

UNITED STATES MARINE CORPS
THE BASIC SCHOOL
MARINE CORPS TRAINING COMMAND
CAMP BARRETT, VIRGINIA 22134-5019

**OBSERVATION
THEORY AND
OPTICS
B1E0795
STUDENT HANDOUT**

Introduction to Observation Techniques

Introduction

In today's dynamic tactical environment, the ability to see, observe, and interpret what is around us is a crucial skill to master in order to successfully operate on the battlefield.

The Marine Corps uses optical enhancing devices on a daily basis. As individual Marines we use them to observe the environment that we operate in so we can see and assess the objects and people in that environment. As a leader on the battlefield we use day optics to build situational awareness and aid us in developing a situation. Our enhanced view and better understanding of the environment or possibly the threat allow us to make better tactical decisions when the time comes.

The Marine Corps utilizes Night Vision Devices on a daily basis. We conduct many successful operations in the night environment in order to take advantage of our superior night capabilities. We have sights for every Marine that will help them employ their weapons systems more effectively in the night environment.

Importance

Awareness is having knowledge of your surroundings and is a state of consciousness. Situational awareness refers to the degree of accuracy by which one's perception of their current environment mirrors reality. Being observant of your environment and being able to recall details of what you see are skills that will allow you to better interpret your area of operations in battle. You want always to be the hunter, and never the hunted.

"Conflict may be viewed as time-competitive cycles of observation-orientation-decision-action (OODA)."

"First, each party to a conflict enters the fray by observing himself, his surroundings, and his enemy. In tactics, this equates to adoption of a hunting instinct: searching, actively looking, hunting for the enemy, and seeing what he is doing or is about to do. It also includes anticipating the enemy's next moves—getting inside his mind."

"Second, based upon those observations, the combatant orients to the situation, that is, produces a mental image of the situation and gains situational awareness. This awareness becomes the foundation on which to erect a plan."

Introduction to Observation Techniques

Generally, the better the orientation, the better the plan.” -MCDP 1-3

Combat hunter is a **MIND SET**

There are 3 Pillars:

- Observation (Basic)
- Combat Profiling (Intermediate)
- Tracking (Advanced)

In order for the Marine Corps to effectively fight enemies with ever changing ways to disguise their action, intent, and themselves we need to understand the capabilities, limitations, and proper use of the optics devices in our inventory. If our devices are not employed properly it will lead to ineffective use on the battlefield. As leaders of Marines, we will need to ensure our Marines know how to properly and effectively utilize day optic devices on the battlefield.

In order for the Marine Corps to effectively fight during the night we need to understand the capabilities, limitations, and proper use of the Night Vision Devices in our inventory. If our devices are not employed properly it will lead to ineffective use on the battlefield. As leaders of Marines we will need to ensure our Marines know how to properly and effective utilize Night Vision Devices on the battlefield.

In This Lesson

You will learn techniques that will help you improve your observation skills and memory, and then learn how to apply those skills to interpreting your environment.

This lesson covers the following topics:

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Learning Objectives

Terminal Learning Objectives

TBS-CMBH-1004 Given a scenario, explain the decision cycle (OODA) process without omission.

TBS-CMBH-1002 Given an area to observe, while wearing a fighting load, identify anomalies as threat or non-threat, without error.

TBS-CMBH-1001 Given an area to observe, with or without the aid of observation devices, while wearing a fighting load, conduct observation, to detect anomalies.

TBS-CMBH-1002 Given a red lens flashlight, chemlight, night vision device with infrared illuminator, infrared emitters, and infrared chemlights, communicate using limited visibility signals, to accomplish the mission while avoiding detection from the enemy.

Enabling Learning Objectives

TBS-CMBH-1001a Given an area to observe, with or without the aid of observation devices, while wearing a fighting load, maintain observation, to detect anomalies.

TBS-CMBH-1001b Given an area to observe, with or without the aid of observation devices, while wearing a fighting load, orient mental process to the situation, to raise situational awareness.

TBS-CMBH-1001c Given an area to observe, while wearing a fighting load, utilize optics to detect anomalies, without omission.

TBS-CMBH-1001d Given an area to observe, with or without the aid of observation devices, while wearing a fighting load, establish a baseline, to facilitate detection of anomalies.

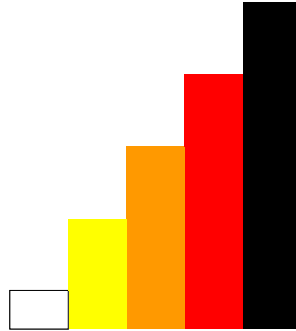
TBS-CMBH-1001g Given an area to observe, with or without the aid of observation devices, while wearing a fighting load, record information for reporting to higher, without omitting key components.

TBS-COMM1002b Given a chemlight, in a simulated combat environment, employ directional chemlights to control friendly movement.

TBS-COMM-1002d Given pull line material, in a simulated combat environment, employ pull lines to accomplish the mission while avoiding detection from the enemy.

Cooper's Color Code

Lieutenant Colonel Jeff Cooper developed a system for levels of awareness by color code. This system helps you determine your level of awareness and be better prepared mentally for the situation. The following are his color code conditions:



White

You are relaxed, unaware of your surroundings, and not prepared to react to anything. Heart rate is between 60 and 80 beats per minute (BPM).

Yellow

You are in a relaxed state of alert and have a general awareness of what is going on around you. You do not perceive any threats, but you are looking for and are aware of possible threats. This state can be maintained for a long period of time. Heart rate is between 60 and 80 BPM.

Orange

You are at a heightened state of alert and are getting ready to deal with a threat. Your mind is preparing for the reaction to the threat. This state cannot be maintained for a long period of time, and your body will want to revert to a state of yellow when the threat is gone. Heart rate is between 60/80 and 115 BPM.

Red

You are reacting to the threat and are in a fighting state of mind. You are executing the plan you developed while in a state of orange. You may experience focus lock, tunnel vision, and other adrenaline effects (shaking, sudden bursts of energy). Heart rate is between 115/145 and 175 BPM.

Black

You are in a state of catastrophic breakdown of mental and physical performance. This usually occurs when you are forced to react to a threat that you have not been able to prepare for, like when you go from white or yellow straight to black. Heart rate will be greater than 175 BPM.

You and your Marines should strive to always be in the yellow.

Observation Theory and Techniques

Observation is a three part process. You must see, assess and then communicate. You cannot be successful as a unit in the conduct of your mission if you are not using this three step process of observation.

According to studies about 90% of the information that your brain uses in order to orient and make decisions comes from your sense of vision. This makes it extremely important to assess what you see and to put it in context and sometimes take it out of context in order to see what is actually there or see what is missing or out of place.

Observation is a two way street. If you can see the enemy then the enemy can see you. There are ways to camouflage yourself when attempting to observe others as well as ways to avoid being observed by others. Being familiar with these methods of camouflage is important in order to use them to your advantage and to understand how the enemy will try to hide themselves from you.

The communication process depends greatly upon the circumstances of your immediate situation. It may be appropriate to simply report information to higher headquarters via radio and continue your current operation; for less time-critical information, you may be able to delay communication until the debrief of your operation. Other situations may dictate an immediate response. Should you come into contact with an enemy unit and they are unaware of your presence, you most likely will have time to communicate an ADDRAC report to orient the rest of your unit and prepare for an assault. If in that same scenario the enemy appears aware of your unit's presence, your communication process may consist of firing the first round followed by additional instructions, as able.

Context and Scanning. Our eyes give us a majority of the information that our brain processes in order to gain situational awareness and build a picture of your surroundings. Our brain, however is a very powerful tool and has a tendency to fill in the blanks or make some things look like they belong when they actually do not because of the context that the objects are in. For instance for Americans, all the years of reading from left to right allow human brain to fill in things that may not actually be there when scanning a scene in that direction because of the context that they are in. Context is a powerful tool which enables us to make quick decisions. However, observation at times requires you to take a detailed look at areas, objects and/or people in order to assess a possible threat or course of action. It is important to see what is actually there and not what the enemy wants you to see or what your brain is causing you to believe is there. Scanning an area in the opposite direction (right to left) than your brain is used to seeing things is one way to allow you to break out the details necessary to accurately assess the environment.

