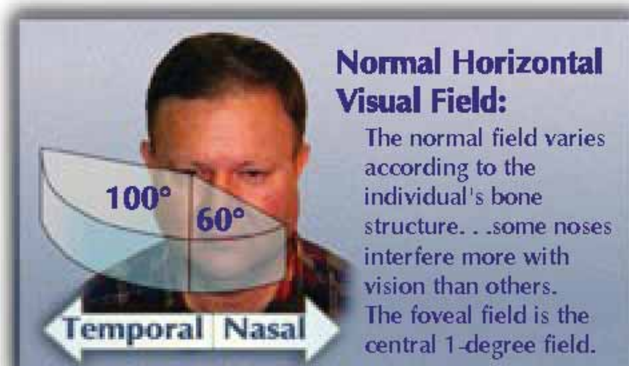
The “Night Blind Spot” appears under conditions of low ambient illumination due to the absence of rods in the fovea, and involves an area 5 to 10 degrees wide in the center of the visual field. Therefore, if an object is viewed directly at night, it may go undetected or it may fade away after initial detection due to the night blind spot.

The Fovea

The fovea is the small depression located in the exact center of the macula that contains a high concentration of cones but no rods, and this is where our vision is most sharp. While the normal field of vision for each eye is about 135 degrees vertically and about 160 degrees horizontally, only the fovea has the ability to perceive and send clear, sharply focused visual images to the brain. This foveal field of vision represents a small conical area of only about 1 degree. To fully appreciate how small a one-degree field is, and to demonstrate foveal field, take a quarter from your pocket and tape it to a flat piece of glass, such as a window. Now back off 4 ½ feet from the mounted quarter and close one eye. The area of your field of view covered by the quarter is a one-degree field, similar to your foveal vision.



Now we know that you can see a lot more than just that one-degree cone. But, do you know how little detail you see outside of that foveal cone? For example, outside of a ten-degree cone, concentric to the foveal one-degree cone, you see only about one-tenth of what you can see within the foveal field. In terms of an oncoming aircraft, if you are capable of seeing an aircraft within your foveal field at 5,000 feet away, with peripheral vision you would detect it at 500 feet. Another example: using foveal vision we can clearly identify an aircraft flying at a distance of 7 miles; however, using peripheral vision (outside the foveal field) we would require a closer distance of .7 of a mile to recognize the same aircraft. That is why when you were learning to fly, your instructor always told you to “put your head on a swivel,” to keep your eyes scanning the wide expanse of space in front of your aircraft.



Types of Vision

• **Photopic Vision.** During daytime or high intensity artificial illumination conditions, the eyes rely on central vision (foveal cones) to perceive and interpret sharp images and color of objects.

• **Mesopic Vision.** Occurs at dawn, dusk, or under full moonlight levels, and is characterized by decreasing visual acuity and color vision. Under these conditions, a combination of central (foveal cones) and peripheral (rods) vision is required to maintain appropriate visual performance.

• **Scotopic Vision.** During nighttime, partial moonlight, or low intensity artificial illumination conditions, central vision (foveal cones) becomes ineffective to maintain visual acuity and color perception. Under these conditions, if you look directly at an object for more than a few seconds, the image of the object fades away completely (night blind spot). Peripheral vision (off-center scanning) provides the only means of seeing very dim objects in the dark.

Factors Affecting Vision

• The greater the object size, ambient illumination, contrast, viewing time, and atmospheric clarity, the better the visibility of such an object.

• During the day, objects can be identified easier at a great distance with good detail resolution. At night, the identification range of dim objects is limited and the detail resolution is poor.

• Surface references or the horizon may become obscured by smoke, fog, smog, haze, dust, ice particles, or other phenomena, although visibility may be above Visual Flight Rule (VFR) minimums. This is especially true at airports located adjacent to large bodies of water or sparsely populated areas where few, if any, surface references are available. Lack of horizon or surface reference is common on over-water flights, at night, and in low-visibility conditions.

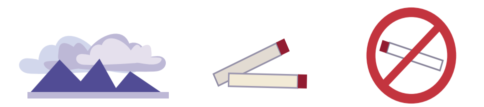
• Excessive ambient illumination, especially from light reflected off the canopy, surfaces inside the aircraft, clouds, water, snow, and desert terrain can produce glare that may cause uncomfortable squinting, eye tearing, and even temporary blindness.

• Presence of uncorrected refractive eye disorders such as myopia (nearsightedness — impaired focusing of distant objects), hyperopia (farsightedness — impaired focusing of near objects), astigmatism (impaired focusing of objects in different meridians), or presbyopia (age-related impaired focusing of near objects).

• Self-imposed stresses such as self-medication, alcohol consumption (including hangover effects), tobacco use (including withdrawal), hypoglycemia, and sleep deprivation/fatigue can seriously impair your vision.

• Inflight exposure to low barometric pressure without the use of supplemental oxygen (above 10,000 ft during the day and above 5,000 ft at night) can result in hypoxia, which impairs visual performance.

