To prevent these symptoms, it is recommended that an ample supply of water be carried and used at frequent intervals on any long flight, whether thirsty or not. The body normally absorbs water at a rate of 1.2 to 1.5 quarts per hour. Individuals should drink one quart per hour for severe heat stress conditions or one pint per hour for moderate stress conditions. If the aircraft has a canopy or roof window, wearing light-colored, porous clothing and a hat will help provide protection from the sun. Keeping the flight deck well ventilated aids in dissipating excess heat.

Alcohol

Alcohol impairs the efficiency of the human body. *[Figure 17-8]* Studies have shown that consuming alcohol is closely linked to performance deterioration. Pilots must make hundreds of decisions, some of them time-critical, during the course of a flight. The safe outcome of any flight depends on the ability to make the correct decisions and take the appropriate actions during routine occurrences, as well as abnormal situations. The influence of alcohol drastically reduces the chances of completing a flight without incident. Even in small amounts, alcohol can impair judgment, decrease sense of responsibility, affect coordination, constrict visual field, diminish memory, reduce reasoning ability, and lower attention span. As little as one ounce of alcohol can decrease the speed and strength of muscular reflexes, lessen the efficiency of eye movements while reading, and increase the frequency at which errors are committed. Impairments in vision and hearing can occur from consuming as little as one drink.

Type Beverage	Typical Serving (oz)	Pure Alcohol Content (oz)
Table wine	4.0	.48
Light beer	12.0	.48
Aperitif liquor	1.5	.38
Champagne	4.0	.48
Vodka	1.0	.50
Whiskey	1.25	.50

0.01–0.05% (10–50 mg)	average individual appears normal
0.03–0.12%* (30–120 mg)	mild euphoria, talkativeness, decreased inhibitions, decreased attention, impaired judgment, increased reaction time
0.09–0.25% (90–250 mg)	emotional instability, loss of critical judgment, impairment of memory and comprehension, decreased sensory response, mild muscular incoordination
0.18–0.30% (180–300 mg)	confusion, dizziness, exaggerated emotions (anger, fear, grief), impaired visual perception, decreased pain sensation, impaired balance, staggering gait, slurred speech, moderate muscular incoordination
0.27–0.40% (270–400 mg)	apathy, impaired consciousness, stupor, significantly decreased response to stimulation, severe muscular incoordination, inability to stand or walk, vomiting, incontinence of urine and feces
0.35–0.50% (350–500 mg)	unconsciousness, depressed or abolished reflexes, abnormal body temperature, coma, possible death from respiratory paralysis (450 mg or above)

* Legal limit for motor vehicle operation in most states is 0.08 or 0.10% (80–100 mg of alcohol per dL of blood).

Figure 17-8. *Impairment scale with alcohol use.*

The alcohol consumed in beer and mixed drinks is ethyl alcohol, a central nervous system depressant. From a medical point of view, it acts on the body much like a general anesthetic. The "dose" is generally much lower and more slowly consumed in the case of alcohol, but the basic effects on the human body are similar. Alcohol is easily and quickly absorbed by the digestive tract. The bloodstream absorbs about 80 to 90 percent of the alcohol in a drink within 30 minutes when ingested on an empty stomach. The body requires about 3 hours to rid itself of all the alcohol contained in one mixed drink or one beer.

While experiencing a hangover, a pilot is still under the influence of alcohol. Although a pilot may think he or she is functioning normally, motor and mental response impairment is still present. Considerable amounts of alcohol can remain in the body for over 16 hours, so pilots should be cautious about flying too soon after drinking.

Altitude multiplies the effects of alcohol on the brain. When combined with altitude, the alcohol from two drinks may have the same effect as three or four drinks. Alcohol interferes with the brain's ability to utilize oxygen, producing a form of histotoxic hypoxia. The effects are rapid because alcohol passes quickly into the bloodstream. In addition, the brain is a highly vascular organ that is immediately sensitive to changes in the blood's composition. For a pilot, the lower oxygen availability at altitude and the lower capability of the brain to use the oxygen that is available can add up to a deadly combination.

Intoxication is determined by the amount of alcohol in the bloodstream. This is usually measured as a percentage by weight in the blood. 14 CFR part 91 requires that blood alcohol level be less than .04 percent and that 8 hours pass between drinking alcohol and piloting an aircraft. A pilot with a blood alcohol level of .04 percent or greater after 8 hours cannot fly until the blood alcohol falls below that amount. Even though blood alcohol may be well below .04 percent, a pilot cannot fly sooner than 8 hours after drinking alcohol.

Although the regulations are quite specific, it is a good idea to be more conservative than the regulations.

Drugs

The Federal Aviation Regulations include no specific references to medication usage. Two regulations, though, are important to keep in mind. Title 14 of the CFR part 61, section 61.53 prohibits acting as pilot-in-command or in any other capacity as a required pilot flight crewmember, while that person:

1. Knows or has reason to know of any medical condition that would make the person unable to meet the requirement for the medical certificate necessary for the pilot operation, or
2. Is taking medication or receiving other treatment for a medical condition that results in the person being unable to meet the requirements for the medical certificate necessary for the pilot operation.

Further, 14 CFR part 91, section 91.17 prohibits the use of any drug that affects the person's faculties in any way contrary to safety.

There are several thousand medications currently approved by the U.S. Food and Drug Administration (FDA), not including OTC (over the counter) drugs. Virtually all medications have the potential for adverse side effects in some people. Additionally, herbal and dietary supplements, sport and energy boosters, and some other "natural" products are derived from substances often found in medications that could also have adverse side effects. While some individuals experience no side effects with a particular drug or product, others may be noticeably affected. The FAA regularly reviews FDA and other data to assure that medications found acceptable for aviation duties do not pose an adverse safety risk. Drugs that cause no apparent side effects on the ground can create serious problems at even relatively low altitudes. Even at typical general aviation altitudes, the changes in concentrations of atmospheric gases in the blood can enhance the effects of seemingly innocuous drugs that can result in impaired judgment, decision-making, and performance. In addition, fatigue, stress, dehydration, and inadequate nutrition can increase an airman's susceptibility to adverse effects from various drugs, even if they appeared to tolerate them in the past. If multiple medications are being taken at the same time, the adverse effects can be even more pronounced.

Another important consideration is that the medical condition for which a medication is prescribed may itself be disqualifying. The FAA will consider the condition in the context of risk for medical incapacitation, and the medication as well for cognitive impairment, and either or both could be found unacceptable for medical certification.

Some of the most commonly used OTC drugs, antihistamines and decongestants, have the potential to cause noticeable adverse side effects, including drowsiness and cognitive deficits. The symptoms associated with common upper respiratory infections, including the common cold, often suppress a pilot's desire to fly, and treating symptoms with a drug that causes adverse side effects only compounds the problem. Particularly, medications containing diphenhydramine (e.g., Benadryl) are known to cause drowsiness and have a prolonged half-life, meaning the drugs stay in one's system for an extended time, which lengthens the time that side effects are present.

Many medications, such as tranquilizers, sedatives, strong pain relievers, and cough suppressants, have primary effects that may impair judgment, memory, alertness, coordination, vision, and the ability to make calculations. *[Figure 17-9]* Others, such as antihistamines, blood pressure drugs, muscle relaxants, and agents to control diarrhea and motion sickness, have side effects that may impair the same critical functions. Any medication that depresses the nervous system, such as a sedative, tranquilizer, or antihistamine, can make a pilot more susceptible to hypoxia.