Using Binoculars to Aid in Observation. Binoculars are a great tool to aid in observation. They allow you to get a magnified view of an object or area that is off in the distance. In that magnified view you are able to make out greater detail. Items or details that your unaided eye would not be able to pick up are now presented with enough clarity to actually assess what you are seeing. Communicating the details that you see to others within the unit will complete the three step process of See, Assess and Communicate. It will also increase the situational awareness for unit leaders and

Observation Theory and Techniques

members of your unit to accomplish the mission.

Binocular Techniques. The following are techniques that can be used in order to aid the individual Marine or unit leaders in recognizing and assessing threats in the environment that they are operating in.

Burning through Vegetation

A bush or piece of vegetation that blocks your vision of things behind it to the un-aided eye can be seen with the help of binoculars. Place the binoculars to your eyes and focus the binoculars past the branches that are in front of you. Objects on the other side of the bush or vegetation can be seen clearly while you remain hidden and camouflaged.

Cresting the Top of Hills

Using the just mentioned technique of burning through vegetation can allow you to remain on the military crest of the hill that you are on and observe the other side. Walk up the hill until your head is just above the crest of the hill. You will have enough standoff from the vegetation on the hill top that you will not be noticed. Place your binoculars to your eyes and focus through the vegetation in front of you in order to bring objects on the other side of the hill into view while remaining hidden and camouflaged.

Looking through Holes

When you come up to a wall or surface that has small holes in it you can use your binoculars to see what is on the other side without exposing yourself to danger. Hold one of the oculars up to the hole in the wall or surface. Look into that ocular with one of your eyes. Objects on the other side can be seen and focused on.

Looking into Shadows

A shadow can be used to mask figures and objects. Using binoculars can help you see those figures and objects that you would not otherwise see if you looking with the un-aided eye. Because of their ability to magnify a picture and collect light, binoculars give the user the ability to see into the shadows. Place the binoculars to your eyes and look at the shadow or into a shaded area. Fill the field of view of the binoculars with the shadowed area. This allows your pupils to adjust to the light level that is in the field of view and allows you to focus on the figures or objects present in that shadow.

Nine Elements of Visual Perception

Line, Edge and Outline

The boundary or border, a spatial location, a separation or distinction.

Everything, especially man-made items, have a line or edge to them. These lines and edges often lead to the outline of an object. The human eye picks up lines, edges and outlines very easily. An untrained individual may see a line or edge while a trained individual will see outline.

Any object silhouetted against a contrasting background is conspicuous. Any smooth, flat background, such as water, a field, or best of all, the sky, will cause an object to become well delineated. However, special care must be taken when searching areas with an uneven background, as it is more difficult to detect the silhouette of an object

Shape

A shape is the visual characteristic surface configuration of a thing. It is distinguished from its surroundings by its outline, contour, or figure.

Outlines are created when lines and edges come together. When we perceive the outline, it becomes a shape.

The human eye readily picks up shapes, especially of other humans or potential threats (e.g. rifle). Some objects can be recognized instantly by their shape, particularly if it contrasts with the background. Experience teaches people to associate an object with its shape or outline. At a distance, the outline of objects can be seen well before the details can be determined. The human body and the equipment that a Marine carries are easily identified unless the outline has been altered. Marines can alter this outline by applying camouflaging techniques.

Contrast or Value

Contrast is a difference, especially a strong dissimilarity, between entities or objects compared. Value is the relative importance or tone of something, darkness or lightness of color.

Nine Elements of Visual Perception (Continued)

Color

The aspect of things that is caused by differing qualities of the light reflected or emitted by them, definable in terms of the observer or of the light as:

The appearance of objects or light sources described in terms of the individual's perception of them, involving hue, lightness, and saturation for light sources.

The characteristics of light by which the individual is made aware of objects or light sources through the receptors of the eye, described in terms of dominant wavelength, luminance, and purity.

Colors have a value to them as well as a baseline. The greater the contrasting color, the more visible the object becomes. This point is especially true when the color is not natural for that area. The best camouflage colors are those that are most difficult to determine exact color. Color alone will usually not identify the object but is often an aid in locating it.

Texture

The distinctive physical composition or structure of something, especially with respect to the size, shape, and arrangements of its parts, appearance and feel of a surface.

Similar to color, texture has a baseline. An object with a smooth surface reflects light and becomes more obvious than an object with a rough surface that casts shadows on itself. An extremely smooth object becomes shiny. If an object has a surface that contrasts with its surroundings, it becomes conspicuous.

Rhythm and Flow

The patterned, recurring alternations of contrasting elements, movement or variation characterized by the regular recurrence or alternation of different quantities or conditions; a pattern created by lines, forms and colors.

Movement

Movement is one of the biggest disturbances to a baseline. The human eye is strongly attracted to any movement. The human eye can detect another human or animal within seconds by watching the movement of an appendage.

- a. Physical movement is from the person actually moving. This is readily detectable.
- b. Visual movement is from a person disturbing vegetation or an object, thus causing the vegetation or object to move. This could also be a lack of movement which creates an anomaly in the baseline

Nine Elements of Visual Perception

Light (reflecting, sunlight and shadow)

Light impacts colors and the value of colors. Some animals have a dark back and light underbelly. The sun lightens the dark back color and the shadow cast from above darkens the lighter underbelly near the ground making the animal seem less three-dimensional.

Flat surfaces reflect light while rough surfaces absorb it. The reflections from a belt buckle, watch, or optical device can be seen over a mile away from the source. Any shine will attract the observer's attention.

In sunlight, an object or a man will cast a shadow that can give away his presence. Shadows may be more revealing than the object itself. Care must be taken to detect alterations of the natural shape of a shadow. Where light is excessively bright, shadows will look especially black. Contrast will be extreme, and in this exaggerated contrast the observer's eye cannot adjust to both areas simultaneously. This requires the observer to "isolate" the shadowed area from the bright sunlight so that his eye can adapt to the shadow.

Positive and Negative Space

Positive Space. Positive space is a space that takes up mass (solid objects) such as buildings, trees, signs, vehicles, etc. Typically, a Marine cannot see through positive space. The human eye will naturally move from positive space to positive space, as the eye is attracted to this. Example: Tree lines, your eyes are attracted to trunks and prominent branches.

Negative Space. Negative space is the space between the positive spaces. This is the area of shadow and background activity that an untrained observer often overlooks. Good camouflage resembles negative space; it doesn't resemble positive space, such as a leaf. When observing, a Combat Hunter must observe the negative space as well. The Marine, like the enemy, wants to operate in the negative spaces when possible.

Rifle Combat Optic (RCO)

The RCO (also known as the ACOG) is a day and night dual source illuminated telescopic sight with a tritium illuminated reticle pattern designed for the M-16 family of weapons. The RCO system uses fiber optics to provide a low light and night aiming capability and eliminates the need for batteries. The RCO incorporates Tritium Lamp lights in order to illuminate the reticle pattern present in the optic. It is calibrated to accommodate for bullet drop when a round is fired which eliminates the need for adjustments once the system is zeroed with the weapon. It is a four power optic. The USMC fielded the RCO in order to give its Marines the ability identify and accurately engage targets out to 800 meters.



- Rifle mounted aiming system
- USMC Nomenclature:
 - AN/PVQ-31A – used with the M-16 (20" Barrel)
 - AN/PVQ-31B – used with the M-4 (14" Barrel)

Rifle Combat Optic (RCO) (Continued)



Specifications of the RCO

- Length
 - 5.8 inches
- Weight
 - 15.3 ounces
- Magnification
 - 4 times
- Objective Aperture
 - 32mm
- Eye Relief (Distance from the eye to the eye piece)
 - 1.5 inches for optimal picture
- Exit Pupil (Size in diameter of the eyepiece you look through)
 - 8mm wide
 - Allows for rapid target acquisition
 - Allows for considerable eye latitude
- Field of View
 - 7.0 degrees at 100m (12.7m across)
- Chevron Width
 - 19 inches at 300m
 - 19 inches is the average width across a person's chest.

