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When light from an object enters the eye, it passes through the cornea. The cornea is a circular, transparent protective tissue that projects forward and protects the eye. Once light travels through the cornea, it enters the pupil. The pupil is the opening (black center portion) in the center of the iris. The pupil allows the light to enter the eye to stimulate the retina. The iris is the round, pigmented (colored) membrane of the eye surrounding the pupil. For example, for people with brown, green, or hazel eyes, that colored portion is the iris. The iris adjusts the size of the pupil by using its ciliary muscles, which are attached to the pupil. The iris adjusts the size of the pupil to regulate the amount of light entering the eye. When the pupil dilates (enlarges) under low light levels, it allows more light to enter the eye to further stimulate the retina. When the pupil constricts (becomes smaller) under high light levels, it decreases the amount of light entering the eye, avoiding oversaturation (stimulation) of the retina. Light entering the eye is regulated so that the retina is not undersaturated or oversaturated with light images, which would negatively affect visual acuity. Once the light travels through the pupil, it will strike the lens. The lens is a transparent, biconvex membrane located behind the pupil. The lens then directs (refracts) the light upon the retina (the posterior or rear portion of the eye). The retina is a complex, structured membrane, consisting of 10 layers called the Jacob’s membrane. The retina contains many tiny photoreceptor cells, called rods and cones. Once light stimulates the retina, it produces a chemical change within the photoreceptor cells. When the chemical change occurs, nerve impulses are stimulated and transmitted to the brain via the optic nerve. The brain deciphers the impulse and creates a mental image that interprets what the individual is viewing.
DAY VERSUS NIGHT VISION (FM 3.04.301 pg 8-6)

**Night Blind Spot**- Occurs when the fovea becomes inactive under darkness or with low-level illumination, central vision becomes less effective and a night blind spot (5 to 10 degrees wide) develops. This results from the concentration of cones in the fovea centralis and parafovea, the area immediately surrounding the fovea of the retina. The night blind spot should not be confused with the physiological blind spot (the so-called day blind spot) caused by the optic disk. Because of the night blind spot, larger and larger objects will be missed as distance increases. To see things clearly at night, an individual must use off-center vision and proper scanning techniques. Utilize the “Off-Center” vision technique to compensate.

**Day or Physiological Blind Spot**- The physiological (day) blind spot is present all the time, not only during the day. This blind spot results from the position of the optic disk on the retina. The optic disk has no light-sensitive receptors. The physiological blind spot covers an area of approximately 5.5 to 7.5 degrees and is located about 15 degrees from the fovea. Compensated by binocular vision, each eye compensates for the blind spot in the optic disk of the opposite eye.

**TYPES OF VISION (PMS / LT CRAB PMS) (FM 3.04.301 pg 8-6)**

<table>
<thead>
<tr>
<th>Types Of Vision Used</th>
<th>Light Level</th>
<th>Techniques Of Viewing</th>
<th>Color Perception</th>
<th>Receptor Used</th>
<th>Best Visual Acuity</th>
<th>Blind Spot</th>
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<tbody>
<tr>
<td><strong>Photopic</strong></td>
<td>High</td>
<td>Central</td>
<td>Good</td>
<td>Cones</td>
<td>20/20</td>
<td>Day</td>
</tr>
<tr>
<td><strong>Mesopic</strong></td>
<td>Med/Low</td>
<td>Both</td>
<td>Some</td>
<td>Cones/Rods</td>
<td>Varies</td>
<td>Day/Night</td>
</tr>
<tr>
<td><strong>Scotopic</strong></td>
<td>Low</td>
<td>Scanning</td>
<td>None</td>
<td>Rods</td>
<td>20/200</td>
<td>Day/Night</td>
</tr>
</tbody>
</table>

**Photopic Vision**- Photopic vision is used during daylight or when a high level of artificial illumination exists. The cones concentrated in the fovea centralis of the eye are primarily responsible for vision in bright light. Because of the high light level, rhodopsin is bleached out and rod cells become less effective. Sharp image interpretation and color vision are characteristic of photopic vision.

**Mesopic Vision**- Mesopic vision is used at dawn, at dusk, and during full moonlight. Vision is achieved by a combination of cones and rods. Visual acuity steadily decreases as available light decreases. Color perception changes because the cones become less effective. As cone sensitivity decreases, crewmembers 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. Cones become ineffective, resulting in poor resolution of detail. Visual acuity decreases to 20/200 or less. This 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. (A person must stand at 20 feet to see what can normally be seen at 200 feet under daylight conditions.) Also, color perception is lost. A night blind spot in the central field of view appears at low light levels. The night blind spot occurs when cone-cell sensitivity is lost.
VISUAL DEFICIENCIES (FM 3.04.301 pg 8-0)

Several visual problems or conditions affect night vision. These include presbyopia, night myopia, myopia, hyperopia and astigmatism.

- **Presbyopia** - This condition is part of the normal aging process, which causes the lens of the eye to harden.
- **Night Myopia** - Myopic individuals do not see distant objects clearly; only nearby objects are in focus for them. Because of this, slightly nearsighted (myopic) individuals will experience visual difficulty at night when viewing blue-green light that could cause blurred vision. Also, image sharpness decreases as pupil diameter increases.
- **Myopia** - When a myopic person views an image at a distance, the actual focal point of the eye is in front of the retinal plane (wall), causing blurred vision. Thus, distant objects are not seen clearly; only nearby objects are in focus. The problem is referred to as nearsightedness.
- **Hyperopia** - Error in refraction, the lens of the eye does not focus an image directly on the retina. When an individual with hyperopia views a near image, the actual focal point of the eye is behind the retinal plane (wall), causing blurred vision. The problem is referred to as farsightedness.
- **Astigmatism** - Astigmatism is an unequal curvature of the cornea that may cause an out-of-focus condition. If, for example, an astigmatic person focuses on power poles (vertical), the wires (horizontal) will be out of focus in most cases.