Painkillers are grouped into two broad categories: analgesics and anesthetics. Analgesics are drugs that reduce pain, while anesthetics are drugs that deaden pain or cause loss of consciousness.

Over-the-counter analgesics, such as acetylsalicylic acid (aspirin), acetaminophen (Tylenol), and ibuprofen (Advil), have few side effects when taken in the correct dosage. Although some people are allergic to certain analgesics or may suffer from stomach irritation, flying usually is not restricted when taking these drugs. However, flying is almost always precluded while using prescription analgesics, such as drugs containing propoxyphene (e.g., Darvon), oxycodone (e.g., Percodan), meperidine (e.g., Demerol), and codeine, since these drugs are known to cause side effects, such as mental confusion, dizziness, headaches, nausea, and vision problems.

Anesthetic drugs are commonly used for dental and surgical procedures. Most local anesthetics used for minor dental and outpatient procedures wear off within a relatively short period of time. The anesthetic itself may not limit flying as much as the actual procedure and subsequent pain.

Stimulants are drugs that excite the central nervous system and produce an increase in alertness and activity. Amphetamines, caffeine, and nicotine are all forms of stimulants. Common uses of these drugs include appetite suppression, fatigue reduction, and mood elevation. Some of these drugs may cause a stimulant reaction, even though this reaction is not their primary function. In some cases, stimulants can produce anxiety and mood swings, both of which are dangerous when flying.

Depressants are drugs that reduce the body's functioning in many areas. These drugs lower blood pressure, reduce mental processing, and slow motor and reaction responses. There are several types of drugs that can cause a depressing effect on the body, including tranquilizers, motion sickness medication, some types of stomach medication, decongestants, and antihistamines. The most common depressant is alcohol.

Substance	Generic Or Brand Name	Treatment for	Possible Side Effects
Alcohol	Beer Liquor Wine	N/A	Impaired judgment and perception Impaired coordination and motor control Reduced reaction time Impaired sensory perception Reduced intellectual functions Reduced tolerance to G-forces Inner-ear disturbance and spatial disorientation (up to 48 hours) Central nervous system depression
Nicotine	Cigars Cigarettes Pipe tobacco Chewing tobacco Snuff	N/A	Sinus and respiratory system infection and irritation Impaired night vision Hypertension Carbon monoxide poisoning (from smoking)
Amphetamines	Ritalin Obetrol Eskatrol	Obesity (diet pills) Tiredness	Prolonged wakefulness Nervousness Impaired vision Suppressed appetite Shakiness Excessive sweating Rapid heart rate Sleep disturbance Seriously impaired judgment
Caffeine	Coffee Tea Chocolate No-Doz	N/A	Impaired judgment Reduced reaction time Sleep disturbance Increased motor activity and tremors Hypertension Irregular heart rate Rapid heart rate Body dehydration (through increased urine output) Headaches
Antacid	Alka-2 Di-Gel Maalox	Stomach acids	Liberations of carbon dioxide at altitude (distension may cause acute abdominal pain and may mask other medical problems)
Antihistamines	Coricidin Contac Dristan Dimetapp Omade Chlor-Trimeton Diphenhydramine	Allergies Colds	Drowsiness and dizziness (sometimes recurring) Visual disturbances (when medications also contain antispasmodic drugs)
Aspirin	Bayer Bufferin Alka-Seltzer	Headaches Fevers Aches Pains	Irregular body temperature Variation in rate and depth of respiration Hypoxia and hyperventilation (two aspirin can contribute to) Nausea, ringing in ears, deafness, diarrhea, and hallucinations when taken in excessive dosages Corrosive action on the stomach lining Gastrointestinal problems Decreased clotting ability of the blood (clotting ability could be the difference between life and death in a survival situation)

Figure 17-9. *Adverse affects of various drugs.*

Some drugs that are classified as neither stimulants nor depressants have adverse effects on flying. For example, some antibiotics can produce dangerous side effects, such as balance disorders, hearing loss, nausea, and vomiting. While many antibiotics are safe for use while flying, the infection requiring the antibiotic may prohibit flying. In addition, unless specifically prescribed by a physician, do not take more than one drug at a time, and never mix drugs with alcohol because the effects are often unpredictable.

The dangers of illegal drugs also are well documented. Certain illegal drugs can have hallucinatory effects that occur days or weeks after the drug is taken. Obviously, these drugs have no place in the aviation community.

14 CFR prohibits pilots from performing crewmember duties while using any medication that affects the body in any way contrary to safety. The safest rule is not to fly as a crewmember while taking any medication, unless approved to do so by the FAA. If there is any doubt regarding the effects of any medication, consult an AME before flying.

Prior to each and every flight, all pilots must do a proper physical self-assessment to ensure safety. A great mnemonic, covered in Chapter 2 on Aeronautical Decision-Making, is IMSAFE, which stands for Illness, Medication, Stress, Alcohol, Fatigue, and Emotion.

For the medication component of IMSAFE, pilots need to ask themselves, "Am I taking any medicines that might affect my judgment or make me drowsy? For any new medication, OTC or prescribed, you should wait at least 48 hours after the first dose before flying to determine you do not have any adverse side effects that would make it unsafe to operate an aircraft. In addition to medication questions, pilots should also consider the following –

- Do not take any unnecessary or elective medications;
- Make sure you eat regular balanced meals;
- Bring a snack for both you and your passengers for the flight;
- Maintain good hydration - bring plenty of water;
- Ensure adequate sleep the night prior to the flight; and
- Stay physically fit.

Additionally, you should wait at least five maximal dosing intervals, the time between recommended or prescribed dosing, (e.g., a dosing interval of 5 to 6 hours would require you to wait 30 hours) before flying after taking any medication that has potentially adverse side effects (e.g., sedating or dizziness). Observing the recommended dosing interval doesn't eliminate the risk for adverse side effects because everyone metabolizes medications differently. However, five times the dosing interval is a reasonable rule of thumb.

Altitude-Induced Decompression Sickness (DCS)

Decompression sickness (DCS) describes a condition characterized by a variety of symptoms resulting from exposure to low barometric pressures that cause inert gases (mainly nitrogen), normally dissolved in body fluids and tissues, to come out of physical solution and form bubbles. Nitrogen is an inert gas normally stored throughout the human body (tissues and fluids) in physical solution. When the body is exposed to decreased barometric pressures (as in flying an unpressurized aircraft to altitude or during a rapid decompression), the nitrogen dissolved in the body comes out of solution. If the nitrogen is forced to leave the solution too rapidly, bubbles form in different areas of the body causing a variety of signs and symptoms. The most common symptom is joint pain, which is known as "the bends." *[Figure 17-10]*

What to do when altitude-induced DCS occurs:

- Put on oxygen mask immediately and switch the regulator to 100 percent oxygen.
- Begin an emergency descent and land as soon as possible. Even if the symptoms disappear during descent, land and seek medical evaluation while continuing to breathe oxygen.
- If one of the symptoms is joint pain, keep the affected area still; do not try to work pain out by moving the joint around.
- Upon landing, seek medical assistance from an FAA medical officer, AME, military flight surgeon, or a hyperbaric medicine specialist. Be aware that a physician not specialized in aviation or hypobaric medicine may not be familiar with this type of medical problem.
- Definitive medical treatment may involve the use of a hyperbaric chamber operated by specially-trained personnel.
- Delayed signs and symptoms of altitude-induced DCS can occur after return to ground level regardless of presence during flight.