Rifle Combat Optic (RCO) (Continued)

Range Estimation

- RCO provides accurate range estimation out to 800m.
 - The reticle pattern in the RCO gives us a range estimation capability.
 - The picture on the right shows a target at 400m and what it would look like in the RCO if aiming center mass on the target.
 - A target that is as wide as the chevron from left to right would be 300m away.
 - Aim point for a target that is 300m away would be the tip of the vertical line between each side of the chevron.
 - Targets that show larger than the width of the chevron are closer than 300m.



Bindon Aiming Concept (BAC)

- The BAC is able to combine the traditional long-standoff marksmanship capability with the ultimate in close combat transitional aiming. BAC utilizes both eyes to acquire, track, identify and aim in on a target. The eye that is not sighted in on the target has a full field of view so that you can acquire, and track moving targets. Once the RCO is positioned on the target the brain automatically starts to use the information from that eye that is getting the magnified image, thus allowing you to identify and aim in on the target.

Benefits of using the RCO

- Allows individual to quickly estimate range of targets.
- Acquire partially camouflaged targets at ranges beyond 300 meters.
- Allows individual to see into and through shadows, windows and foliage.
- Acquire targets in low light conditions.
- ID enemy vs. non-combatant vs. friendly.
- Reduce potential for fratricide.
- Enhance combat exchange ratio in our favor.
- Allows for accurate fire support.
- Reduce ammo expenditure.

Battle Sight Zero (BZO) for the RCO

- RCO can be zeroed using two methods.
 - 100m BZO (preferred method)
 - Uses the top tip of the chevron to aim in on the target.

Battle Sight Zero (BZO) for the RCO (Continued)

- Fire three rounds.
 - Find the center of the grouping.
 - Adjust the center of the grouping both vertically and horizontally. Three clicks will move the impact of the round one inch at 100m.
 - 33m BZO (36 yard)
 - Use the 300m aim point.
 - Fire three rounds.
 - Find the center of the grouping
 - Adjust the center of the grouping both vertically and horizontally. Nine clicks will move the impact of the round
-

Squad Day Optic (SDO)

The Squad Day Optic is a 3.5 power, day/night, dual source illuminated telescopic sight with a tritium illuminated reticle pattern designed for the M249 Squad Automatic Weapon (SAW) with either the long or short barrel. The SDO uses fiber optics to provide a low light and night aiming capability and eliminates the need for batteries. Similar to the RCO, the SDO incorporates Tritium Lamp lights in order to illuminate the reticle pattern present in the optic. The reticle pattern is also similar to the RCO, in that it is calibrated to accommodate for bullet drop when a round is fired. This eliminates the need for adjustments once the sight is zeroed to the weapon. The SDO also incorporates a ruggedized miniature reflex sight (RMR) bolted to the top of the SDO body. The RMR provides no magnification, but is designed to engage targets at close ranges when speed is critical. The USMC is fielding the SDO in order to give M249 gunners the ability identify and accurately engage targets at greater distances.



Squad Day Optic (SDO)

Specifications of the SDO

- Length
 - 8.7 inches
 - Weight
 - 1.34 pounds
 - Magnification
 - 3.5 times
 - Objective Aperture
 - 35mm
 - Eye Relief (Distance from the eye to the eye piece)
 - 2.4 inches for optimal picture
 - Virtual Aperture
 - 10mm wide
 - Allows for rapid target acquisition
 - Allows for low light use
 - Field of View
 - 5.5 degrees at 100m (31.5 feet across)
 - Reticule
 - Horseshoe Dot with BDC
-

Specifications of the RMR

- Length
 - 45mm
 - Weight
 - 1.2 ounces
 - Magnification
 - 1 time
 - Sight Window
 - 22mm x 16mm
 - Reticule
 - Horseshoe Dot with BDC
-

Binoculars (Leupold Binoculars)

Binoculars are a day optic that allows the individual Marine the ability to acquire, identify and track targets and objects on the battle field. Approximately 90% of the information that a normal human being uses comes from their sense of sight. The use of binoculars can enhance the detail and situational awareness of units and unit leaders.

Nomenclature of Binoculars

- Diopter lens (eyepiece lens)
 - This lens and lens adjustment is used to focus the image from the binoculars on to the retina.
 - Body
-

Binoculars (Leupold Binoculars) (Continued)

- Section of the binoculars that houses the internal workings and lenses of the binoculars.
- Objective lens
 - This is the light collecting portion of the binoculars and it is the most important part of providing the picture that you are trying to see.



Binoculars (Leupold Binoculars) (Continued)

Specifications of the Leupold Cascade Binoculars

- Length
 - 5.5 inches
- Weight
 - 22.9 ounces
- Magnification
 - 8 times
- Objective Aperture
 - 42 mm
- Angular Field of View
 - 6.5 degrees
- Field of View
 - 11.4 m @ 100m
- Eye Relief
 - 18 mm for optimal picture
- Exit Pupil
 - 5 mm wide
 - Allows for rapid target acquisition
 - Allows for considerable eye latitude

Techniques for Holding Binoculars to Your Eyes. Using these techniques will aid in the quality of picture that you will get when using your binoculars.

- Hold binoculars lightly to your eyes in order to not transmit any of your body movement through your binoculars.
- Rest the binoculars on the heels of your hands.
- Wrap your thumbs and fingers around the objective lenses in order to block out any unwanted light.

Binocular Holding Positions. There are two basic positions for holding binoculars, the unsupported method and the supported method.

- Unsupported Method - allow your elbows to rest naturally along your body with just enough tension to keep the binoculars steady and to your eyes as you look through them.
- Supported Method - resting your elbows or arms on a sturdy tree limb, a vehicle, the prone position, or using a stable sitting position and allowing the binoculars to remain steady as you look through them.

Binoculars (Leupold Binoculars) (Continued)

Adjusting and Focusing Binoculars. Using binoculars is very simple, but you need to know how to adjust them to your individual eyes and eyesight. You do this by setting an inter-pupillary distance, adjusting the diopter adjustment, focusing the binoculars and using the proper eye relief. Once adjusted, binoculars can become an invaluable tool for you in the field.

Setting Inter-pupillary Distance

- Hold the binoculars up to your eyes.
- Look through the binoculars with both eyes.
- Move the two lenses (body) closer or farther away from each other until you see one circular image. The two optical tubes will move upon a hinge in the middle of the body of the binoculars.

Setting the Diopter Adjustment

(Center Diopter)

-
- Pull up the lockable diopter adjustment dial on the top of the center focus dial.
 - View an object about 100 yards away.
 - Cover the left objective lens with your hand.
 - Adjust the center focus wheel (located in between the two optical tubes) until the image presented to your right eye is clear and sharp.
 - Cover the right objective lens with your hand.
 - Adjust the diopter adjustment dial until the image presented to your left eye is clear and sharp.
 - Push down the lockable diopter adjustment dial so that it locks in place.
 - Your binoculars are now set for your eyes.
-

Setting Focus

-
- Look at object.
 - Rotate center focus wheel until picture is clear and sharp.

History of Night Vision Devices

History

Military tacticians throughout history have seen the advantages of being able to maneuver effectively under cover of darkness. In the Battle of Trenton, in 1776, for example, George Washington led Continental troops across the Delaware River in darkness, though a snowstorm delayed their attack until morning. In the War of 1812 and the Civil War, troops would sometimes surround the enemy at night and then attack the next day.

With no means of effectively seeing at night, such strategy often ended in disaster. Knowing this, commanders traditionally elected to take their chances on being annihilated by day rather than risk nocturnal miscalculations.

The earliest effort at technology-assisted night fighting was with the Union navy's use of calcium lights to bombard Charleston Harbor in 1864; however, casting a powerful light on a target has the unwanted effect of revealing the attacker's location. The first true night-vision systems would have to wait for the development of devices that could detect invisible wavelengths of light and amplify weak signals.

Late in World War II, German, American, and British forces introduced crude infrared riflescopes that allowed snipers to operate at night. These "**active**" systems—meaning that they provided light rather than just rely on existing light—had a near-infrared (NIR) light source mounted on the scope. (NIR is next up in wavelength from visible light on the electromagnetic radiation spectrum.) The NIR light would shine on the object to be seen and reflect back to the scope, which converted the reflection into a visual image and made it brighter with a device called an image tube.