DARK ADAPTATION (DSSTT) (FM 3.04.301 pg 8-6, 8-10)

**Definition** - Dark adaptation is the process by which the eyes increase their sensitivity to low levels of illumination.

**Starting level** -
- the lower the starting level of illumination, the less time is required for adaptation.
- Each person adapts to darkness in varying degrees and at different rates.
- Exposure to intense sunlight for 2-5hrs decreases visual sensitivity for up to 5hrs.
- Cumulative effect - the rate of dark adaptation and degree of night visual acuity decrease. May persist for several days.

**Sensitivity** -
- When fully dark-adapted rods become 10,000 times more sensitive than at the start.
- Through a dilated pupil, total eye sensitivity becomes 100,000 times more sensitive.

**Time to Dark Adapt** - 30 to 45 min under minimal lighting conditions.
**Time to Readapt After High intensity Lighting** - several to 45min
SPATIAL DISORIENTATION (SD) (FM 3.04.301 pg 9-1)
Spatial disorientation is an individual’s inability to determine his position, attitude, and motion relative to the surface of the earth, or significant objects. i.e. Trees, poles, or building during a hover. When it occurs, pilots are unable to see, believe, interpret, or prove the information derived from their flight instruments.

TYPES OF SPATIAL DISORIENTATION (FM3-04-301 pg 9-1)

**Type I (UNRECOGNIZED)**- A disoriented aviator does not perceive any indication of spatial disorientation. In other words, he does not think anything is wrong. What he sees or thinks he sees is corroborated by his other senses. Type I disorientation is the most dangerous type of disorientation. The pilot unaware of a problem fails to recognize or correct the disorientation, usually resulting in a fatal aircraft mishap.

**Type II (RECOGNIZED)**- The pilot perceives a problem (resulting from SD). The pilot may fail to recognize it as SD.

**Type III (INCAPACITATING) -** The pilot experiences such an overwhelming sensation of movement that he cannot orient himself by using visual cues or the aircraft instruments. Not fatal if co-pilot can gain control of the aircraft.

EQUILIBRIUM MAINTENANCE (FM 3-04-301 pg 9-2)

**Visual System**- The visual system is the most important in maintaining equilibrium and orientation. 80% of our orientation information comes from the visual system.
- IMC- must rely on instruments for spatial orientation.
- Demands disciplined training

VISUAL ILLUSIONS (FFF CRASH SCAR) (FM 3.04.301 pg 9-9)
Illusions give false impressions or misconceptions of actual conditions; therefore aircrew members must understand the type of illusions that can occur & the resulting disorientation. Although the visual system is the most reliable of the senses, some illusions can result from misinterpreting what is seen; what is perceived is not always accurate.

**Flicker Vertigo**- Flicker vertigo may be created by helicopter rotor blades or airplane propellers interrupting direct sunlight at a rate of 4 to 20 cycles per second. Flashing anticollision strobe lights, especially while the aircraft is in the clouds, can also produce this effect. Viewing a flickering light can be both distracting and annoying, could produce seizures in those rare individuals who are susceptible to flicker-induced epilepsy.

*Solution - Turn off light source*

**Fascination (Fixation) -** Fascination, or fixation, flying can be separated into two categories: task saturation and target fixation. Task saturation may occur during the accomplishment of simple tasks within the cockpit. Crew members may become so engrossed with a problem or task within the cockpit that they fail to properly scan outside the aircraft.

*Solution - Refrain from staring at objects too long; scan*
**False Horizon Illusion** - The false horizon illusion occurs when the aviator confuses cloud formations with the horizon or the ground. An aviator may perceive the cloudbank below to be horizontal although it may not be horizontal to the ground; thus, the pilot may fly the aircraft in a banked attitude.

*Solution - Conduct a proper scan of instruments and other visual cues*

**Confusion with Ground Lights** - Confusion with ground lights occurs when an aviator mistakes ground lights for stars. This illusion prompts the aviator to place the aircraft in an unusual attitude to keep the misperceived ground lights above them.

*Solution - Conduct a proper scan, both aided and unaided*

**Relative Motion** - Relative motion is the falsely perceived self-motion in relation to the motion of another object. This illusion can be encountered during flight in situations such as formation flight, hover taxi, or hovering over water or tall grass.

*Solution - Proper scanning, experience and knowledge of the occurrence*

**Altered Planes of Reference** - In altered planes of reference the pilot has an inaccurate sense of altitude, attitude, or flight-path position in relation to an object so great in size that the object becomes the new plane of reference rather than the correct plane of reference, the horizon. A pilot approaching a line of mountains may feel the need to climb although the altitude of the aircraft is adequate.

*Solution - Perform map recon to determine height of obstacle, and search for true plane of reference*

**Structural Illusions** - Structural illusions are caused by the effects of heat waves, rain, snow, sleet, or other visual obscurants. A straight line may appear curved when it is viewed through the heat waves of the desert. The curvature of the aircraft windscreen can also cause structural illusion. This illusion is due to the refraction of light rays as they pass through the windscreen.