DCS After Scuba Diving

Scuba diving subjects the body to increased pressure, which allows more nitrogen to dissolve in body tissues and fluids. *[Figure 17-11]* The reduction of atmospheric pressure that accompanies flying can produce physical problems for scuba divers. A pilot or passenger who intends to fly after scuba diving should allow the body sufficient time to rid itself of excess nitrogen absorbed during diving. If not, DCS due to

DCS Type	Bubble Location	Signs and Symptoms (Clinical Manifestations)
BENDS	Mostly large joints of the body (elbows, shoulders, hip, wrists, knees, ankles)	• Localized deep pain, ranging from mild (a "niggle") to excruciating–sometimes a dull ache, but rarely a sharp pain • Active and passive motion of the joint aggravating the pain • Pain occurring at altitude, during the descent, or many hours later
NEUROLOGIC Manifestations	Brain	• Confusion or memory loss • Headache • Spots in visual field (scotoma), tunnel vision, double vision (diplopia), or blurry vision • Unexplained extreme fatigue or behavior changes • Seizures, dizziness, vertigo, nausea, vomiting, and unconsciousness
	Spinal cord	• Abnormal sensations, such as burning, stinging, and tingling, around the lower chest and back • Symptoms spreading from the feet up and possibly accompanied by ascending weakness or paralysis • Girdling abdominal or chest pain
	Peripheral nerves	• Urinary and rectal incontinence • Abnormal sensations, such as numbness, burning, stinging and tingling (paresthesia) • Muscle weakness or twitching
CHOKES	Lungs	• Burning deep chest pain (under the sternum) • Pain aggravated by breathing • Shortness of breath (dyspnea) • Dry constant cough
SKIN BENDS	Skin	• Itching usually around the ears, face, neck, arms, and upper torso • Sensation of tiny insects crawling over the skin • Mottled or marbled skin usually around the shoulders, upper chest, and abdomen accompanied by itching • Swelling of the skin, accompanied by tiny scar-like skin depressions (pitting edema)

Figure 17-10. *Signs and symptoms of altitude decompression sickness.*

evolved gas can occur during exposure to low altitude and create a serious inflight emergency.

The recommended waiting time before going to flight altitudes of up to 8,000 feet is at least 12 hours after diving that does not require controlled ascent (nondecompression stop diving), and at least 24 hours after diving that does require controlled ascent (decompression stop diving). The waiting time before going to flight altitudes above 8,000 feet should be at least 24 hours after any scuba dive. These recommended altitudes are actual flight altitudes above mean sea level (MSL) and not pressurized cabin altitudes. This takes into consideration the risk of decompression of the aircraft during flight.

Vision in Flight

Of all the senses, vision is the most important for safe flight. Most of the things perceived while flying are visual or heavily supplemented by vision. As remarkable and vital as it is, vision is subject to limitations, such as illusions and blind spots. The more a pilot understands about the eyes and how they function, the easier it is to use vision effectively and compensate for potential problems.

The eye functions much like a camera. Its structure includes an aperture, a lens, a mechanism for focusing, and a surface for registering images. Light enters through the cornea at the front of the eyeball, travels through the lens, and falls on the retina. The retina contains light sensitive cells that convert

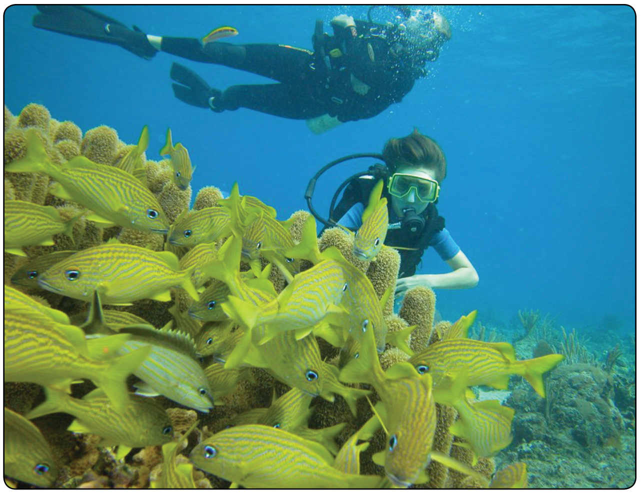

Figure 17-11. *To avoid the bends, scuba divers must not fly for specific time periods following dives.*

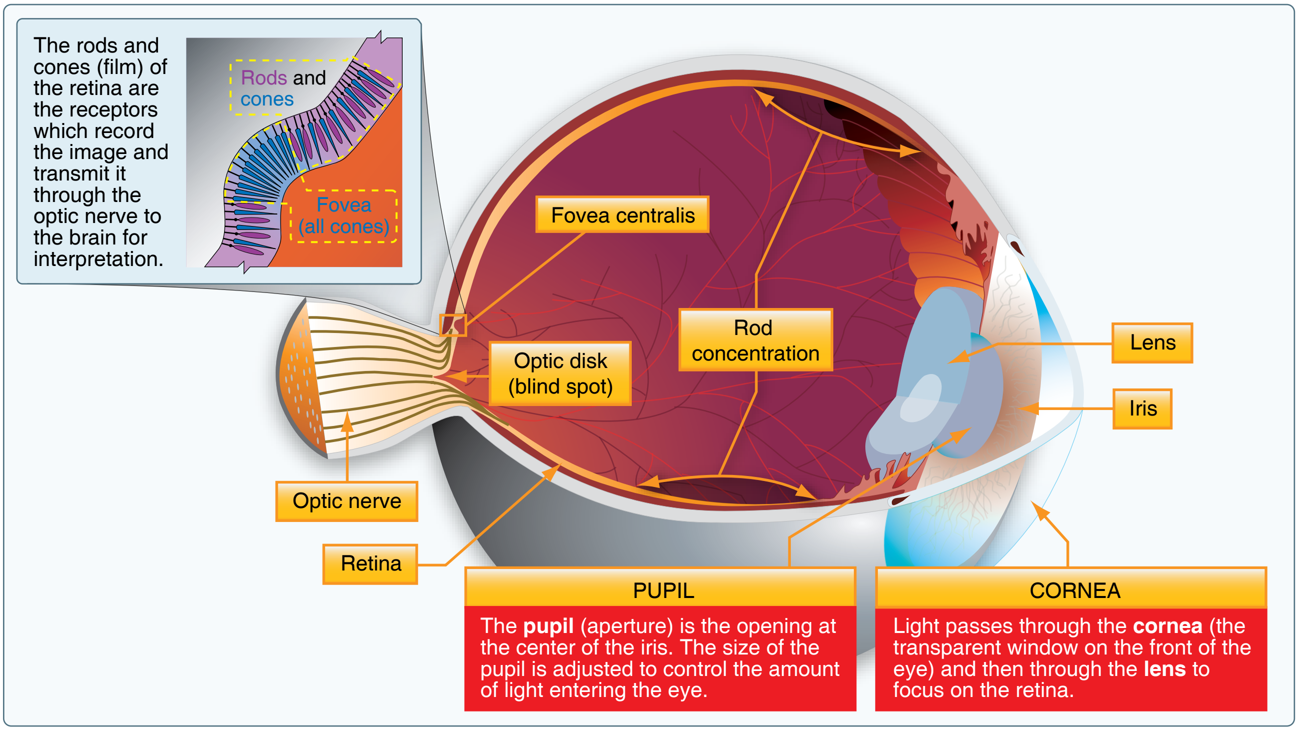

Figure 17-12. *The human eye.*

light energy into electrical impulses that travel through nerves to the brain. The brain interprets the electrical signals to form images. There are two kinds of light-sensitive cells in the eyes: rods and cones. *[Figure 17-12]*

The cones are responsible for all color vision, from appreciating a glorious sunset to discerning the subtle shades in a fine painting. Cones are present throughout the retina, but are concentrated toward the center of the field of vision at the back of the retina. There is a small pit called the fovea where almost all the light sensing cells are cones. This is the area where most "looking" occurs (the center of the visual field where detail, color sensitivity, and resolution are highest).