The infrared sniper scope showed that night vision technology was on the horizon. Military leaders immediately saw many uses for this technology beyond sniping at the enemy under cover of darkness. A unit equipped with night vision goggles, helmets, and weapons sights would be able to operate 24 hours a day. Interest in night-vision equipment declined after its experimental use in

History of Night Vision Devices (Continued)

World War II, and development proceeded slowly for the remainder of the 1940s. But in 1950, the overwhelming success of the Chinese Communist attack in Korea, much of it effectively pressed after dark, dramatically demonstrated that the ability to fight at night was essential in modern warfare. Our experiences in the Korean War fueled a movement to expand our night fighting capabilities.

In 1954, the Army decided to upgrade components of the rudimentary NIR sniper scopes they had developed. In using these scopes, each sniper had to wear a heavy battery-backpack with a wire reaching over the shoulder due to the hefty 16,000 volts needed to power the system. This type of active NIR technology became known as Generation 0. The first enhancement would be to reduce the apparatus's power usage at both ends by developing a more efficient NIR source and a more sensitive image tube. This would make a smaller, more-practical, and lighter battery pack. A program was started to couple two image tubes end to end to create a cascading effect, greatly multiplying the gain. The image tube now took on the name of image intensifier.

The photocathodes and phosphor displays required curved surfaces to get an optically correct image. Because the curvature of the phosphor display of one tube was counter to that of the adjacent photocathode surface, stacking multiple sets of curved surfaces took up a lot of space. In 1958, the use of fiber optics solved the three-stage tube-length problem. By growing the photocathode or applying the phosphor screen directly onto the surface of a fiber bundle, they could invert the image by simply twisting the bundle.

By the mid-1960's, scientists and engineers fielded the first generation of passive night vision devices for US troops, including a small starlight scope that served as a rifle-mounted sight or as a handheld viewer. Realizing these systems were far from perfected, night vision research personnel came to refer to the development of this early equipment as the First Generation Image Intensifier Program. Scientists and engineers would go on to improve upon this technology to deliver a second and third generation of night vision equipment.

The first generation small starlight scope was soon put to practical use in the field. With the United States' growing involvement in Vietnam, the US Army quickly recognized that they faced an enemy that relied on the cover of darkness to conduct its maneuvers and offensive operations. In 1964, the US Army issued night vision equipment to the troops in Vietnam. The Vietnam War proved to be an important stage in the development of night vision systems.

An increase in research and development (R&D) efforts led to a host of new technologies after Vietnam. The major test of these technological efforts came in

History of Night Vision Devices (Continued)

late 1990/early 1991 when Iraqi armed forces invaded Kuwait. The United States of America and its allies immediately mobilized to force Saddam Hussein's forces out of Kuwait in Operation Desert

Storm. Night vision systems would prove vital to operating in the desert environment. Ground troops and major weapon systems such as tanks, helicopters, missile systems and infantry fighting vehicles used night vision systems. Night vision offered the coalition forces a capability Iraq didn't have, as ground troops and helicopter pilots used image- intensification devices, such as binoculars, while fighter jet crews used thermal imaging in aiming their weapons. The combination of the two technologies resulted in an unprecedented offensive capability. The guided munitions we saw on television (footage that was itself taken with

night-vision equipment) were actually only a small fraction of the ordnance used, but they had an enormous impact.

NVD Overview

Passive Night Sights

Type	Description
Thermals	Thermal Weapon Systems (TWS) <ul style="list-style-type: none"> • Completely passive • Primarily designed for target detection and engagement with Marine Corps crew served weapons • May also be used for all weather surveillance • A family of sights which will include a <ul style="list-style-type: none"> ○ Medium weapons sight (MWTS) ○ Heavy weapons sight (HWTS) • Will be mounted to the <ul style="list-style-type: none"> ○ M249 squad automatic weapon (SAW) ○ M240G machine gun ○ M2 .50 cal machine gun ○ MK 19 40mm grenade machine gun.
Type	Description

Ambient light NVDs	<ul style="list-style-type: none"> • Have been around for more than 40 years beginning with sniper scopes of World War II, which <ul style="list-style-type: none"> ○ Were cumbersome devices ○ Had short battery lives and indifferent performance ○ Required the use of infrared lighting ○ Were not much more sensitive to light than the human eye • NVDs are categorized by generation; each substantial change in NVD technology establishes a new generation: <ul style="list-style-type: none"> ○ Generation I, developed in 1960s ○ Generation II, developed in 1970s ○ Generation III, developed in 1990s ○ Generation IV developed in 2000
Generation I	<ul style="list-style-type: none"> • Beginning of passive night vision • Included <ul style="list-style-type: none"> ○ Vacuum tight fused fiber optics for good center resolution and improved gain ○ Multi-alkali photo cathodes ○ Fiber optic input and output windows • Lacked the sensitivity and light amplification necessary to see below full moonlight • Were <ul style="list-style-type: none"> ○ Often staged or cascaded to improve gain ○ Large and cumbersome ○ Less reliable ○ Relatively poor low light imagers ○ Characterized by streaking and distortion • Characteristics: <ul style="list-style-type: none"> ○ Vacuum tube technology ○ Full moon operation ○ Amplification: 1,000 - 2,000 ○ Operating life: 2,000 hours
Generation II	<ul style="list-style-type: none"> • Born out of the development of the micro channel plate (MCP): <ul style="list-style-type: none"> ○ Higher electron gains were now possible through smaller packaging ○ Performance improvements made observation possible down to 1/4 moonlight • First proximity focused MCP image intensifier tube was an 18mm tube used in the original AN/TVS-5 NVG • Generation II+ improved performance by providing increased gain at high and low levels • Generation II+ equipment <ul style="list-style-type: none"> ○ Will provide the best image under full moonlight conditions ○ Is recommended for urban environments. • First MCP application • Characteristics <ul style="list-style-type: none"> ○ One-quarter moon operation ○ Amplification: 20,000 - 40,000 ○ Operating life: 2,500 hours

Generation III	<ul style="list-style-type: none"> • Intensifier <ul style="list-style-type: none"> ○ Multiplies the light gathering power of the eye or video receptor up to 30,000 times ○ Is typically characterized by a gallium arsenide (GaAs) photocathode • Photocathode <ul style="list-style-type: none"> ○ Is grown using a metal organic vapor-phase epitaxy (MOVPE) process ○ Has photon sensitivity that extends into the near-infrared region, where night sky illuminance and contrast ratios are highest ○ Sealed to an input window which minimizes veiling glare, generates an electron current which is proximity focused onto a phosphor screen, where the electron energy is converted into green light which can then be relayed to the eye or sensor through an output window • Characteristics: <ul style="list-style-type: none"> ○ Improved MCP and photocathode ○ Starlight operation ○ Amplification: 35,000 - 60,000 ○ Operating life: 10,000 hours
Generation IV	<ul style="list-style-type: none"> • Gated filmless technology • Represents biggest technological breakthrough in image intensification of past 10 years • Removing the ion barrier film and “gating” the system demonstrates substantial increases in target detection range and resolution, particularly at extremely low light levels <p>NOTE: The term 4th generation is used/accepted among night vision manufacturers to describe gated filmless tubes; however, this designation is widely debated. Currently US military referred to it as “filmless and gated image intensifiers.”</p> <p>NOTE: The sensitivity of a first generation scope is far behind that of the second generation; in the areas of resolution and distortion, the performance of the first generation lags far behind that of the second, third, and fourth generation.</p>

NVD Overview (Continued)

Night Aiming Devices

Type	Description
Advanced Target Pointer Illuminator Aiming Light	<p>The Advanced Target Pointer Illuminator Aiming Light (ATPIAL), PEQ-15, provides a highly collimated beam of infrared energy for weapon aiming and an adjustable focus infrared beam for target illumination. This Class 3b laser device also provides a highly collimated beam of visible energy for weapon aiming. The ATPIAL has low profile aiming and illumination boresight adjusters. This device is 50% smaller and lighter than the TPIAL. The system comes with a MIL-STD-1913 rail grabber interface using the integral rail grabber bracket. The ATPIAL is the successor to the AN/PEQ-2A.</p> <p>Weapon Platforms: The ATPIAL has an Integral Rail Grabber Bracket that mounts to any weapon using the standard MIL-STD-1913 Rail, which includes the M4/M16-A4 rifles, M249, M240, M2, and Mk 19. The ATPIAL can also be used as a handheld illuminator/pointer.</p> <p>The AN/PEQ-15 has replaced both the AN/PEQ-2 and the AN/PAQ-4C.</p>