*Solution - Experience and knowledge*

**Height - Depth Perception Illusion** - The height-depth perception illusion is due to a lack of sufficient visual cues and causes an aircrew member to lose depth perception. Flying over an area devoid of visual references—such as desert, snow, or water—will deprive the aircrew member of his perception of height. The aviator, misjudging the aircraft’s true altitude, may fly the aircraft dangerously low in reference to the ground or other obstacles above the ground.

*Solution - Trust instruments and scan horizon*

**Size-Distance Illusion** - The size-distance illusion is the false perception of distance from an object or the ground, created when a crew member misinterprets an unfamiliar object’s size to be the same as an object that he is accustomed to viewing. This illusion can occur if the visual cues, such as a runway or trees, are of a different size than expected. An aviator making an approach to a larger, wider runway may perceive that the aircraft is too low.

*Solution - Experience and knowledge of the occurrence*
**Crater Illusion** - The crater illusion occurs when aircrew members land at night, under NVG conditions, and the IR searchlight is directed too far under the nose of the aircraft. This will cause the illusion of landing with up-sloping terrain in all directions.

*Solution - Proper use of landing and search light, knowledge of occurrence, and proper scanning*

**Autokinesis** - Autokinesis primarily occurs at night when ambient visual cues are minimal and a small, dim light is seen against a dark background. After about 6 to 12 seconds of visually fixating on the light, one perceives movement at up to 20 degrees in any particular direction or in several directions in succession, although there is no actual displacement of the object.

*Solution - Avoid fixating on objects, develop a good scan.*

**Reversible Perspective Illusion** - At night, an aircraft may appear to be going away when it is, in fact, approaching a second aircraft. This often occurs when an aircraft is flying parallel to another’s course. Therefore, it is difficult to tell the direction of the aircrafts travel.

*Solution-proper scanning technique and the 3-r’s: red on the right is returning.*

**VESTIBULAR SYSTEM (FM 3.04.301 pg 9-3)**

Inner ear contains the vestibular system, which contains the motion- & gravity detecting sense organs. Located in the temporal bone, on each side of the head. Each vestibular consist of 2 distinct structures; semicircular canals / vestibule proper, which contain the otolith organs.

![Vestibular System Diagram](image)

**Vestibule Proper** - The otolith organs are small sacs located in the vestibule. Sensory hairs project from each macula into the otolithic membrane, an overlying gelatinous membrane that contains chalklike crystals, called otoliths. They respond to gravity & linear accelerations/decelerations. Changes in position of the head, relative to the gravitational force, cause the otolithic membrane to shift position on the macula. The sensory hairs bend, signaling a change in head position.
**Semicircular Canals** - They sense changes in an angular acceleration. The canals will react to any changes in roll, pitch, or yaw attitude. The endolymph fluid in the canals moves with inertial torque resulting from angular acceleration in one of three planes. The motion of the fluid bends the cupula which moves the hairs of the hair cells situated beneath the cupula. This movement stimulates the vestibular nerve & these impulses are transmitted to the brain where they are interpreted as rotation of the head.

**Vestibular Illusions (FM 3.04.301 pg 9-14)**

**Somatogyral Illusions** - Are caused when angular accelerations & decelerations stimulate the semicircular canals.

**Leans** - The most common form. The pilot fails to perceive angular motion. During continuous straight-& level flight, the pilot will correctly perceive that he is straight & level. However, a pilot rolling into or out of bank may experience perceptions that disagree with the reading on the attitude indicator & other instruments. To counter the falsely perceived position, the pilot will lean his body until the false sensation leaves.

**Graveyard Spin** - Usually occurs in fixed-wing aircraft. If you enter a spin & remain in it for several seconds, the semicircular canals will reach equilibrium; no motion is perceived. Upon recovering from the spin, you undergo deceleration, which is sensed by the semicircular canals. You then have a strong sensation of being in a spin in the opposite direction even though the flight instruments contradict that perception. If deprived of external references, you may disregard the instruments & make control corrections against the falsely perceived spin. The aircraft will then enter a spin in the original direction.

**Coriolis Illusion** - The most dangerous of all, occurs whenever a prolonged turn is initiated & the pilot makes a head motion in a different geometrical plane. When a pilot enters a turn & then remains in the turn, the semicircular canal corresponding to the yaw axis is equalized. The endolymph fluid no longer deviates, or bends, the cupula. If the pilot initiates a head movement in a geometrical plane other than that of a turn, the yaw axis semicircular canal is moved from the plane of rotation to a new plane of nonrotation. The fluid then slows in that canal, resulting in a sensation of a turn in the direction opposite that of the original turn. Simultaneously, the two other canals are brought within a plane of rotation. The fluid stimulates the other two other cupulas. The combined effect of the coupler deflection in all three canals creates the new perception of motion in three different planes of rotation: yaw, pitch, & roll. The Pilot experiences an overwhelming head-over-heels tumbling sensation.

**Somatogravic Illusions** - are caused from changes in linear acceleration & gravity that stimulate the Otolith Organs.

**Oculogravic** - Occurs when an aircraft is accelerated or decelerates in a forward direction. Inertia from linear acceleration causes the otolith organs to sense a nose-high altitude. A pilot correcting for this illusion without cross checking the instruments would most likely
dive the aircraft, catastrophic during an approach. This illusion does not occur if adequate references are outside.