While the cones and their associated nerves are well suited to detecting fine detail and color in high light levels, the rods are better able to detect movement and provide vision in dim light. The rods are unable to discern color but are very sensitive at low-light levels. The trouble with rods is that a large amount of light overwhelms them, and they take longer to "reset" and adapt to the dark again. There are so many cones in the fovea that are at the very center of the visual field but virtually has no rods at all. So in low light, the middle of the visual field is not very sensitive, but farther from the fovea, the rods are more numerous and provide the major portion of night vision.

Vision Types

There are three types of vision: photopic, mesopic, and scotopic. Each type functions under different sensory stimuli or ambient light conditions. *[Figure 17-13]*

Photopic Vision

Photopic vision provides the capability for seeing color and resolving fine detail (20/20 or better), but it functions only in good illumination. Photopic vision is experienced during daylight or when a high level of artificial illumination exists.

Types of Vision						
Types of vision used	**Light level**	**Technique of viewing**	**Color perception**	**Receptors used**	**Acuity best**	**Blind spot**
Photopic	High	Central	Good	Cones	20/20	Day
Mesopic	Medium/Low	Both	Some	Cones/Rods	Varies	Day/Night
Scotopic	Low	Scanning	None	Rods	20/200	Day/Night

Figure 17-13. *Types of vision.*

The cones concentrated in the fovea centralis of the eye are primarily responsible for vision in bright light. *[Figure 17-12]* Because of the high light level, rhodopsin, which is a biological pigment of the retina that is responsible for both the formation of the photoreceptor cells and the first events in the perception of light, is bleached out causing the rod cells to become less effective.

Mesopic Vision

Mesopic vision is achieved by a combination of rods and cones and is experienced at dawn, dusk, and during full moonlight. Visual acuity steadily decreases as available light decreases and color perception changes because the cones become less effective. Mesopic viewing period is considered the most dangerous period for viewing. As cone sensitivity decreases, pilots should use off-center vision and proper scanning techniques to detect objects during low-light levels.

Scotopic Vision

Scotopic vision is experienced under low-light levels and the cones become ineffective, resulting in poor resolution of detail. Visual acuity decreases to 20/200 or less and enables a person to see only objects the size of or larger than the big "E" on visual acuity testing charts from 20 feet away. In other words, a person must stand at 20 feet to see what can normally be seen at 200 feet under daylight conditions. When using scotopic vision, color perception is lost and a night blind spot in the central field of view appears at low light levels when the cone-cell sensitivity is lost.

Central 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. *[Figure 17-14]* As a result, it is referred to as the blind spot that everyone has in each eye. Under normal binocular vision conditions (both eyes are used together), 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 divider or another aircraft), a visual target could fall in the blind spot of the other eye and remain undetected.

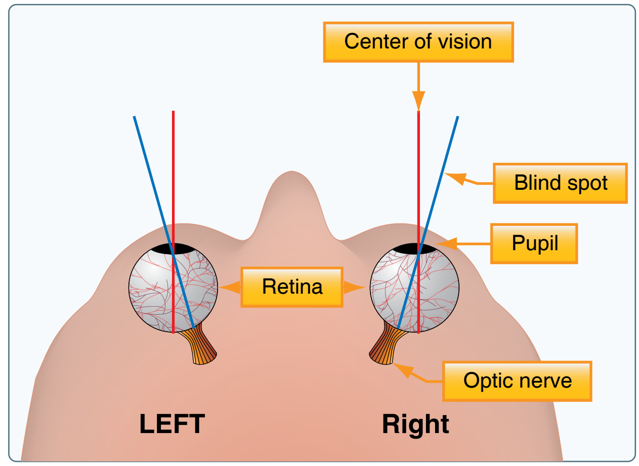

Figure 17-14. *Central blind spot.*

Figure 17-15 provides a dramatic example of the eye's blind spot.

1. Hold this page at an arm's length.
2. Completely cover your left eye (without closing or pressing on it) using your hand or other flat object.
3. With your right eye, stare directly at the airplane on the left side of the picture page. In your periphery, you will notice the black X on the right side of the picture.
4. Slowly move the page closer to you while continuing to stare at the airplane.

Figure 17-15. *The eye's blind spot.*

5. When the page is about 16–18 inches from you, the black X should disappear completely because it has been imaged onto the blind spot of your right eye. (Resist the temptation to move your right eye while the black X is gone or else it reappears. Keep staring at the airplane.)
6. As you continue to look at the airplane, keep moving the page closer to you a few more inches, and the black X will come back into view.
7. There is an interval where you are able to move the page a few inches backward and forward, and the black X will be gone. This demonstrates to you the extent of your blind spot.
8. You can try the same thing again, except this time with your right eye covered stare at the black X with your left eye. Move the page in closer and the airplane will disappear.

Another way to check your blind spot is to do a similar test outside at night when there is a full moon. Cover your left eye, looking at the full moon with your right eye. Gradually move your right eye to the left (and maybe slightly up or down). Before long, all you will be able to see is the large halo around the full moon; the entire moon itself will seem to have disappeared.

Empty-Field Myopia

Empty-field myopia is a condition that usually occurs when flying above the clouds or in a haze layer that provides nothing specific to focus on outside the aircraft. This causes the eyes to relax and seek a comfortable focal distance that may range from 10 to 30 feet. For the pilot, this means looking without seeing, which is dangerous. Searching out and focusing on distant light sources, no matter how dim, helps prevent the onset of empty-field myopia.

Night Vision

There are many good reasons to fly at night, but pilots must keep in mind that the risks of night flying are different than during the day and often times higher. *[Figure 17-16]* Pilots who are cautious and educated on night-flying techniques can mitigate those risks and become very comfortable and proficient in the task.

Figure 17-16. *Night vision.*

Night Blind Spot

It is estimated that once fully adapted to darkness, the rods are 10,000 times more sensitive to light than the cones, making them the primary receptors for night vision. Since the cones are concentrated near the fovea, the rods are also responsible for much of the peripheral vision. The concentration of cones in the fovea can make a night blind spot in the center of the field of vision. To see an object clearly at night, the pilot must expose the rods to the image. This can be done by looking 5° to 10° off center of the object to be seen. This can be tried in a dim light in a darkened room. When looking directly at the light, it dims or disappears altogether. When looking slightly off center, it becomes clearer and brighter.