How Night Vision Devices Work

Spectrum

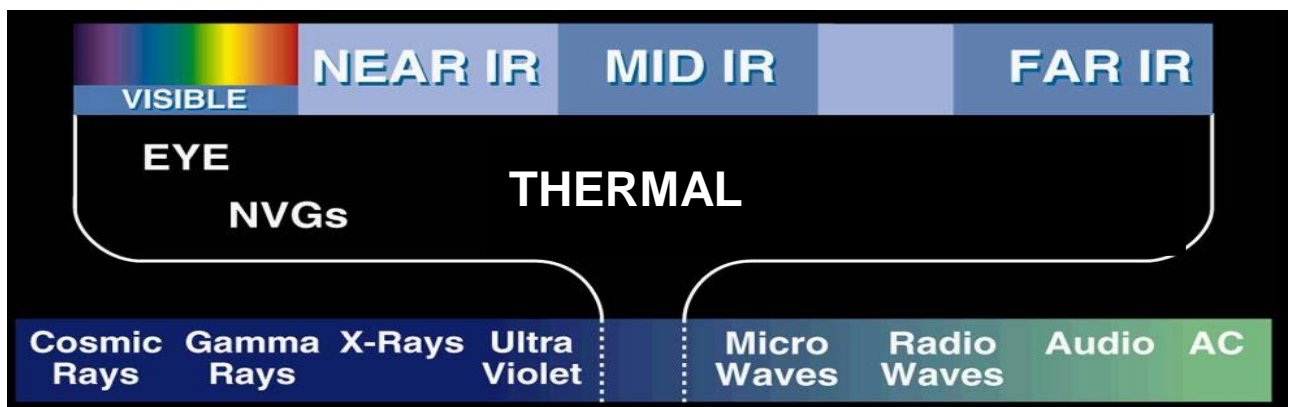
Electromagnetic waves are waves that are capable of traveling through a vacuum. Unlike mechanical waves, which require a medium in order to transport their energy, electromagnetic waves are capable of transporting energy through the vacuum of outer space. Electromagnetic waves are produced by a vibrating electric charge, and as such, they consist of both an electric and a magnetic component.

Electromagnetic waves exist with an enormous range of frequencies. This continuous range of frequencies is known as the electromagnetic spectrum. The entire range of the spectrum is often broken into specific regions. The subdividing of the entire spectrum into smaller spectra is done mostly on the basis of how each region of electromagnetic waves interacts with matter.

The diagram below depicts the electromagnetic spectrum and its various regions:

- The longer wavelength, lower frequency regions are located on the far left of the spectrum
- The shorter wavelength, higher frequency regions are on the far right
- Two very narrow regions within the spectrum are the visible light region and the X-ray region

You are undoubtedly familiar with some of the other regions of the electromagnetic spectrum.



Electromagnetic Spectrum

How Night Vision Devices Work (Continued)

Though electromagnetic waves exist in a vast range of wavelengths, our eyes are sensitive to only a very narrow band. Since this narrow band of wavelengths is the means by which humans see, we refer to it as the visible light spectrum. Normally when we use the term "light," we are referring to a type of electromagnetic wave, which stimulates the retina of our eyes. In this sense, we are referring to visible light, a small spectrum of the enormous range of frequencies of electromagnetic radiation. This visible light region consists of a spectrum of wavelengths, which range from approximately 700 nanometers (abbreviated nm) to approximately 400 nm; that would be 7×10^{-7} meters to 4×10^{-7} meters.

Each individual wavelength within the spectrum of visible light wavelengths is representative of a particular color. That is, when light of that particular wavelength strikes the retina of our eye, we perceive that specific color sensation. Isaac Newton showed that light shining through a prism will be separated into its different wavelengths and will thus show the various colors of which visible light is comprised.

The separation of visible light into its different colors is known as dispersion. Each color is characteristic of a distinct wavelength; and different wavelengths of light waves will bend varying amounts upon passage through a prism; for these reasons, visible light is dispersed upon passage through a prism.

Dispersion of visible light produces these colors (see electromagnetic spectrum above); thus, visible light is sometimes referred to as ROY G. BIV:

- Red (R)
- Orange (O)
- Yellow (Y)
- Green (G)
- Blue (B)
- Indigo (I)
- Violet (V)

When all the wavelengths of the visible light spectrum strike your eye at the same time, white is perceived. Thus, visible light is sometimes referred to as white light. Technically speaking, white is not a color at all, but rather the combination of all the colors of the visible light spectrum.

If all the wavelengths of the visible light spectrum give the appearance of white, then none of the wavelengths would lead to the appearance of black. Once more, black is not actually a color. Technically speaking, black is merely the absence of the wavelengths of the visible light spectrum. So when you are in a room with no lights and everything around you appears black, it means that no wavelengths of visible light are striking your eye as

How Night Vision Devices Work (Continued)

you sight at the surroundings.

How Night Vision Technology Works

NVGs are electro-optical devices that intensify (or amplify) existing light instead of relying on a light source of their own. Image intensifiers capture ambient light (which comes from the stars, moon, or sky glow from distant manmade sources, such as cities) and amplify it thousands of times by electronic means to display the battlefield to a Marine via a phosphor display such as night vision goggles. The devices are sensitive to a broad spectrum of light, from visible to infrared (invisible). Users do not look through NVGs; they look at the amplified electronic image on a phosphor screen. Light enters the NVG through an objective lens and strikes a photo cathode powered by a high energy charge from the power supply. The energy charge accelerates across a vacuum inside the intensifier and strikes a phosphor screen (like a TV screen) where the image is focused. The eyepiece magnifies the image.

An NVG phosphor screen is purposefully colored green because the human eye can differentiate more shades of green than other phosphor colors. Like cameras, NVGs have various image magnifications. The distance at which a human-sized figure can be clearly recognized under normal conditions (moon and star light with no haze or fog) depends on the

- Magnifying power of the objective lens
- Strength of the image intensifier

A Marine can conduct his combat missions without any active illumination sources using only image intensifiers. The main advantages of image intensifiers as night vision devices are their

- Small size
- Light weight
- Low power requirements
- Low cost

These attributes have enabled image intensifier goggles for head-worn, individual Marine applications and resulted in hundreds of thousands of night vision goggles to be procured by the Marine Corps. Research and development continues today on image intensifiers in the areas of longer wavelength spectral response, higher sensitivity, larger fields of view and increased resolution.

The view through NVGs can be a lot like looking down a tunnel. Your normal field of view is almost 190 degrees. NVGs cut that down to 40 degrees; side or “peripheral” vision you’re accustomed to and from which you often see dangers is just not there. To adjust for the narrow field of view, you must constantly turn

How Night Vision Devices Work (Continued)

your head to scan for the dangers on either side of you.

NVGs cannot provide the same level of clarity you are accustomed to during the day. While normal vision is 20/20, NVGs can, at best, provide only 20/25 to 20/40 and even this is possible only during optimal illumination and when you have a high-contrast target or scene. As either illumination or contrast decreases, the NVGs visual acuity drops, giving you an even more “fuzzy” image.

Normally you use both eyes (binocular vision) to pick up cues to help estimate the distance and depth of an object. However, with NVGs you are essentially using one eye (monocular) vision, which can pose real problems. For example, when you are wearing NVGs and view two objects of different sizes that are side-by-side, the larger object appears to be nearer. When you view overlapping objects through an NVG, the one that is in front “appears” to be nearer – maybe much more so than is true. In addition, some objects viewed through NVGs may appear to be farther away than they actually are. The reason for these optical illusions is that we tend to associate the loss of detail sharpness with distance. On the other hand, a light source that is not part of a terrain feature—for example, a light atop a tower—may look closer than it actually is. Be aware of these potential problems and that NVG users tend to overestimate distance and underestimate depth (how tall an object is).