**Elevator Illusion** - This occurs during upward acceleration. Because of inertia, the pilot’s eyes track downward as his body tries, through inputs supplied by the inner ear, to maintain visual fixation on the environment or instrument panel. With the eyes downward, the pilot senses that the nose of the aircraft is rising. Common when encountering updrafts.

**Oculoagravic Illusion** - Results from the downward motion of the aircraft. Because of inertia the pilot’s eyes will track upward. This usually results in a sensation that the aircraft is in a nose-low attitude. This illusion is commonly encountered during autorotation.

**PROPRIOCEPTIVE SYSTEM (FM 3.04.301 pg 9-8)** - The systems reacts to the sensation resulting from pressures on joints, muscles, & skin & from slight changes in the position of internal organs. Forces act upon the seated pilot in flight.

**Proprioceptive Illusions (FM 3-04.301 pg 9-18)**
These illusions rarely occur alone. They are closely associated with the vestibular system and to a lesser degree, with the visual system. During turns, banks, climbs and descending maneuvers, proprioceptive information is fed into the central nervous system. A properly executed turn vectors gravity and centrifugal force through the vertical axis of the aircraft. Without visual reference, the body only senses being pressed firmly into the seat. Because this sensation is normally associated with climbs, the pilot may falsely interpret it as such. Recovering from turns lightens pressure on the seat and creates an illusion of descending. This false perception of descent may cause the pilot to pull back on the stick, which would reduce airspeed.

**Prevention**
These sensations can happen to anyone because they are due to the normal functions and limitations of the senses. Training, instrument proficiency, good health, and aircraft design minimize SD. SD becomes dangerous when pilots become incapable of making their instruments read right. All pilots regardless of experience level can experience of SD.
- Never fly without visual reference points.
- Trust your instruments.
- Avoid fatigue, smoking, hyperglycemia, hypoxia and anxiety.
- Never try to fly VMC and IMC at the same time.

**Treatment**
Spatial disorientation can easily occur in the aviation environment. Aviators should:
- Refer to the instruments and develop a good cross check.
- Delay intuitive actions long enough to check both visual references and instruments.
- Transfer control to the other pilot. Rarely will both experience disorientation at the same time.
DISTANCE ESTIMATION AND DEPTH PERCEPTION (BM GRAM) (FM 3-04.301 pg 8-16)

Aircrew members normally use subconscious factors to determine distance. They can more accurately estimate distance if they understand those factors and then learn to look for or be aware of other distance cues. These cues to distance or depth perception may be monocular or binocular.

**Binocular Cues**- Binocular cues depend on the slightly different view each eye has of an object. Thus, binocular perception is of value only when the object is close enough to make a perceptible difference in the viewing angle of both eyes. In the flight environment, most distances outside the cockpit are so great that the binocular cues are of little, if any, value. In addition, binocular cues operate on a more subconscious level than do monocular cues.

**Monocular Cues**- Several monocular cues aid in distance estimation and depth perception. These cues are geometric perspective, motion parallax, retinal image size, and aerial perspective. They can be remembered by the acronym GRAM.

**Geometric perspective (LAV)**- 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 railroad tracks, appear to converge as distance from the observer increases.
- **Apparent foreshortening**- The true shape of an object or terrain feature appears elliptical (oval and narrowed appearance) when viewed from a distance. As the distance to the object or terrain feature decreases, the apparent perspective changes to its true shape or form.
- **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.

**Retinal image size (KITO)** An image focused on the retina is perceived by the brain to be of a given size.

- **Known size of objects**- The nearer an object is to the observer, the larger its retinal image.
- **Increasing or decreasing size of objects**- If the retinal image size of an object increases, the relative distance is decreasing. If the image size decreases, the relative distance is increasing. If the image size is constant, the object is at a fixed relative distance.
- **Terrestrial associations**- objects ordinarily associated together are judged to be at about the same distance. For example, a helicopter that is observed near an airport is judged to be in the traffic pattern and, therefore, at about the same distance as the airfield.
- **Overlapping contours**- When objects overlap, the overlapped object is farther away.
Aerial perspective (FLP)- The clarity of an object and the shadow cast by it are perceived by the brain and are cues for estimating distance.

- **Fading of Colors or Shades**- Objects viewed through haze, fog, or smoke are seen less distinctly and appear to be at a greater distance than they actually are. If atmospheric transmission of light is unrestricted, an object is seen more distinctly and appears to be closer than it actually is.

- **Loss of detail or texture**- As a person gets farther from an object, discrete details become less apparent.

- **Position of light source and direction shadows**- Every object will cast 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 toward the observer, the object is closer than the light source is to the observer.

**Motion parallax**- This is often considered the most important cue to depth perception. Motion parallax refers to the apparent, relative motion of stationary objects as viewed by an observer who is moving across the landscape. Near objects appear to move 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 that the observer is from the objects. Objects near the aircraft appear to move rapidly, while distant objects appear to be almost stationary.