• Other factors that may have an adverse effect on visual performance include: windscreen haze, improper illumination of the cockpit and/or instruments, scratched and/or dirty instrumentation, use of cockpit red lighting, inadequate cockpit environmental control (temperature and humidity), inappropriate sunglasses and/or prescription glasses/contact lenses, and sustained visual workload during flight.



Altitude (ft)	Smokers (% Reduction)	Non-Smokers (% Reduction)
4,000	20	0
6,000	25	5
10,000	40	20
14,000	55	35
16,000	60	40

Focusing

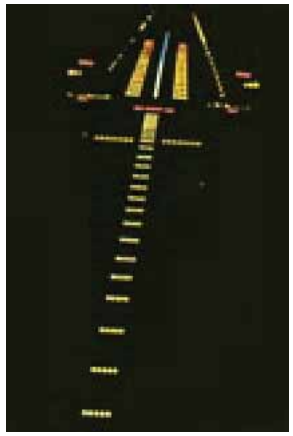
The natural ability to focus your eyes is critical to flight safety. It is important to know that normal eyes may require several seconds to refocus when switching views between near (reading charts), intermediate (monitoring instruments), and distant objects (looking for traffic or external visual references).

Fatigue can lead to impaired visual focusing, which causes the eyes to overshoot or undershoot the target, and can also affect a pilot’s ability to quickly change focus between near, intermediate, and distant vision. The most common symptoms of visual fatigue include blurred vision, excessive tearing, “heavy” eyelid sensation, frontal or orbital headaches, and burning, scratchy, or dry eye sensations.

Distance focus, without a specific object to look at, tends to diminish rather quickly. If you fly over water or under hazy conditions with the horizon obscured or between cloud layers at night, your distance focus relaxes after about 60-80 seconds.

If there is nothing specific on which to focus, your eyes revert to a relaxed intermediate focal distance (10 to 30 ft). This means that you are looking without actually seeing anything, which is dangerous. The answer to this phenomenon is to condition your eyes for distant vision. Focus on the most distant object that you can see, even if it's just a wing tip. Do this before you begin scanning the sky in front of you. As you scan, make sure you repeat this re-focusing exercise often.

Dark Adaptation or Night Vision Adaptation

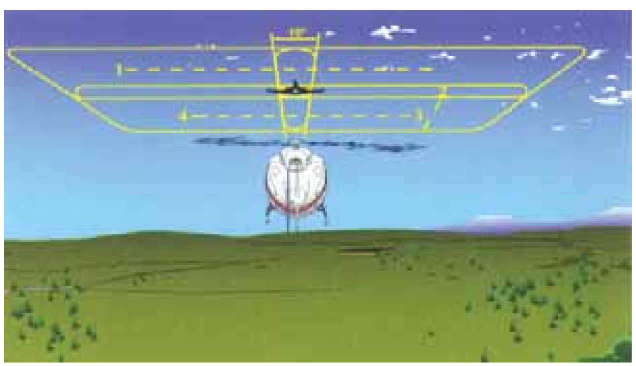


Dark adaptation is the process by which the eyes adapt for optimal night visual acuity under conditions of low ambient illumination. The eyes require about 30 to 45 minutes to fully adapt to minimal lighting conditions. The lower the starting level of illumination, the more rapidly complete dark adaptation is achieved. To minimize the time necessary to achieve complete dark adaptation and to maintain it, you should:

- avoid inhaling carbon monoxide from smoking or exhaust fumes
- get enough Vitamin A in your diet
- adjust instrument and cockpit lighting to the lowest level possible
- avoid prolonged exposure to bright lights
- use supplemental oxygen when flying at night above 5,000 ft (MSL)

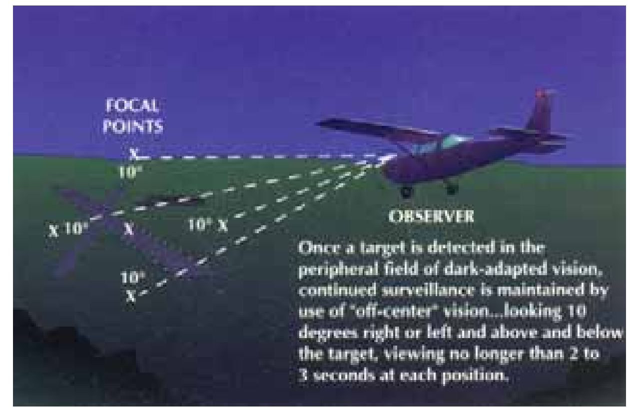
If dark-adapted eyes are exposed to a bright light source (searchlights, landing lights, flares, etc.) for a period in excess of 1 second, night vision is temporarily impaired. Exposure to aircraft anti-collision lights does not impair night vision adaptation because the intermittent flashes have a very short duration (less than 1 second).