Originated in the 1920s to increase the sensitivity of television cameras, image tubes work by converting light into electricity. Certain substances, such as selenium, had been known since the 1870s to be photo emissive—that is, to emit electrons when a light shone on them.

With the proper use of lenses, a pattern of light—visible or invisible—upon a photo emissive surface can be converted into electrical impulses. In an image tube, a voltage is applied across the photo emissive surface, which is called a photocathode. This voltage accelerates the emitted electrons and causes them to multiply.

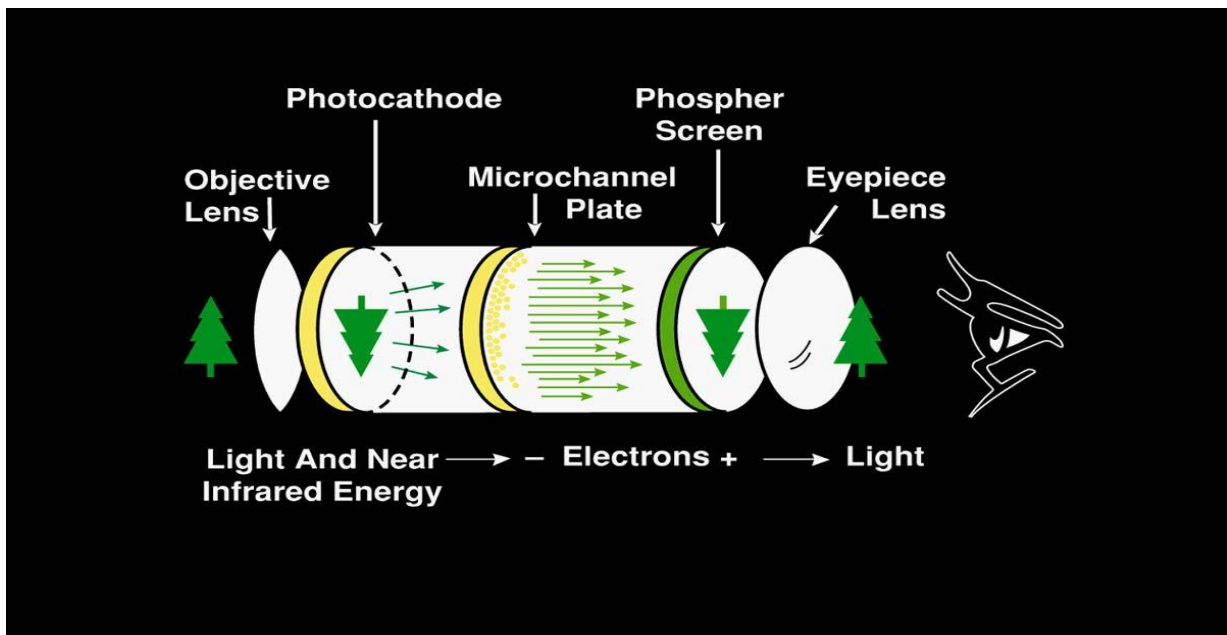
To create a visible image, the emitted electrons are directed against a phosphor surface. This type of surface is the opposite of photo emissive; it emits light when electrons strike it. The phosphor is in the form of a coating on an optic lens, which focuses the resulting visible image. The phosphor screen looks much like a black-and-white television with a greenish tint (green is used because the eye is most sensitive to that color). In essence, then, the earliest NVGs converted NIR light to electricity, amplified it, and then converted it to visible light. A microchannel plate (MCP) is a form of glass plate with millions of microscopic holes, or channels, running through it (this replaces the bundle of optical fibers). When a voltage is applied to accelerate electrons through it, the electrons repeatedly bounce off the channel walls, which are coated with the residue from etching the holes. As they do so, they dislodge additional electrons. The gain is proportional to the voltage applied. Each channel in the MCP corresponds to a pixel in the final

How Night Vision Devices Work (Continued)

image.

In Generation 2, the photocathode, microchannel plate, and phosphor screen—detector, amplifier, and display—are sealed together in a module less than an inch thick (see diagram below):

- The photocathode converts light to an electric current
- The microchannel plate amplifies it
- The phosphor screen converts it back to light



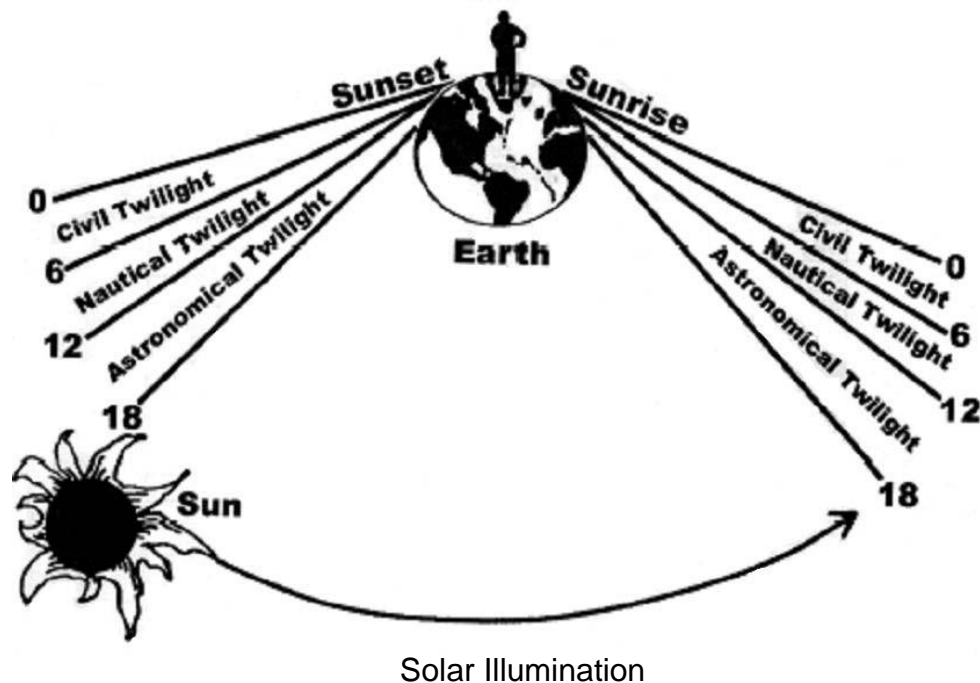
Generation 2 Module

Night vision systems are electro-optical devices which allow you to see at night. The objective lens of the night vision device collects small particles of light called photons, such as moonlight and starlight, and focuses them on the image tube. The photocathode converts this light energy into electrons. The electrons pass through a thin wafer disk, the microchannel plate, which contains millions of channels. As the electrons pass through the channels, they are amplified thousands of times. These multiplied electrons then strike a phosphor screen which converts them back into photons and provides you with the nighttime image of the scene in which you are viewing.

Planning Considerations

Planning Considerations

When using NVDs that require ambient light, illumination will be a major factor in planning operations. Some type of illumination must exist in order for the NVDs to be effective; too much illumination can severely degrade them or make them completely ineffective. Lunar and solar cycles (see diagram and table below) play an important part of determining natural illumination at various times:



Solar Illumination	Definition
Moonrise	The instant when, <ul style="list-style-type: none"> In the eastern sky Under ideal meteorological conditions With standard refraction of the moon's rays, the upper edge of the moon's disk is coincident with an ideal horizon
Moonset	The instant when, <ul style="list-style-type: none"> In the western sky Under ideal meteorological conditions With standard refraction of the moon's rays, the upper edge of the moon's disk is coincident with an ideal horizon
Twilight	<ul style="list-style-type: none"> Before sunrise and again after sunset, intervals of time during which