When looking directly at an object, the image is focused mainly on the fovea, where detail is best seen. At night, the ability to see an object in the center of the visual field is reduced as the cones lose much of their sensitivity and the rods become more sensitive. Looking off center can help compensate for this night blind spot. Along with the loss of

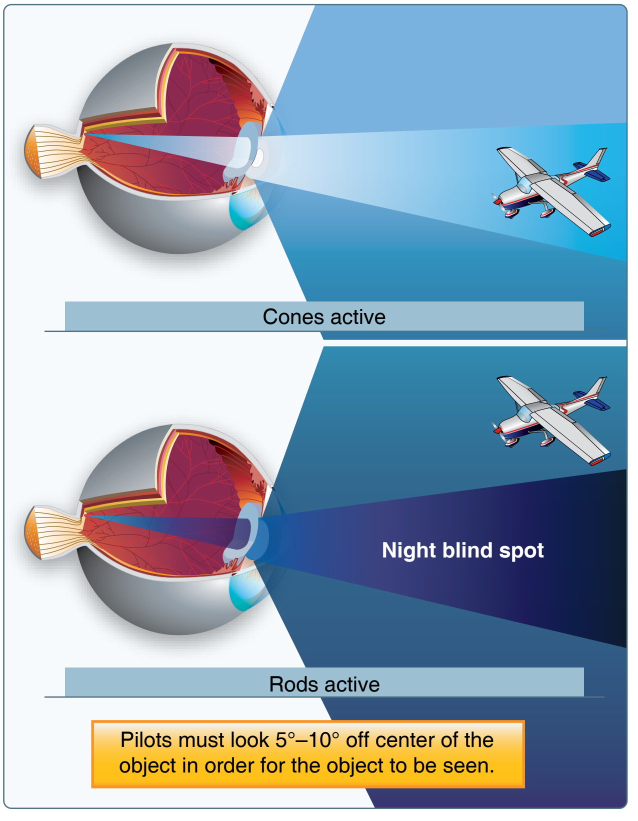

Figure 17-17. *Night blind spot.*

sharpness (acuity) and color at night, depth perception and judgment of size may be lost. *[Figure 17-17]*

Dark Adaptation

Dark adaptation is the adjustment of the human eye to a dark environment. That adjustment takes longer depending on the amount of light in the environment that a person has just left. Moving from a bright room into a dark one takes longer than moving from a dim room and going into a dark one.

While the cones adapt rapidly to changes in light intensities, the rods take much longer. Walking from bright sunlight into a dark movie theater is an example of this dark adaptation period experience. The rods can take approximately 30 minutes to fully adapt to darkness. A bright light, however, can completely destroy night adaptation, leaving night vision severely compromised while the adaptation process is repeated.

Scanning Techniques

Scanning techniques are very important in identifying objects at night. To scan effectively, pilots must look from right to left or left to right. They should begin scanning at the greatest distance an object can be perceived (top) and move inward toward the position of the aircraft (bottom). For each stop, an area approximately 30° wide should be scanned. The duration of each stop is based on the degree of detail that is required, but no stop should last longer than 2 to 3 seconds. When moving from one viewing point to the next, pilots should overlap the previous field of view by 10°. *[Figure 17-18]*

Off-center viewing is another type of scan that pilots can use during night flying. It is a technique that requires an object be viewed by looking 10° above, below, or to either side of the object. *[Figure 17-19]* In this manner, the peripheral vision can maintain contact with an object.

With off-center vision, the images of an object viewed longer than 2 to 3 seconds will disappear. This occurs because the rods reach a photochemical equilibrium that prevents any further response until the scene changes. This produces a potentially unsafe operating condition. To overcome this night vision limitation, pilots must be aware of the phenomenon and avoid viewing an object for longer than 2 or 3 seconds. The peripheral field of vision will continue to pick up the object when the eyes are shifted from one off-center point to another.

Night Vision Protection

Several things can be done to help with the dark adaptation process and to keep the eyes adapted to darkness. Some of the steps pilots and flight crews can take to protect their night vision are described in the following paragraphs.