**OPERATIONAL THEORY OF THE ANVIS (FM 3-04.203 pg 4-16)**

An I2 is an electronic device that amplifies light energy. Light energy, consisting of photons, enters the objective lens, is inverted and focused onto a photocathode that is receptive to both visible and near IR radiation. Photons striking the photocathode are then converted to a proportionate number of electrons. Electrons are accelerated away from the photocathode to the microchannel plate (MCP) via an electrical field produced by the power supply. The MCP is a thin wafer of tiny glass tubes that are tilted about 8 degrees. Electrons enter these tubes and strike the walls, creating a reaction which exponentially increases the amount of electrons. These increased numbers of electrons are then accelerated to the phosphor screen. The phosphor screen emits an amount of photons proportional to the number and velocity of the electrons striking it creating a lighted image. The image is then passed through a fiber-optic inverter to rotate the image 180 degrees to correct the inverted image caused by the objective lens. The image is then focused onto the viewer’s eye through an eyepiece lens. The power supply provides automatic brightness control (ABC) that automatically adjusts MCP voltage to maintain image brightness at preset levels by controlling the number of electrons that exit the MCP. Another feature is bright source protection (BSP) which reduces the voltage to the photocathode when exposed to bright light sources. This feature protects the I2 from damage and enhances its life; however, it lowers resolution. Exposure to bright light sources could result in damage to the photocathode, MCP, or the operator’s eye.
OPERATIONAL DEFECTS (SEEFFI) (AN/AVS-6/-10) - If identified, they are an immediate cause for reject.

**SHADING** - You will not see a fully circular image. Shading always begins on the edge and moves inward.

**EDGE GLOW** - A bright area in the outer portion of the viewing area. To check for this defect, block out all light by cupping your hand over the lens.

**EMMISSION POINTS** - A steady or fluctuating pinpoint of bright light in the image area and does not go away when all light is blocked from the objective lens of that monocular.

**FLICKERING, FLASHING, INTERMITTENT OPERATION** - the NVG may appear to flicker on and off, or the output may flash. This can occur in one or both tubes. If you see more than one flicker, consult the troubleshooting chart in the operator’s manual.

COSMETIC BLEMISHES (BBICFO) (AN/AVS-6/-10) - These are usually the result of manufacturing imperfections that do not affect image intensifier reliability and are not normally a cause for rejection unless they interfere with the ability to perform the mission.

**BRIGHT SPOTS** - These are signal induced. A bright spot is a small, bright area that may flicker or remain constant.

**BLACK SPOTS** - These are blemishes in the image intensifier or dirt or debris between the lenses.

**IMAGE DISPARITY** - This condition exists when there is a difference in brightness between the two image intensifier assemblies within the same binocular.

**CHICKEN WIRE** - An irregular pattern of dark thin lines in the field of view either throughout the image or in parts of the image. Under worst conditions, these lines will form hexagonal shaped lines.
**FIXED-PATTERERN NOISE (HONEYCOMB)** - Characterized by faint hexagonal pattern throughout the viewing area that most often occurs at highlight levels.

**OUTPUT BRIGHTNESS VARIATION** - This condition is evidenced by areas of varying brightness in or across the image area. Do not confuse with shading.

**NVG CHARACTERISTICS (DAALVP)** *(FM 3-04.203 pg 4-16, AN/AVS-6/-10)*

**Definition** - A helmet mounted, light-intensification device that allows aircrews to conduct operations at terrain flight altitudes during low ambient light levels.

**Amplification** - ANVIS amplifies light 2,000 to 3,000 times.

**Acuity** - 20/25 under optimum conditions.

**Limited Field of View** - 40-degree field of view.

**Voltage Low Indicator** - A red LED light on the helmet mount will come on when the battery is at 2.4 volts or less.

**Power Supply** - Power is supplied through one of three types of sources:
- Two 1.5v Lithium batteries L91
- Two AA Alkaline 1.5v
- The third source is the aircraft. 3.8vdc
- The ANVIS can also be powered by a Clip On Power Source (COPS).

**NVG CONSIDERATIONS (CALM WWAD SOS)** *(FM 3-04.203 pg 4-18)*

**Color Discrimination** - Color discrimination is absent when a crewmember views scenes through NVGs.

**Monochromatic (single color)** - It has a green hue because of the type of phosphor used on the phosphor screen.

**Chromatic adaptation** - The green hue may cause crewmembers to experience a pink, brown, or purple afterimage when they remove NVGs. This is a normal physiological phenomenon. The length of time the afterimage remains varies with each individual.
Air Speed & Ground Speed Limits: NEVER OUT FLY THE CAPABILITY of the NVGs! Aviators using NVGs tend to overfly their capability to see. To avoid obstacles, they must understand the relationship between the NVG’s visual range, forward lighting capability, and airspeed. Variables affecting the ability to see with NVGs include—

- Type, age, and condition of NVGs.
- Cleanliness of aircraft windscreen or sensor window.
- Moisture content in the air (humidity).
- Individual and collective proficiency and capability.
- Weather conditions (fog, rain, low clouds, or dust) and amount of ambient light.

Lights- (PET)

Performance Relations-
- Directly proportional to the amount of ambient light available.
- High ambient light-good performance-good visual acuity. -fixed pattern noise, honeycomb, and chicken wire
- Low ambient light-poor performance-poor visual acuity. -scintillation

Effects Bright Lights-
- ABC (automatic brightness control)-Reduces the voltage to the Micro-Channel plate to keep the image intensifiers brightness within a set limit. When coming from a low illuminated area to a high illuminated area, image gets brighter and then after a momentary delay, suddenly dims slightly to a constant level.
- BSP (bright source protection)-Reduces the voltage to the Photo cathode when NVGs are exposed to bright lights such as flares and spotlights. Protects the goggles (image intensifier) from damaging bright light sources.