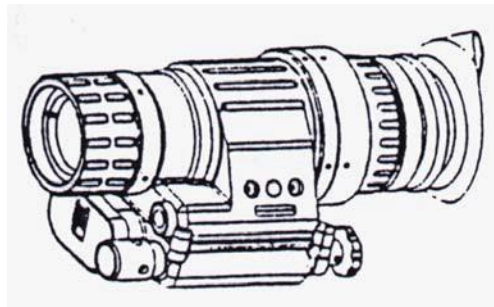
	<ul style="list-style-type: none"> ○ The upper atmosphere receives direct sunlight and reflects part of it toward the Earth's surface to provide natural light ○ Some outdoor activities may be conducted without artificial illumination • Major determinants of the amount of natural light during twilight are the <ul style="list-style-type: none"> ○ State of the atmosphere generally ○ Local weather conditions in particular • Atmospheric conditions are best determined at the actual time and place of events; however, it is possible to establish useful, though necessarily approximate, limits applicable to large classes of activities by considering only the position of the Sun below the local horizon. • Reasonable and convenient definitions have evolved for three kinds of twilight: <ul style="list-style-type: none"> ○ Civil twilight ○ Nautical twilight ○ Astronomical twilight
Civil Twilight	<ul style="list-style-type: none"> • Begins in the morning and ends in the evening when the center of the Sun is geometrically 6 degrees below the horizon • Is the limit at which twilight illumination is sufficient, under good weather conditions, for terrestrial objects to be clearly distinguished • At the beginning of morning civil twilight or end of evening civil twilight (ECT), the horizon is clearly defined and the brightest stars are visible under good atmospheric conditions in the absence of moonlight or other illumination • In the morning before the beginning of civil twilight and in the evening after the end of civil twilight, artificial illumination is normally required to carry on ordinary outdoor activities • Beginning of morning civil twilight (BMCT) is the period of time at which the sun is halfway between beginning morning and nautical twilight and sunrise, when there is enough light to see objects clearly with the unaided eye. At this time, light intensification devices are no longer effective, and the sun is six degrees below the eastern horizon • End of evening civil twilight (EECT) is the instant in the evening, when the center of the sun is at a depression angle of six degrees below an ideal horizon. At this time in the absence of moonlight, artificial lighting or adverse atmospheric conditions, the illumination is such that large objects may be seen, but no detail is discernible. The brightest stars and planets can be seen and for navigation purposes at sea, the sea horizon is clearly defined. • Complete darkness, however, ends sometime prior to BMCT and begins sometime after EECT

Nautical Twilight	<ul style="list-style-type: none">• Begins in the morning and ends in the evening, when the center of the sun is geometrically 12 degrees below the horizon.• At the dark limit of nautical twilight, the center of the Sun is geometrically 12 degrees below a horizontal plane. At the beginning or end of nautical twilight, under good atmospheric conditions and in the absence of other illumination, general outlines of ground objects may be distinguishable, but detailed outdoor operations are not possible, and the horizon is indistinct.• Beginning of morning nautical twilight (BMNT) is the start of that period where, in good conditions and in the absence of other illumination, enough light is available to identify the general outlines of ground objects and conduct limited military operations. Light intensification devices are still effective and may have enhanced capabilities. At this time, the sun is 12 degrees below the eastern horizon.• End of evening nautical twilight (EENT) is the instant in the evening, when the center of the sun is at a depression angle of 12 degrees below an ideal horizon. At this time in the absence of moonlight, artificial lighting or adverse atmospheric conditions, it is dark for normal practical purposes. For navigation purposes at sea, the sea horizon is not normally visible.
Astronomical Twilight	<ul style="list-style-type: none">• Begins in the morning and ends in the evening when the center of the Sun is geometrically 18 degrees below the horizon.• At the dark limit of astronomical twilight, the center of the Sun is geometrically 18 degrees below a horizontal plane. Before the beginning of astronomical twilight in the morning and after the end of astronomical twilight in the evening the Sun does not contribute to sky illumination; for a considerable interval after the beginning of morning twilight and before the end of evening twilight, sky illumination is so faint that it is practically imperceptible.

AN/PVS-14

The PVS-14 (see diagram below) allows the user to see at night using moonlight or starlight. The PVS-14 is a GEN III image intensification device similar in performance to the previously-used PVS-7 NVGs, yet smaller, lighter, and more versatile. PVS-14s can be

- Hand-held
- Carried in the utility uniform pocket
- Head-mounted
- Helmet-mounted
- Mounted to a weapon



PVS-14

The table below provides more information on the PVS-14.

Nomenclature	NSN	Manual
AN/PVS-14 monocular night vision device	5855-01-432-0524	TM 10271A-10/1 TM 11-5855-306-10 Operator's Manual, Monocular NVD, AN/PVS-14, 30 Dec 97

Characteristics

- Weight: 14 oz
- Focus range: 25 cm to infinity
- Range:
 - 150 m (starlight)
 - 300 m (moonlight)
- Battery: 2 AA
 - Alkaline
 - Lithium
- Battery life: 12 hours
- Magnification: 1X
- Field of view: 40 degrees

AN/PVS-14 (Continued)

Accessories

- Monocular with lens cap to protect lens
- Demist shield for high humidity and rain. Degrades visual acuity.
- Light interference filter (LIF) to protect eyes from lasers
- Sacrificial window to protect monocular lens from dust and sand scratches
- Compass to orient at night
- Tether cord is a dummy cord for
 - Compass
 - 3X magnifier
- Head mount and 3 brow-pads to mount monocular on head
- Helmet mount to mount monocular on helmet
- Head/helmet mount adapter to attach monocular to mounts
- Small arms mount to mount monocular to weapon
- 3X magnifier lens is available as an optional accessory
- Carrying case and strap to carry monocular
- Storage case to store monocular and all accessories
- Operator's manual

Limitations

In complete darkness, such as inside buildings, PVS-14s are ineffective unless additional IR illumination is present.

Indicator Lights

- Low battery: Blinking red dot in eyepiece means less than 30 minutes of battery life.
- IR beacon is on: Steady red dot in eyepiece.

Switch

- OFF/RESET turns monocular off. Resets monocular after automatic shutoff.
- ON turns monocular on.
- IR turns IR beacon on. Pull and turn. A steady red dot appears.

Automatic Shutoff

The monocular shuts off automatically

- In excessive light
- When monocular is removed from head mount

AN/PVS-14 (Continued)

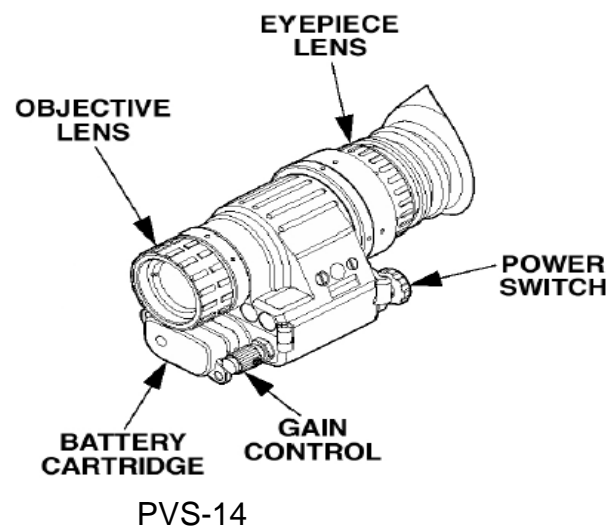
- When monocular is flipped up from the helmet mount

To turn monocular back on, turn switch to OFF/RESET, then back to ON.

Monocular Adjustment

The PVS-14 has four adjustments:

- Variable gain: Adjusts the brightness of the image to reduce eyestrain, especially in changing light.
- Objective lens focus: Adjusts for sharpest image of viewed object.
- Diopter adjustment ring: Focuses eyepiece for sharpest image of intensifier screen. To adjust,
 - Rotate diopter adjustment ring (see diagram below) for the clearest view of the image.
 - If done in a lighted condition, line up the image through the goggle and the image in your naked eye.
- Eye relief: On helmet and head mounts, the distance between the user's eye and the monocular needs to be adjusted as close to the eye as is comfortable.