Visual Scanning



Scanning the sky for other aircraft is a very important factor in avoiding midair collisions, and it should cover all areas of the sky visible from the cockpit. Most of us are instinctively alert for potential head-on encounters with another aircraft. Actually, a study of 50 midair collisions revealed that only 8% were head-on. However, 42% were collisions between aircraft heading in the same direction. So, compared with opposite-direction traffic, your chances of having a midair are over 5 times greater with an aircraft you are overtaking or one that is overtaking you. It is necessary for you to develop and practice a technique that allows the efficient scanning of the surrounding airspace and the monitoring of cockpit instrumentation as well. You can accomplish this by performing a series of short, regularly spaced eye movements that bring successive areas of the sky into the central (foveal) visual field. To scan effectively, scan from right to left or left to right. Begin scanning at the top of the visual field in front of you and then move your eyes inward toward the bottom. Use a stop-turn-stop type eye motion. The duration of each stop should be at least 1 second but not longer than 2 to 3 seconds.

To see and identify objects under conditions of low ambient illumination, avoid looking directly at an object for more than 2 to 3 seconds (because it will bleach out). Instead, use the off-center viewing that consists of searching movements of the eyes (10 degrees above, below, or to either side) to locate an object, and small eye movements to keep the object in sight. By switching your eyes from one off-center point to another every 2 to 3 seconds, you will continue to detect the object in the peripheral field of vision. The reason for using off-center viewing has to do with the location of rods in the periphery of the retina for night or low-intensity night vision (peripheral), and their absence in the center of the retina (fovea). Pilots should practice this off-center scanning technique to improve safety during night flights.



A Word about Monocular Vision

A pilot with one eye (monocular), or with effective visual acuity equivalent to monocular (i.e. best corrected distant visual acuity in the poorer eye is no better than 20/200), may be considered for medical certification, any class, through the special issuance procedures of Part 67 (14CFR67.401) if:

- A 6-month period has elapsed to allow for adaptation to monocularity; during the adaptation period to monovision, an individual may experience hazy vision and occasional loss of balance.
- A complete evaluation by an eye specialist, as reported on FAA Form 8500-7, Report of Eye Evaluation, reveals no pathology of either eye that could affect the stability of the findings.
- Uncorrected distant visual acuity in the better eye is 20/200 or better and is corrected to 20/20 or better by lenses of no greater power than ±3.5 diopters spherical equivalent.
- The applicant passes an FAA medical flight test.

A Word about Contact Lenses

Use of contact lenses has been permitted to satisfy the distant visual acuity requirements for a civil airman medical certificate since 1976. However, **monovision contact lenses, a technique of fitting older patients who require reading glasses with one contact lens for distant vision and the other lens for near vision, ARE NOT ACCEPTABLE for piloting an aircraft.**

The use of a contact lens in one eye for distant visual acuity and a lens in the other eye for near visual acuity is not acceptable because this procedure makes the pilot alternate his/her vision; that is, a person uses one eye at a time, suppressing the other, and consequently impairs binocular vision and depth perception. Since this is not a permanent condition for either eye in such persons, there is no adaptation, such as occurs with permanent monocularity. Monovision lenses, therefore, should NOT be used by pilots while flying an aircraft.

The Eyes Have It

As a pilot, you are responsible to make sure your vision is equal to the task of flying—that you have good near, intermediate, and distant visual acuity because:

- Distant vision is required for VFR operations including take-off, attitude control, navigation, and landing
- Distant vision is especially important in avoiding midair collisions
- Near vision is required for checking charts, maps, frequency settings, etc.
- Near and intermediate vision are required for checking aircraft instruments

Learn about your own visual strengths and weaknesses. Changes in vision may occur imperceptibly or very rapidly. Periodically self-check your range of visual acuity by trying to see details at near, intermediate, and distant points. If you notice any change in your visual capabilities, bring it to the attention of your Aviation Medical Examiner (AME). And, if you use corrective glasses or contacts, carry an extra pair with you when you fly. Always remember: Vision is a pilot's most important sense.

KEY POINTS

- The sharpest distant focus is only within a one-degree cone.
- Outside of a 10° cone, visual acuity drops 90%.
- Scan the entire horizon, not just the sky in front of your aircraft.
- You are 5 times more likely to have a midair collision with an aircraft flying in the same direction than with one flying in the opposite direction.
- Avoid self-imposed stresses such as self-medication, alcohol consumption, smoking, hypoglycemia, sleep deprivation, and fatigue.
- Do not use monovision contact lenses while you are flying an aircraft.
- Use supplemental oxygen during night flights above 5,000 ft MSL.
- Any pilot can experience visual illusions. Always rely on your instruments to confirm your visual perceptions during flight.

Medical Facts for Pilots

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Other Pilot Safety Brochures Available

Number	Title
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AM-400-95/2	Altitude Decompression Sickness
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AM-400-01/1	Physiological Training Courses for Civil Aviation Pilots
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AM-400-05/1	Sunglasses for Pilots: Beyond the Image

To view these pilot and passenger safety brochures,
visit the Federal Aviation Administration's Web Site
www.faa.gov/pilots/safety/pilotsafetybrochures/

Physiological Training Classes for Pilots

If you are interested in taking a one-day aviation physiological training course with altitude chamber and vertigo demonstrations or a one-day survival course, learn about how to sign up for these courses that are offered at 14 locations across the U.S. by visiting this FAA Web site:

www.faa.gov/pilots/training/airman_education/aerospace_physiology/index.cfm