Tunnel Vision- when flying with the landing light, searchlight, or IR band-pass filter installed, an aircrew should avoid concentrating on the area illuminated by the light.

Magnification- NVG systems do not magnify an image; they enhance the illumination of an object. An object viewed through an NVG system is the same size as if seen with the naked eye.

Weather - When using NVGs, aviators may fail to detect entry into or presence of IMC. NVGs enable crewmembers to see through obscurations, such as fog, rain, haze, dust, and smoke, depending on density. As density increases, aircrews can detect a gradual reduction in visual acuity as less light is available. Certain visual cues are evident when restriction to visibility occurs. The apparent increase in size and density of halos during bad weather is an illusion. The halos are due to the electron spread for bright light sources; size remains the same. Any reduction in visibility decreases light intensity and reduces density of the halo. While contrast decreases, video noise may increase. There may be a loss of celestial lights, while the moon and stars may fade or disappear due to overcast conditions. When these conditions are present, severity of the condition is evaluated and appropriate action taken. Actions include reducing airspeed, increasing altitude, reversing course, aborting the mission, or landing. If visual flight cannot be maintained, the crew must execute appropriate IMC recovery procedures.
Weapons- When firing 7.62 millimeter, or .50-caliber machine guns, aircrews may briefly lose sight of the target. Although the bright flash resulting from the rocket launch lasts only milliseconds, the muzzle flash from the weapons may cause the aircrew to lose sight of the target throughout the entire firing burst. The recovery from bright flash illumination is more rapid with NVGs than unaided. A greater concern is observing impact due to flash signature momentarily degrading the NVG.

Aircraft Lighting- The AN/AVS-6 is designed to be operated with blue-green cockpit lighting. Red cockpit lighting is not compatible and not authorized for use with NVGs. Other aircraft external lights such as position lights, formation lights, anti-collision lights, or electroluminescent light panels should be turned off or subdued as appropriate for the operation.

Depth Perception and Distance Estimation (DATE )- NVGs distort depth perception and distance estimation. The quality of depth perception in a given situation depends on factors including available light, type and quality of NVGs, degree of contrast in the FOV, and user experience.

Scanning Techniques- To view an area while using NVGs, a crewmember’s head and eyes must rotate slowly and continuously. When scanning to the right, crewmembers should move their eyes slowly from the left limit of vision inside the device to the right limit while moving their head to the right. This enables a crewmember to cover a 70- to 80-degree FOV with only 30 to 40 degrees of head movement, minimizing head rotation.

Obstruction Detection- Obstructions having poor reflective surfaces, such as wires and small tree limbs, are difficult to detect. The best way to locate wires is by looking for the support structures.

Spatial Disorientation- Maneuvers requiring large bank angles or rapid attitude changes tend to induce spatial disorientation. An aviator should avoid making drastic changes in attitude/bank angles and use proper scanning and viewing techniques.

NIGHT VISION TECHNIQUES (SOS) (FM 3-04.301 pg 8-13)

Scanning
To scan effectively, aircrew members look from right to left or left to right. They should begin scanning at the greatest distance at which an object can be perceived (top) and move inward toward the position of the aircraft (bottom). Because the light-sensitive elements of the retina are unable to perceive images that are in motion, a stop-turn-stop-turn motion should be used. For each stop, an area about 30 degrees wide should be scanned. This viewing angle will include an area about 250 meters wide at a distance of 500 meters. The duration of each stop is based on the degree of detail that is required, but no stop should last more than two or three seconds. When moving from one viewing point to the next, aircrew members should overlap the previous field of view by 10 degrees.
**Off-Center Viewing**
- Compensates for the night Blind spot
- This technique requires that an object be viewed by looking 10 degrees above, below, or to either side of the object.
- Optimum view time is 0.5-1.0 second, no more than a 2-3 second view time.

**Shapes or Silhouettes** - since visual acuity is reduced at night; objects must be identified by their shapes or silhouettes. To use this technique, the crewmember must be familiar with the architectural design of structures and the shape or silhouette of vehicles in the area covered by the mission (i.e. Church Steeples, tanks, etc.). Features depicted on the map will also aid in recognizing silhouettes.

**NIGHT VISION PROTECTION (ROSCEL) (FM 3-04.301 pg 8-11)**

**Red lens goggles and Red Lighting** - If worn prior to flight they can start you into your dark adaptation process. They also can preserve up to 90 percent of your dark adaptation.

**Oxygen supply** - Unaided night vision depends on optimum function and sensitivity of the rods of the retina. You should use supplemental oxygen above 4,000’ PA, because you will start to lose night vision at that altitude. Lack of oxygen to the rods (hypoxic-hypoxia) significantly reduces their sensitivity starting in the indifferent stage (0-10,000’). This increases the time required for dark adaptation and decreases the ability to see at night. Rhodopsin, the chemical found in rods, is oxygen dependant.

**Sunglasses** - When exposed to bright sunlight for prolonged periods, aircrew members should wear military-issued, neutral-density sunglasses (ND-15) or equivalent filter lenses when anticipating a night flight. This precaution minimizes the negative effects of sunlight (solar glare) on rhodopsin production, which maximizes the rate of dark adaptation and improves night vision sensitivity and acuity.