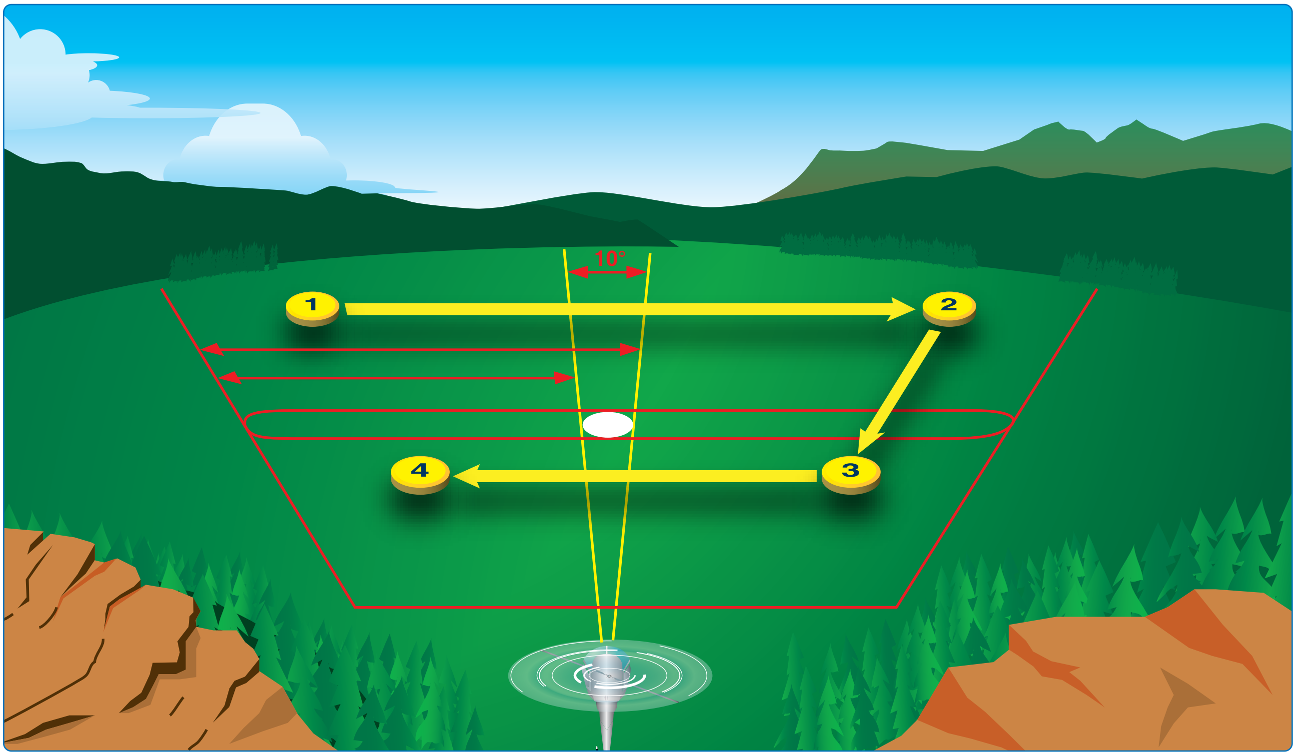

Figure 17-18. *Scanning techniques.*

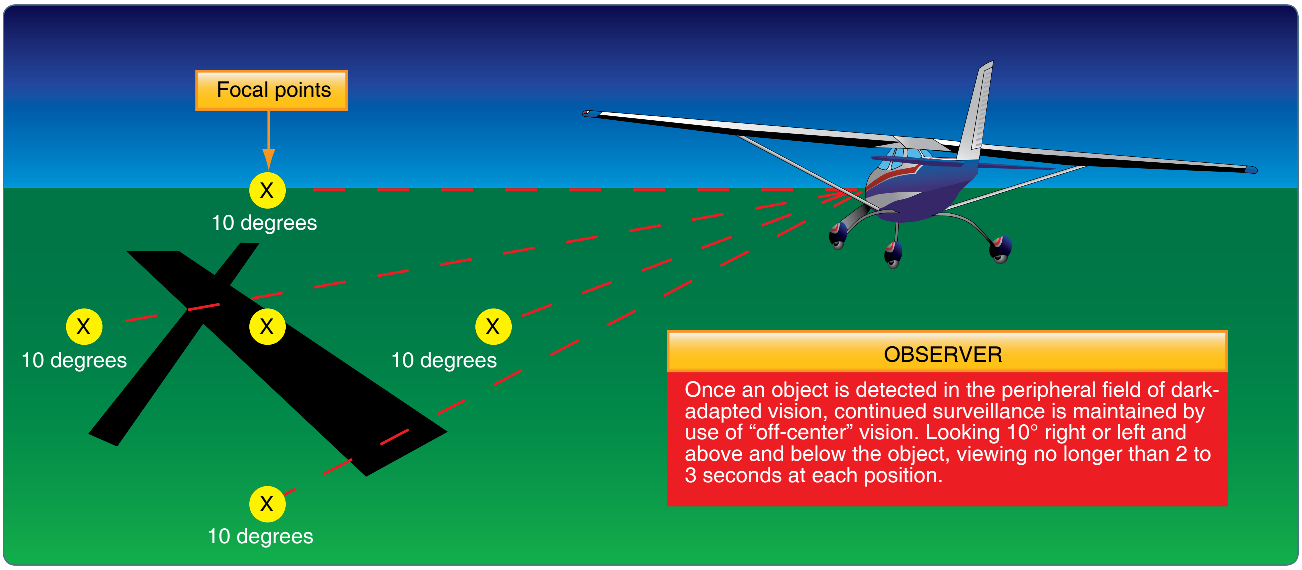

Figure 17-19. *Off-center viewing.*

Sunglasses

If a night flight is scheduled, pilots and crew members should wear neutral density (N-15) sunglasses or equivalent filter lenses when exposed to bright sunlight. This precaution increases the rate of dark adaptation at night and improves night visual sensitivity.

Oxygen Supply

Unaided night vision depends on optimum function and sensitivity of the rods of the retina. Lack of oxygen to the rods (hypoxia) significantly reduces their sensitivity. Sharp clear vision (with the best being equal to 20–20 vision) requires significant oxygen especially at night. Without supplemental oxygen, an individual's night vision declines measurably at pressure altitudes above 4,000 feet. As altitude increases, the available oxygen decreases, degrading night vision. Compounding the problem is fatigue, which minimizes physiological well being. Adding fatigue to high altitude exposure is a recipe for disaster. In fact, if flying at night at an altitude of 12,000 feet, the pilot may actually see elements of his or her normal vision missing or not in focus. Missing visual elements resemble the missing pixels in a digital image while unfocused vision is dim and washed out.

For the pilot suffering the effects of hypoxic hypoxia, a simple descent to a lower altitude may not be sufficient to reestablish vision. For example, a climb from 8,000 feet to 12,000 feet for 30 minutes does not mean a descent to 8,000 feet will rectify the problem. Visual acuity may not be regained for over an hour. Thus, it is important to remember, altitude and fatigue have a profound effect on a pilot's ability to see.

High Intensity Lighting

If, during the flight, any high intensity lighting areas are encountered, attempt to turn the aircraft away and fly in the periphery of the lighted area. This will not expose the eyes to such a large amount of light all at once. If possible, plan your route to avoid direct over flight of built-up, brightly lit areas.

Flightdeck Lighting

Flightdeck lighting should be kept as low as possible so that the light does not monopolize night vision. After reaching the desired flight altitude, pilots should allow time to adjust to the flight conditions. This includes readjustment of instrument lights and orientation to outside references. During the adjustment period, night vision should continue to improve until optimum night adaptation is achieved. When it is necessary to read maps, charts, and checklists, use a dim white light flashlight and avoid shining it in your or any other crewmember's eyes.

Airfield Precautions

Often time, pilots have no say in how airfield operations are handled, but listed below are some precautions that can be taken to make night flying safer and help protect night vision.

- Airfield lighting should be reduced to the lowest usable intensity.
- Maintenance personnel should practice light discipline with headlights and flashlights.
- Position the aircraft at a part of the airfield where the least amount of lighting exists.

- Select approach and departure routes that avoid highways and residential areas where illumination can impair night vision.

Self-Imposed Stress

Night flight can be more fatiguing and stressful than day flight, and many self- imposed stressors can limit night vision. Pilots can control this type of stress by knowing the factors that can cause self-imposed stressors. Some of these factors are listed in the following paragraphs. *[Figure 17-20]*

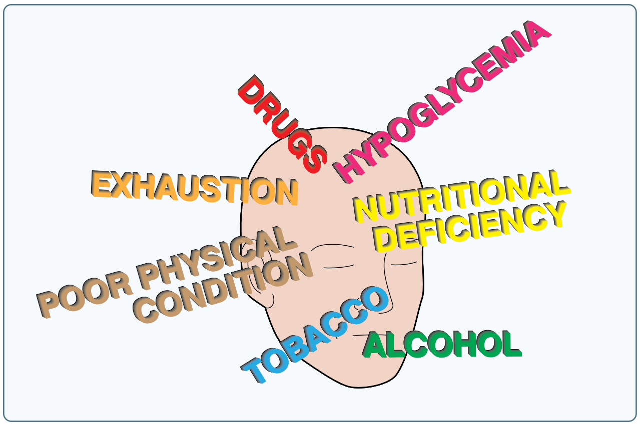

Figure 17-20. *Self-imposed stress.*

Drugs

Drugs can seriously degrade visual acuity during the day and especially at night. Pilots who become ill should consult an aviation medical examiner (AME) or flight surgeon as to which drugs are appropriate to take while flying.

Exhaustion

Pilots who become fatigued during a night flight will not be mentally alert and will respond more slowly to situations requiring immediate action. Exhausted pilots tend to concentrate on one aspect of a situation without considering the total requirement. Their performance may become a safety hazard depending on the degree of fatigue and instead of using proper scanning techniques may get fixated on the instruments or stare off rather than multitask.

Poor Physical Conditioning

To overcome poor physical conditioning, pilots should participate in regular exercise programs. People who are physically fit become less fatigued during flight and have better night scanning efficiency. However, too much exercise in a given day may leave crew members too fatigued for night flying.

Alcohol

Alcohol is a sedative and its use impairs both coordination and judgment. As a result, pilots who are impaired by alcohol fail to apply the proper techniques of night vision. They are likely to stare at objects and to neglect scanning techniques. The amount of alcohol consumed determines the degree to which night vision is affected. The effects of alcohol are long lasting and the residual effects of alcohol can also impair visual scanning efficiency.

Tobacco

Of all the self-imposed stressors, cigarette smoking most decreases visual sensitivity at night. Smoking significantly increases the amount of carbon monoxide carried by the hemoglobin in red blood cells. This reduces the blood's capacity to combine with oxygen, so less oxygen is carried in the blood. Hypoxia caused by carbon monoxide poisoning affects peripheral vision and dark adaptation. The results are the same as those for hypoxia caused by high altitude. Smoking 3 cigarettes in rapid succession or 20 to 30 cigarettes within a 24-hour period may saturate from 8 to 10 percent of the capacity of hemoglobin. Smokers lose 20 percent of their night vision capability at sea level, which is equal to a physiological altitude of 5,000 feet.

Hypoglycemia and Nutritional Deficiency

Missing or postponing meals can cause low blood sugar, which impairs night flight performance. Low blood sugar levels may result in stomach contractions, distraction, breakdown in habit pattern, and a shortened attention span. Likewise, an insufficient consumption of vitamin A may also impair night vision. Foods high in vitamin A include eggs, butter, cheese, liver, apricots, peaches, carrots, squash, spinach, peas, and most types of greens. High quantities of vitamin A do not increase night vision but a lack of vitamin A certainly impairs it.