Maintenance

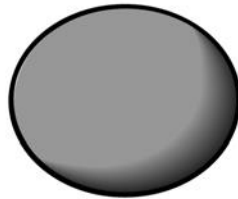
To maintain the PVS-14, clean lens with lens paper. Turn in for maintenance if monocular operates intermittently or has

- Shading

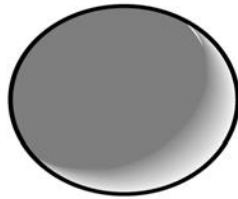
AN/PVS-14 (Continued)

- Edge flow
- Flashing
- Flickering

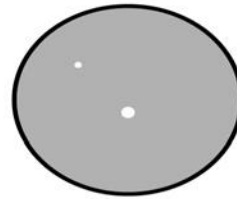
Some blemishes or spots on screen are not deadline issues. Only higher echelon maintenance can adjust goggle resolution.



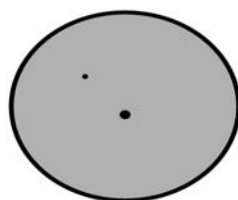
Shading



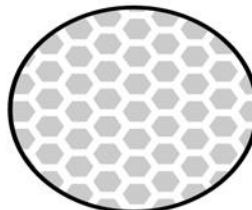
Edge Glow



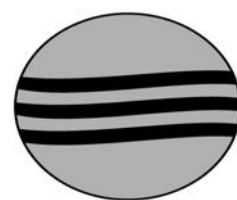
Bright Spots



Dark Spots



Honeycomb



Distortion

Mounts

- Head mount:
 - Don head mount.
 - Adjust straps.
 - Attach head/helmet mount adapter to monocular.
 - Attach monocular to mount.
 - Adjust eye relief by sliding mounting bracket toward or away from eyes.
- Helmet mount:
 - Strap helmet mount to helmet.
 - Attach head/helmet mount adapter to monocular.
 - Attach monocular to mount.
 - Slide monocular up and down by loosening bracket knob.
 - Adjust eye relief by sliding mounting bracket toward or away from eyes..
 - Monocular can be
 - Flipped up when not in use
 - Removed from the helmet by depressing the lever

AN/PVS-14 (Continued)

- on the right side of the helmet mount and removing the entire bracket
 - Worn on either eye. Loosen the knob on the end of the mount adapter, rotate the monocular to the desired eye, and once the monocular is positioned, tighten the knob
- Small arms weapons mount:
 - Attach to weapon.
 - Mount PVS-14 to mount.
 - Can be used with 3X magnifier.

Pre-Combat Checks

- Install batteries.
- Remove lens cap.
- Install
 - Sacrificial window
 - Compass
 - 3X magnifier
- Don and adjust head or helmet mount.
- Make the four monocular adjustments.

IR Beacon

IR beacon illuminates near objects in very dark conditions or for signaling. An enemy equipped with NVGs can detect the IR beacon. Turn beacon on by pulling switch out and forward.

PVS-14 Training

Most of the tactics, techniques, and procedures for the PVS-7 are the same as for PVS-14. The TTPs specific to PVS-14 are as follows:

- Fire the M-16A2 with PVS-14 mounted:
 - Mount the PVS-14 to the weapon using the small arms mount.
 - Adjust PVS-14 far enough away from eye to prevent injury from weapon recoil.
 - Op-check PEQ-16A / PEQ-16B beam by observing through PVS-14 monocular.

- Mounting PVS-14 to the M-16A4 is best done in stationary or defensive operations where the Marine is covering a sector from behind his weapon.
- Common error: Using a mounted PVS-14 during offensive actions. It is nearly impossible to use a mounted PVS-14 while moving with the weapon.

AN/PAS-13D Thermal Sight



MWTS

Weight:	2.9 lbs with Full Battery Pack and Rail Grabber with Spacer
Length:	13.5 in.
Width:	3.5 in.
Height:	4.75 in. (with Spacer and Rail Grabber)
Controls:	Menu Based 6 Button Control and Power Switch
Video Output:	Integrated LCD and RS-170 Video Output at I/O Port.
Operating Temperature:	-40°F (-40°C) to 120.2°F (49°C)
Diopter Range:	-6 to +2
Field of View (FOV):	18° and 6° FOV (Wide & Narrow FOV)
Range of 70% probability of recognition of a moving man with moderate clutter on a:	
Clear battlefield:	1100 meters
Dirty battlefield:	360 meters

AN/PAS-28 Thermal Sight



Rugged lightweight extended-range infrared binocular system

Specifications

- Detect/recognize upright moving man => 2,200 m
- Detect vehicle => >5,000 meters
- Magnification => 2x to 4x

Physical Features

- Size => 12.7 in. (L) x 7 in. (W) x 3.5 in. (H)
- Display type => 640 x 480 color display
- Weight => <3.6 pounds with batteries (<1.6 kg)
- Operational temperature range => -36°C to 60°C
- Rugged Design - Aluminum housing surrounded by rubber armor
- Tripod mounting
- Accessory rail adapter
- Video output => NTSC and digital USB streaming

Power Requirements

- Internal power
 - 4 AA lithium batteries > 7 hours at 25°C

AN/PAS-28 Thermal Sight (Continued)

- External power
 - NATO slave cable for vehicle power
 - BA5590 battery cable
 - Power save mode

Additional Features

- Image capture Digital image/video recording
- Integrated Class 1 and 3B infrared laser
- Electronic Compass Azimuth readings ($\pm 3^\circ$ accuracy), Elevation, Tilt
- MIL-DOT style, with size adjusted to zoom setting; Cross Hair Style; or Stadiametric Reticle
- Black hot / white hot
- Gain/level control
- Calibration

AN/ PEQ-16



Multifunction laser device incorporating visible and infrared aim lasers

Features

Integrated Infrared Aim Laser
Infrared Illuminator
Visible Aim Laser
White Light Illuminator

AN/PEQ-16 (Continued)

Characteristics

Dimensions: 4.1" L x 3.2" W x 1.7" H
Weight (with batteries): 9.9 oz.
Battery Type: (2) 3-volt lithium
Battery Life: >100 two-second illuminations in D (DUAL) mode
Visible Aim Laser Specifications Safety Class Output Power:
4.0 mW 3a Beam Divergence: .5 mrad Wavelength: 605-665 nm
Range: 25m
IR Aim Laser Output Power Low: .6 mW 1
Output Power High 25 mW 3b
Beam Divergence: .5 mrad Wavelength: 820-860 nm Range: >600m (LO), >2000m (HI)
IR Illuminator Output Power Low: <3.5 mW 3a Output Power High: 30 mW 3b Beam Divergence: 1-105 mrad (min) Wavelength: 820-860 nm Range: >600m (LO), >2000m (HI)
White Light Illuminator Output Power: >100 lumens

Summary

The techniques discussed here are tools that will help you better observe your environment and operate within it. Maintaining the proper state of alert, remembering what you see, and evaluating what is normal and what is abnormal for your environment are all techniques that will make you better able to execute your mission.

References

Reference Number or Author	Reference Title
AN/PAS-13d(V) 2 & 3 THERMAL WEAPONS MCIP 3-11.01	TM 11-5855-317-10 Combat Hunter Operations (Draft)
AN/PEQ-16A Technical Manual	TM 11407A
MRTB AN/PAS-28	TM 11237B-OR
MIPIM AN/PEQ-16A	TM 11407A-OI
AN/PVS-14	TM 10271A-10/1
Rifle Combat Optic (RCO)	TM 11064-OI w/ ch 1
SDO Operator's Manual	TM 11758A-OR
Leupold Binocular	TM 10291A-12&P

Glossary of Terms and Acronyms

Term or Acronym	Definition or Identification
BPM	Beats Per Minute
SDO	Squad Day Optic
ACOG	Advanced Combat Optical Gunsight
BZO	Battle Sight Zero. Sets a weapon systems aimpoint for a specific distance. M-16s have a BZO of 300m.
Diopter	Is the adjustable eyepiece lens that focuses an image onto the retina for the clearest picture.
Exit Pupil	Also known as Virtual Aperture, it is a measurement of the amount of light that will pass through the optical system. To find the size of the Exit pupil divide the size of the Objective Aperture by the magnification of the optic.
Eye Relief	Distance between your eye(s) and the eyepiece of the optic.
Objective Aperture	The light collecting lens of an optic. Measured in millimeters across the diameter of the lens.
RCO	Rifle Combat Optic
RMR	Ruggedized Miniature Reflex Sight (part of the SDO)