**Cockpit lighting** - Instrument, cockpit, and rear cargo area overhead lights (if applicable) should be adjusted to the lowest readable level that allows instruments, charts, and maps to be interpreted without prolonged staring or exposure.

**Exterior lighting** - Exterior lights should be dimmed or turned off if possible and the mission permits. Aviators should consult command policy for local procedures.

**Light flash compensation: (CAAT)**
- Close one eye - preserves the dark adaptation in that eye.
  - Lose of depth perception
  - Now have both night and physiological blind spots because you are no longer compensating with binocular vision.
- Auto weapons fire - Use short bursts
- Alter course - Plan around built-up areas
- Turn away - Fly around flares and spotlights. If a flare is popped near by, turn away and fly around the peripheral of the illuminated area.
HYPOXIA (FM 3-04.301 pg 2-16)

Hypoxia results when the body lacks oxygen. Hypoxia tends to be associated with flights at altitudes. However, many other factors such as alcohol abuse, heavy smoking, & various medications interfere with the blood’s ability to carry oxygen.

Types of Hypoxia (FM 3-04.301 pg 2-16)

- **Hypoxic**: Occurs when not enough O₂ is in the air or when decreasing atmospheric pressures prevent the diffusion of O₂ from the lungs to the bloodstream. Typically, Occurs at higher altitudes.

- **Hypemic** or anemic, hypoxia is caused by a reduction in the oxygen-carrying capacity of the blood. Anemia & blood loss are the most common causes. CO, nitrites, & sulfa drugs also cause this by forming compounds w/ hemoglobin & reducing the hemoglobin that is available to combine w/ O₂.

- **Stagnant**: O₂ carrying capacity of the blood is adequate, but circulation is inadequate. Conditions as heart failure, arterial spasm, & occlusion of a blood vessel predispose the individuals to stagnant hypoxia. More often, a crew member experiences extreme gravitational forces, causing the blood to be stagnant.

- **Histotoxic**: Results when there is interference with the use of O₂ by body tissues. Alcohol, narcotics, & certain poisons-cyanide- interfere with the cell’s ability to use an adequate supply of oxygen.

STAGES of Hypoxia (ICDC) (FM 3-04.301)

- **Indifferent**: (0’ – 10,000’)
  Night vision deteriorates at about 4000’. Visual acuity begins to decrease.

- **Compensatory**: (10,000’ – 15,000’)
  The circulatory & the respiratory system provide some defense against hypoxia at this stage. The pulse rate, systolic blood pressure, circulation rate, & cardiac output increase. Respiration increases in depth & sometimes in rate. At 12,000’ to 15,000’ the effects of hypoxia on the nervous system become increasingly apparent. After 10-15 min, impaired efficiency is obvious. Crew members may become drowsy & make frequent errors in judgment. May become difficult to do even simple task. Easy to overlook these symptoms.

- **Disturbance**: (15,000’ – 20,000’)
  The physiological responses can no longer compensate for the O₂ deficiency. Subjective symptoms include fatigue, sleepiness, dizziness, headache, breathlessness, & euphoria. Objective symptoms include:
  - **Senses**: peripheral & central vision are impaired, & visual acuity is diminished. Weakness & loss of muscular coordination are experienced. Sensations of touch & pain are diminished or lost. Hearing is one of the last senses lost.
  - **Mental Processes**: Intellectual impairment is an early sign that often prevents the individual from recognizing disabilities. Thinking is slow, & calculations are unreliable. Short-term memory is poor, & judgment & reaction time is affected.
  - **Personality Traits**: Person may display traits & emotions much the same as with intoxication. Euphoria, aggressiveness, overconfidence, or depression can occur.
• **Psychomotor Functions:** Muscular coordination is decreased, & delicate or fine muscular movements may be impossible. Stammering & illegible handwriting are typical impairments.

• **Cyanosis:** the skin becomes bluish in color. This effect is caused by O₂ molecules failing to attach to hemoglobin molecules.

**Critical- (20,000’ – 25,000’)**

Within 3 to 5 minutes, judgment, & coordination usually deteriorate. Subsequently, mental confusion, dizziness, incapacitation, & unconsciousness occur.

Prevention of Hypoxic Hypoxia- Preventive measures include—

• Limiting the time at altitude.
• Using supplemental oxygen.
• Pressurizing the cabin.

**Treatment of Hypoxia**- Treatment must begin immediately and consists of giving 100% O₂, descend below 10,000ft.

**STRESS (FM 3-04.301, pg 3-1)**

Stress is the nonspecific response of the body to any demand placed upon it. Stress is a physiological phenomenon involving actual changes in the body’s chemistry & function, and Stress involves some perceived or actual demand for action. Any event which requires you to adjust or adapt in some way is a source of stress, also called a stressor.

**TYPES OF STRESSORS-** (PEPC) (**FM 3-04.301 pg 3-1**)

**Psychosocial (JIF)-** These stressors may trigger adaptation or change in one’s lifestyle, career, and/or interaction with others. Positive or negative.

• **Job stress**- low morale/unit cohesion/boredom/fatigue/over-tasking/poorly defined responsibilities
• **Illness**- organic diseases/fatigue
• **Family issues**- family commitments/spousal relationships.