Distance Estimation and Depth Perception

Knowledge of the mechanisms and cues affecting distance estimation and depth perception assist pilots in judging distances at night. These cues may be monocular or binocular. The monocular cues that aid in distance estimation and depth perception include motion parallax, geometric perspective, retinal image size, and aerial perspective.

Motion Parallax

Motion parallax refers to the apparent motion of stationary objects as viewed by an observer moving across the landscape. When the pilot or crewmember looks outside the aircraft perpendicular to the direction of travel, near objects appear to move backward, past, or opposite the path of motion; far objects seem to move in the direction of motion or remain fixed. The rate of apparent movement depends on the distance the observer is from the object.

Geometric Perspective

An object may appear to have a different shape when viewed at varying distances and from different angles. Geometric perspective cues include linear perspective, apparent foreshortening, and vertical position in the field.

- Linear perspective—parallel lines, such as runway lights, power lines and railroad tracks, tend to converge as distance from the observer increases. *[Figure 17-21A]*
- Apparent foreshortening—the true shape of an object or a terrain feature appears elliptical when viewed from a distance. *[Figure 17-21B]*
- Vertical position in the field—objects or terrain features farther away from the observer appear higher on the horizon than those closer to the observer. *[Figure 17-21C]*

Aerial Perspective

The clarity of an object and the shadow cast by it are perceived by the brain and are cues for estimating distance. Subtle variations in color or shade are clearer the closer the observer is to an object. However, as distance increases, these distinctions may become blurry. The same applies to an object detail or texture. As a person gets farther from an object, its discrete details become less apparent. Another important fact to remember while flying at night is that every object casts a shadow from a light source. The direction in which the shadow is cast depends on the position of the light source. If the shadow of an object is cast toward the observer, the object is closer than the light source is to the observer.

Binocular Cues

Binocular cues of an object are dependent upon the slightly different viewing angle of each eye of an object. Binocular perception is useful only when the object is close enough to make an obvious difference in the viewing angle of both eyes. In the flight environment, most distances outside the cockpit are so great that binocular cues are of little, if any, value. In addition, binocular cues operate on a more subconscious level than monocular cues and are performed automatically.

Night Vision Illusions

There are many different types of visual illusions that commonly occur at night. Anticipating and maintaining awareness of them is usually the best way to avoid them.

Autokinesis

Autokinesis is caused by staring at a single point of light against a dark background for more than a few seconds. After a few moments, the light appears to move on its own. Apparent movement of the light source will begin in about 8 to 10 seconds. To prevent this illusion, focus the eyes on objects at varying distances and avoid fixating on one source of light. This illusion can be eliminated or reduced by visual scanning, by increasing the number of lights, or by varying the light intensity. The most important of the three solutions is visual scanning. A light or lights should not be stared at for more than 10 seconds.

False Horizon

A false horizon can occur when the natural horizon is obscured or not readily apparent. It can be generated by confusing bright stars and city lights. It can also occur while flying toward the shore of an ocean or a large lake. Because of the relative darkness of the water, the lights along the shoreline can be mistaken for stars in the sky. *[Figure 17-22]*

Reversible Perspective Illusion

At night, an aircraft may appear to be moving away from a second aircraft when it is, in fact, approaching a second aircraft. This illusion often occurs when an aircraft is flying

Figure 17-21. *Geometric perspective.*

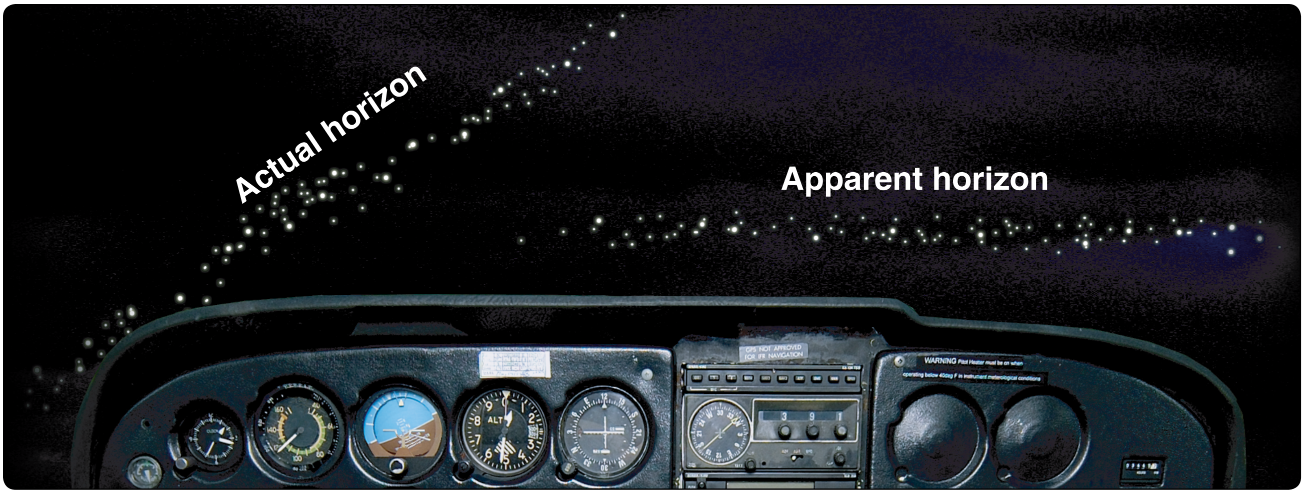

Figure 17-22. *At night, the horizon may be hard to discern due to dark terrain and misleading light patterns on the ground.*

parallel to another's course. To determine the direction of flight, pilots should observe aircraft lights and their relative position to the horizon. If the intensity of the lights increases, the aircraft is approaching; if the lights dim, the aircraft is moving away.

Size-Distance Illusion

This illusion results from viewing a source of light that is increasing or decreasing in luminance (brightness). Pilots may interpret the light as approaching or retreating.

Fascination (Fixation)

This illusion occurs when pilots ignore orientation cues and fix their attention on a goal or an object. Student pilots tend to have this happen when they are concentrating on the aircraft instruments or attempting to land. They become fixated on one task and forget to look at what is going on around them. At night, this can be especially dangerous because aircraft ground-closure rates are difficult to determine, and there may be minimal time to correct the situation.

Flicker Vertigo

A light flickering at a rate between 4 and 20 cycles per second can produce unpleasant and dangerous reactions. Such conditions as nausea, vomiting, and vertigo may occur. On rare occasions, convulsions and unconsciousness may also occur. Proper scanning techniques at night can prevent pilots from getting flicker vertigo.

Night Landing Illusions

Landing illusions occur in many forms. Above featureless terrain at night, there is a natural tendency to fly a lower-than-normal approach. Elements that cause any type of visual obscurities, such as rain, haze, or a dark runway environment, can also cause low approaches. Bright lights, steep surrounding terrain, and a wide runway can produce the illusion of being too low with a tendency to fly a higher-than-normal approach. A set of regularly spaced lights along a road or highway can appear to be runway lights. Pilots have even mistaken the lights on moving trains as runway or approach lights. Bright runway or approach lighting systems can create the illusion that the aircraft is closer to the runway, especially where few lights illuminate the surrounding terrain.