**Environmental (SADFAC)-** Those things found in our every day job.

• **Speed**- a higher degree of alertness & concentration over long periods.
• **Altitude**- altitudes below 5000'/ trapped gas causing ear or sinus problems.
• **Design of Aircraft**- cockpit illumination/instrument location/seat comfort/heating & ventilating systems/visibility/noise level.
• **Instrument Flight Conditions**-poor WX, night flying, combat environment
• **Airframe Characteristics**- Rotarywing A/C requires constant pilot attention to maintain stability.
• **Cold or Hot**- use proper clothing or equipment and members need to gradually adapt to the extremes

**Physiological**- Self-imposed stressors or maladaptive behaviors that are potentially debilitating & threaten aviation safety. Acronym DEATH.

• **Drugs**- Self-medication- may incur unwanted side-effects. Caffeine most commonly ingested. Limit or avoid drugs unless prescribed by an flt surgeon.
• **Exhaustion**- Lack of rest and poor sleep. Lack of exercise impairs circulatory efficiency, reduces endurance, & increases likelihood of illness.

• **Alcohol**- Affects of alcohol depend on: the amount of alcohol consumed/the rate of absorption from the stomach & small intestines/the body’s rate of metabolism, 1 oz every 3 hrs.

• **Tobacco**- Use of any tobacco product is detrimental.

• **Hypoglycemia**- maintain a well-balanced diet to avoid low blood sugar, which could cause weakness or fainting, , fatigue, & inefficiency’s.

**Cognitive (FMC)**

How one perceives a given situation or problem is a potentially significant & frequently overlooked source of stress. Pessimism, obsession, failure to focus on the present, and/or low self-confidence can create a self-fulfilling prophecy that will ensure a negative outcome.

• **Failure to Focus on the Here & Now**- Living in the past or future & overemphasizing what should have been or what could be, can increase one’s overall stress.

• **Musts & Shoulds**- Lack of flexibility in thinking causes problems when reality does not accommodate one’s wishes.

• **Choice or No Choice**- There are choices in life, although sometimes unpalatable, there are still choices. People who feel they have no choice and blame the world for their problems.

**RESPONSE to STRESS (PEBC) (FM 3-04.301 pg 3-10)**

**Physical Responses**- involves overall heightened arousal of the body. Increased heart rate, increased blood pressure, more rapid breathing, tensing of the muscles, & the release of sugars & fats into circulation to provide fuel for “fight or flight.” Prolonged stress & its continuous effects: muscle tension & pain, headaches, high blood pressure, decreased immunity to infectious diseases.

**Emotional Responses**- Ranges from increased anxiety, irritability, or hostility to depressed mood, loss of ones self-esteem, hopelessness, & inability to enjoy life.

**Behavioral Responses**- High stress can adversely affect one’s work performance, decrease motivation, & increase the likelihood of conflict, insubordination, & violence in the workplace. Some individuals become socially isolated. Others may abuse drugs or alcohol.

**Cognitive Responses**- Stress can significantly affect one’s thought processes. It can decrease attention & concentration, interfere with judgment & problem solving, & impair memory.

• **Simplification Heuristic**- under high stress conditions, people tend to oversimplify problem solving & ignore important relevant information, taking the easy way out.

• **Stress-Related Regression**- individuals under high-stress conditions will forget learned procedures & skills & revert to bad habits.

• **Perceptual Tunneling**- individual or an entire crew under high stress becomes focused on one stimulus, & neglects to attend to other important task/information such as flying the aircraft. A similar situation may occur when an aviator realizes during flight that he or she overlooked some aspect of flight such as missing a radio call. The stressed aviator may then over attend to rectifying this problem/become emotionally & mentally fixated on the error & fall “behind the aircraft.”

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of sugars & fats into circulation to provide fuel for “fight or flight.” Prolonged stress & its continuous effects: muscle tension & pain, headaches, high blood pressure, decreased immunity to infectious diseases.

**STRESS MANAGEMENT (FM3-04.301 pg 3-12)**

- Avoiding stressors- most powerful mechanism. Avoid with good planning, foresight, realistic training, good time management, and effective problem solving. Stay physically fit and eat right. Good crew coordination and communication.
- Changing your thinking- practice positive self talk, taking responsibility for your actions, avoiding perfectionism and inflexibility in thinking, focusing on the here and now rather than the past or future.
- Learning to realize- breathing excises, meditation, or regularly engaging in a quiet hobby greatly reduces stress.
- Venting stress- “blowing off steam” in some manner either through talking or vigorous exercise.

**FATIGUE (FM3-04.301 pg 3-13)**

The state of feeling tired, weary, or sleepy that results from prolonged mental or physical work, extended periods of anxiety, exposure to harsh environments, or loss of sleep.

- **Acute Fatigue**- Associated with physical or mental activity between two regular sleep periods. Loss of awareness of errors and coordination first to develop. Crew members feel this tiredness at night after being awake for 12 to 15 hrs in a day. Characterized by: inattention, distractibility, errors in timing, neglect of secondary task loss of accuracy and control, lack of awareness of error accumulation, and irritability.
- **Chronic Fatigue**- Result of inadequate recovery from successive periods of acute fatigue. It may take several weeks of rest to completely eliminate chronic fatigue and there may be underlying social causes, such as family or financial difficulties. Characterized by: insomnia, depressed mood, irritability, weight loss, poor judgment, loss of appetite, slowed reaction time, poor motivation and performance on the job.
- **Motivational Exhaustion or Burnout**- if chronic fatigue proceeds untreated for too long, the individual will eventually “Shut Down,” and cease functioning occupationally and socially.