Prior to flying at night, it is best to learn and know the challenges of the area in which you are flying in. Study the area and know how to navigate your way through areas that may pose a problem at night. For example, many areas near water may be obscured by low lying clouds or fog. To help deal with this type of situation, it is important to have a plan before you leave the ground. In the daytime, fly the routes and passes that you will be flying at night and determine the minimum altitude you are willing to use at night. If weather prevents you from maintaining the altitude that you planned, make a decision early to turn 180° and land at an alternate airport with better weather conditions. Always consider safer alternatives rather than hope things will work out by taking a chance.

Pilots who fly at night should strongly consider oxygen supplementation at altitudes and times not required by the FAA, especially at night when critical judgment and hand-eye coordination is necessary (e.g., IFR) or if he/she is a smoker or not perfectly healthy.

Enhanced Night Vision Systems

Synthetic Vision Systems (SVS) and Enhanced Flight Vision Systems (EFVS) are two systems that can improve the safety of flight at night. The technology of both is evolving rapidly and being used more and more. *[Figure 17-23]*

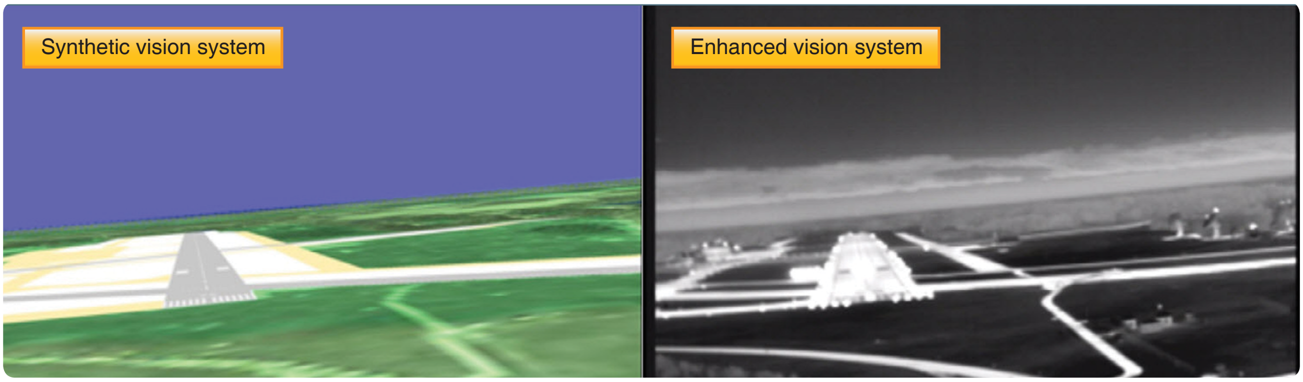

Figure 17-23. *Synthetic and enhanced vision systems.*

Synthetic Vision System

A Synthetic Vision System (SVS) is an electronic means to display a synthetic vision image of the external scene topography to the flight crew. *[Figure 17-24]* It is not a real-time image like that produced by an EFVS. Unlike EFVS, SVS requires a terrain and obstacle database, a precise navigation solution, and a display. The terrain image is based on the use of data from a Digital Elevation Model (DEM) that is stored within the SVS. With SVS, the synthetic terrain/vision image is intended to enhance pilot awareness of spatial position relative to important features in all visibility conditions. This is particularly useful during critical phases of flight, such as takeoff, approach, and landing, where important features, such as terrain, obstacles, runways, and landmarks, may be depicted on the SVS display. *[Figure 17-25]* During approach operations, the obvious advantages of SVS are that the digital terrain image remains on the pilot's display regardless of how poor the visibility is outside.

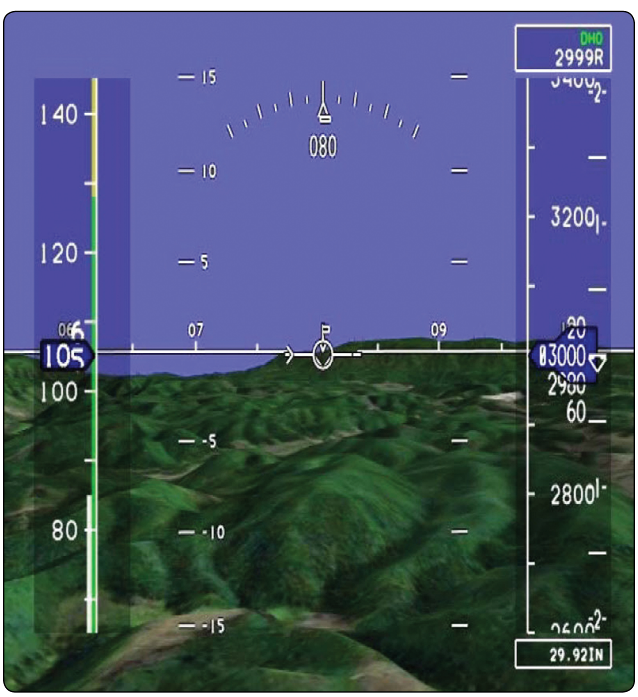

Figure 17-24. *SVS system.*

An SVS image can be displayed on either a head-down display or head-up display (HUD); however, to date, SVS has only been certified on head-down displays. Development efforts to display a synthetic image on a HUD are currently underway as are efforts that would combine SVS with a real-time sensor image produced by an EFVS. These systems are known as Combined Vision Systems. While SVS is currently certified as an aid to situation awareness only, the FAA and aviation industry are working on defining operational concepts and airworthiness criteria that would enable SVS to be used for operational credit in certain low visibility conditions. Other future enhancements to SVS displays could include integrating ADS-B to display traffic information.

Enhanced Flight Vision System

Enhanced Vision (EV) or Enhanced Flight Vision System (EFVS) is an electronic means to provide a display of

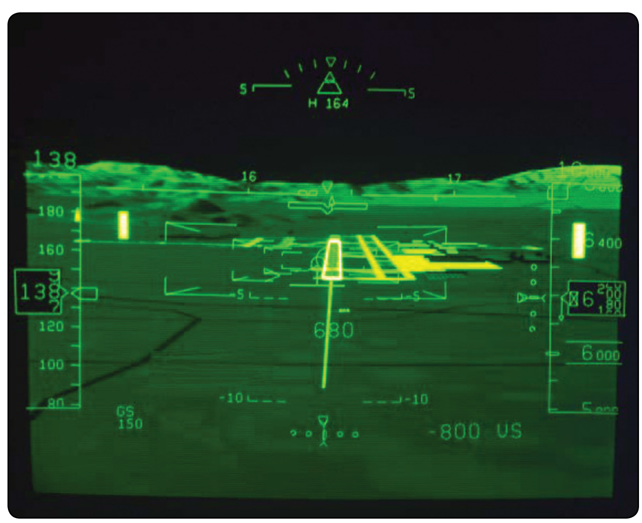

Figure 17-25. *Night time SVS system.*

the external scene by use of an imaging sensor, such as a Forward-Looking InfraRed (FLIR) or millimeter wave radar (MMWR). In 2004, 14 CFR part 91, section 91.175 was amended to reflect that operators conducting straight-in instrument approach procedures (in other than Category II or Category III operations) may now operate below the published decision height (DH) or minimum descent altitude (MDA) when using an approved EFVS shown on the pilot's HUD. This rule change provides "operational credit" for EV equipage. No such credit exists for SV.

Chapter Summary

This chapter provides an introduction to aeromedical factors relating to flight activities. More detailed information on the subjects discussed in this chapter is available in the Aeronautical Information Manual (AIM) and online at www.faa.gov.